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Voyages of Discovery on Oceans of Air: Scientific Observation and the Image of Science in an Age of “Balloonacy”

Jennifer Tucker*

The Balloon, considered as an instrument for vertical exploration, presents itself to us under a variety of aspects, each one of which is fertile in suggestions. . . . Do not the waves of the aerial ocean contain, within their nameless shores, a thousand discoveries to be developed in the hands of chemists, meteorologists, and physicists? . . . It seems unnecessary to justify further the attempt to make the Balloon a philosophical instrument, instead of an object of exhibition, or a vehicle for carrying into the higher regions of the air excursionists desirous of excitement, mere seekers after adventure.

—James Glaisher, Travels in the Air, 1871

On 31 August 1863, spectators crowded into the Mathematics and Physics Session of the British Association for the Advancement of Science meeting in Newcastle to hear the astronomer and meteorologist, James Glaisher, superintendent of the Magnetic and Meteorological Department at the Royal Observatory at Greenwich. Glaisher was to relate the results of his firsthand observations of atmospheric phenomena at varied elevations in aeronaut Henry Coxwell’s balloon, Mammoth. Following the lecture, Glaisher and Coxwell made a public ascent from the

* Division of the Humanities and Social Sciences, California Institute of Technology, Pasadena, California 91125. The Glaisher papers of the Royal Astronomical Society Archives are cited courtesy of the Royal Astronomical Society. A portion of this research was done in preparation for a M.Phil. thesis at Cambridge University in 1990. Papers based on this research were presented at the National Air and Space Museum, Smithsonian Institution, in July 1992, and at the History of Science Society annual meeting in December 1992; subsequent work was done in 1996. The research for this project was assisted by support from the Marshall Scholarship Commission, the Smithsonian Institution Office of Fellowships and Grants, and the National Endowment for the Humanities. I would like to thank Peter Hingley, Librarian of the Royal Astronomical Society, and the librarians and staff of the National Air and Space Museum, the Royal Meteorological Society, and the Guildhall Library, Corporation of London, for their assistance: J. A. Bennett, Thomas Crouch, David DeVorkin, David Dewhirst, Bruce Hevly, Henrikka Kuklick, Bernard Lightman, Dylan Penningroth, Mary Poovey, and Charles Scribner, Jr., for helpful comments on earlier drafts; and especially Simon Schaffer, Robert Smith, and Judith Walkowitz for their insights and encouragement.

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Figure 1. "Path of the Balloon Over London, at Night, 2nd Oct., 1865." "Over London at Night" invites comparison with the famous panorama, "London by Night," by the theatrical scene-painter George Danson, which opened at the Coliseum in Regent’s Park in 1845. Glaisher recalled: "On leaving Charing Cross I looked back over London, the model of which could be seen and traced—its squares by their lights; the river, which looked dark and dull, by the double row of lights on every bridge spanning it. . . . It seemed to me to realize a wish I have felt when looking through a telescope at portions of the Milky Way; when the fields of view appeared covered with gold-dust, to be possessed of the power to see those minute spots of light as brilliant stars; for certainly the intense brilliancy of London this night must have rivalled such a view." (Lithograph in James Glaisher, ed., Travels in the Air [Philadelphia: J. B. Lippincott, 1871], p. 80).

local cricket ground. Their scientific balloon ascension with meteorological instruments excited more interest than all other events connected with the Association's annual meeting, according to local newspapers. As military bands enlivened the proceedings, hundreds of British Association members and their guests assembled in a fenced enclosure around the balloon, and local townspeople, enjoying a general holiday declared by the mayor, jostled for good positions from which to watch the pair ascend. The next evening, Glaisher lectured on his scientific balloon voyages before an audience of around three thousand people in the town hall. In a Victorian age fascinated by discovery and exploration, Glaisher’s experiments in a balloon, a flying laboratory of sorts, appealed to the appetite for topographical, topical news from remote regions (Figure 1). In the eyes of many, the balloon, like the microscope, was a tool that allowed access to a new world of wonders. Glaisher declared that the British Association’s scientific balloon ascents, a major investment of resources and hopes, formed a bright chapter, “perhaps the brightest,” in the history of the
Association; he expressed the hope that, the balloon having done so much for science, science would do something for the balloon. Ambitions in the first half of the nineteenth-century to appropriate for ballooning the cultures and traditions of science were jeopardized by the balloon's persisting association with vulgar amusement and unruly crowds—an association that scientists could not fully control. The values of ballooning and science seemed antithetical: Victorian science was a moral enterprise, as witness the relation between Victorian values and Victorian precision, while the balloon was a “vehicle” for champagne “picnics in the air,” a fixture of morally ambiguous pleasure gardens, and, in some contexts, a symbol of social and political defiance. More than once, crowds mobbed and burned a balloon. Balloon ascents were a major feature of Victorian entertainment, not only in London, where aeronauts offered their services and balloon for hire in several pleasure gardens, but at carnivals, fairs, and private parties throughout the country. Many who commented on the “balloon craze” in Regency and Victorian England expressed tremendous moral ambivalence about balloon ascensions, symbols not just of discovery, innovation, and exotic travel, but of excited crowds, riots, humbuggery, French decadence, reckless endangerment of passengers and spectators, and of the loss of reason and moral propriety. In the early years of aerostation following the invention of the balloon in France in 1783, the Royal Society had, in fact, refused to support systematic exploration in balloons in England, on the grounds that to do so would encourage “Ballomania.”


On the Royal Society’s rejection of support for balloon experiments, see R. Gillespie, “Balloonning” (cit. n. 2). After learning of the French experiments in ballooning, the president of the Royal Society, Joseph Banks, wrote to Benjamin Franklin in 1783, “I think I see an inclination of the more respectable sort of the Royal Society to guard against the Ballomania which has prevailed in France, and not to patronise Balloons on account of their rising in the atmosphere, until some experiment likely to prove beneficial either to Society or Science is proposed to be annexed to them” (quoted in R. Gillespie, “Balloonning” (cit. n. 2), p. 262). Gillespie concludes that the development of ballooning took remarkably divergent paths in England and France in the late eighteenth century; whereas French aerostation was controlled by state-supported natural philosophers and inventors, English ballooning was the province of “adventurers seeking instant fame and fortune” (p. 262).
In the 1860s, when, as I shall argue, scientific ballooning and Victorian entertainment were still inextricably linked, Glaisher tried to demonstrate that his ascents were in the realm of science, not “mere amusement.” Just as balloon ascents themselves provided occasions for gentlemen of science to demonstrate how one ought to comport oneself in a scientific public, Glaisher’s lectures and writings for scientific and general audiences were the means through which he communicated, in words and pictures, how a man of science made scientific observations in a balloon. To encourage a connection between ballooning and Victorian precision, Glaisher propagated a new enterprise of observing in a balloon, one that produced data, not thrills. This paper examines a series of efforts by Glaisher and the Balloon Committee of the British Association in the mid-nineteenth century to legitimate the balloon as a “philosophical instrument” for field work in the new science of the Earth’s atmosphere. Assessing the rise of scientific ballooning in mid-nineteenth-century Britain compels us to reflect on the impact of a variety of cultural and intellectual forces at work in the 1850s and 1860s—forces associated, for example, with Victorian developments in the field of meteorology; the popularity of London shows, attacks on sensation-producing entertainments and “balloon experiences,” the forging of links between geomagnetic and meteorological networks and astronomical observatories at Kew and at Greenwich, and the valuation of precision.
measurement. Only by analyzing Glaisher's project "in motion," from the planning stage to the building of the balloon to the interactions among scientists, aeronauts, news reporters, and crowds, can we unravel the meanings and values inscribed in Victorian scientific ballooning and in the Victorian image of scientific observation.

The paper is in four parts. The first articulates the connections among Glaisher's ascents, Victorian astronomy, and the networks of geomagnetism and meteorology developing around the British Association, a major sponsor of field research in the mid-Victorian era. The next examines some of the means Glaisher used to try to control the public image of his ascents as science, not "mere amusement," such as directing people's attention away from the balloon itself and toward his observations with instruments in the balloon car. The third section points to the British Association's lack of control over the balloon not only in the air, but on the ground. I conclude with some reflections on the image of the scientific observer and of scientific observation in the age of "ballooancy." Although the ostensible aim of scientific balloon ascents was to gather empirical facts, it was observation itself, I shall argue, that became the object of scrutiny. Glaisher had to work against stereotypes of the "balloonatic" and the "mere adventure-seeker" to fashion a credible position for himself as an authoritative narrator, but these stereotypes nevertheless constituted the background for his own exceptionality as a hardy scientific traveler and for his celebrity status as a hero of discovery. Victorian values of discipline and duty were central to Glaisher's public image as a neutral, detached observer who focused on his instruments even at dizzying altitudes above the clouds, and who possessed the self-discipline to make precise measurements, even in sight of picturesque views.

VICTORIAN ASTRONOMY AND VICTORIAN EXPLORATION

Glaisher transported science into the air. The son of a watchmaker in Rotherhithe, London, Glaisher was at the time of the ascents a distinguished gentleman of science in his early fifties. Born in 1809, he had worked on the ordnance survey of Ireland.
from 1829 to 1830 before becoming an astronomical assistant to Airy, then director
of the Cambridge University observatory. Glaisher's career was firmly bound to
Airy's. Five years after Airy moved to the Royal Observatory at Greenwich in his
new role as the Royal Astronomer, Airy appointed Glaisher as superintendent of the
Magnetic and Meteorological Department at the Royal Observatory. At Greenwich,
Glaisher superintended Britain's first system of precise, simultaneous meteorological
observation by volunteers (mostly medical men, clergymen, and railroad station
managers) in different parts of the country for the preparation of meteorological
reports in the *Daily News* and the registrar-general's returns of births, marriages, and
deaths. He joined the Royal Astronomical Society in 1841, was elected a Fellow of
the Royal Society in 1849, and served as a Juror in the Class of Philosophical Instru-
ments at the Great Exhibition of 1851. During his long scientific career, Glaisher
played an important role in the development, dissemination, and calibration of new
empirical instruments and techniques in the distinct but related fields of Victorian
meteorology, astronomy, microscopy, photography, and aeronautics—fields that
connected the cultural practice of science and experienced seeing to the conquest of
new "frontiers" of knowledge. Glaisher served as the first president of the Royal
Microscopical Society, as the president of the Photographic Society, and as a mem-
er of the Council of the Aeronautical Society. In 1850, he, with the cooperation of
Dr. J. Lee and S. C. Whitbread, founded the British (now Royal) Meteorological
Society. Although involved in the ascents as an instructor to the other observers in
1859 and 1860, Glaisher did not make the balloon observations himself until 1862,
when his dissatisfaction with the way that previous observers (two medical students
and his Greenwich assistant, Mr. Criswick) had made the observations motivated
him to make them himself.

Although Glaisher came to be personally identified with Victorian scientific bal-
loon ascensions, the British Association was the major institutional force behind
them.9 The British Association, founded in 1831, had a special interest in advancing
meteorology, then a new science that depended on the cooperation of many observ-
ers, some with little or no specialist training. In considering grant proposals, the
British Association gave priority to projects that best met two major institutional
goals, articulated by Vernon Harcourt in his opening address of 1831: to bring to-
gether multiple disciplines ("the chief interpreters of nature have always been those
who grasped the widest field of inquiry"), and to heighten public awareness of sci-
ence ("Let philosophy . . . come forth and shew herself public").10 Like other
research projects funded by the British Association with public funds, scientific bal-
looning provided a focus for questions from a range of different sciences, including
chemistry, meteorology, and physiology, and thus presented a unified image of sci-
ence at work during a period of rising concern about the fragmentation of natural
science. Second, it promised to bring research results to a public already interested

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9 On the British Association and its activities in Victorian science, see especially Cannon, *Science in Culture* (cit. n. 1); T. W. Heyck, *The Transformation of Intellectual Life in Victorian Britain* (Lon-
don: Croom Helm, 1982); O. J. R. Howarth, *The British Association for the Advancement of Science: A Retrospect, 1831–1931* (London: British Association, 1931); Roy MacLeod and Peter Collins, eds., *The Parliament of Science: The British Association for the Advancement of Science, 1831–1981* (Lon-
in discovering what travelers observed from the vantage point of balloons. Third, it represented a new movement in scientific investigation, one that required substantial financial backing if repeated ascents were to be made. Finally, it was a research program with potentially valuable practical applications, such as determining laws for predicting wind currents, weather changes, and rainfall, and for assessing the effect of height on human and animal physiology as well as on instruments positioned at various geographical elevations. All were concerns of major scientific, military, and national interest in Britain during the age of mapping surveys, expansion of shipping networks and agricultural trade, and colonization.

Victorian astronomy provided the models for Britain’s first systematic use of the balloon for scientific purposes. Already at this time a close connection existed between astronomy at Victorian Britain’s two leading astronomical institutions, Kew Observatory and the Royal Observatory, Greenwich, and the networks of geomagnetism and meteorology developing around the British Association.11 In 1852, the Kew Committee of the British Association funded four scientific balloon ascents from Vauxhall Gardens, a popular London pleasure resort known for its open-air theaters, balloon ascents, and pictorial and optical entertainments. The purpose of the ascents was to test the claim by French astronomers in 1850 that the temperature changed radically above 19,000 feet, a point of special interest to astronomers, who used the temperature of the air at high altitudes to determine the coefficient of refraction. The primary observer for the British Association’s balloon ascents in 1852 was John Welsh of Kew Observatory. The aeronaut was Charles Green, owner and manager of the great Nassau balloon and Britain’s most famous aeronaut in the 1850s. In four ascents to altitudes ranging from 19,000 to 22,000 feet, Welsh found results that modified current understanding of the decrease of temperature with height above the Earth’s surface and that confirmed previous reports that the composition of the atmosphere on the Earth’s surface was fundamentally similar to the composition of the atmosphere at the greatest heights accessible to humans. Although not as widely publicized as Glaisher’s later ascents, Welsh’s scientific ascents excited great public interest, and, in 1852, an illustration portraying Welsh with two other observers and Green in the Nassau appeared, for example, in a feature story in the stylish Illustrated London News. Welsh, who died in 1859 after a long illness, discovered that at varying elevations, temperatures remained stable for a space of roughly 2,000 feet.12

In 1858, Colonel William Sykes, a leading gentleman of science in the British Association, obtained the appointment of the Balloon Committee under the auspices of the Mathematics and Physics Section of the British Association.13 The Balloon

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11 See Cannon, Science in Culture (cit. n. 1); and Schaffer, “Astronomers Mark Time” (cit. n. 7). On Cambridge astronomy, see Robert Smith, “The Cambridge Network in Action: The Discovery of Neptune,” Isis, 1989, 80:395–422. Victorian astronomers such as Sir George Airy made numerous field expeditions, for example, to test gravitational constants and chronometers (see n. 7).


Committee included some of the British Association's most distinguished men of science: William H. Sykes, Sir George Airy, Lord Wrottesley, David Brewster, John Herschel, John Lee, Thomas R. Robinson, John Gassiot, William Fairbairn, John Tyndall, and W. A. Miller, many of whom had already made balloon ascents with Green. Members framed a research agenda that focused on the importance of verifying temperature observations made previously at great heights. They also provided the necessary funds (two hundred pounds in 1858) to hire a balloon and to pay for gas and an aeronaut. In their efforts to apply the balloon to science, however, members of the Balloon Committee had to confront mechanical failures, bad weather, and the sheer shortage of balloons designed to make very high ascents.

The Balloon Committee soon discovered that ballooning was a difficult field of work with resources not easily accommodated within Victorian science. On August 15, 1859, the entire Balloon Committee, including William Fairbairn, president of the Association, traveled to Wolverhampton to watch a scientific balloon ascension, only to discover an “aerial shipwreck” after strong winds tore the balloon apart. With the Nassau in tatters, the only balloon in England big enough to elevate two men and instruments to heights of 19,000 feet and above was the Royal Cremorne, a popular attraction at London's Cremorne Gardens. It again proved impossible, however, to get the project off the ground. Reconvened at Wolverhampton to watch the scientific balloon ascension, Committee members watched helplessly as the Royal Cremorne, after rising a mile, descended slowly, full of minute holes. Glaisher, who had arranged for meteorological observations to be made simultaneously, every few minutes, at thirty different places to test and compare terrestrial and upper atmospheric data, said this check to the proceedings “disgusted many with aeronautical experiences,” and he pointed out that “one would have believed that the real difficulties would have been met with in the air, but, on the contrary, the greatest difficulties had to be overcome on earth.”

Dependent on resources controlled by persons and institutions outside the British Association, including gasworks, balloons, railroads, favorable newspaper publicity, and pleasure-garden venues, men of science on the Balloon Committee had to negotiate successfully with people from a myriad of social positions on the ground before they could send an observer with instruments into the so-called “higher regions.” Although Sykes negotiated with aeronauts, imploring them to build a reliable big balloon and even offering them an advance of money for materials and to offset their loss of income during the manufacture of the balloon, his efforts were unrewarded. In his report “Scientific Objects to be sought for by continuing the Balloon Ascents formerly undertaken to great Altitudes,” Robert Walker, reader in experimental philosophy at Oxford, tried to justify the extension of the Committee's grant at the British Association’s annual meeting in 1860. Walker declared that the Committee’s main objects—to verify Welsh’s finding of stabilization in the decrease of temperature at high elevations and to determine whether this arrest occurred in all seasons—still had not been accomplished. The Committee won an extension of their grant in 1860, but Sykes’s persistent efforts to obtain a big balloon again failed, and the Committee lapsed months later. Although scientists had proposed investigations

14 The Committee's troubles are discussed in Glaisher, Travels in the Air (cit. n. 12), pp. 31–32.
in a wide range of related fields, including chemistry, magnetism, electricity, and physiology, Sykes exclaimed that inviting further opinions from members of the Balloon Committee as to the objects to be sought in balloon ascents served no purpose, "as means were wanting, whatever those opinions might be, to give practical opinion to them." Learning that Mr. Simpson of Cremorne Gardens had constructed a new balloon at a cost of six hundred pounds with sufficient capacity to ascend to great heights, Sykes moved the reappointment of the Committee in 1861, but the reports were discovered to be unfounded.

The failures and frustrations of the British Association Balloon Committee from 1858 to 1862, when they battled predicaments caused by wretched weather and defective balloons, indicate some of the obstacles to be overcome before scientific balloon ascensions to great heights were feasible. Not until 1861, when Henry Coxwell volunteered to build an especially big balloon for the scientific balloon ascensions with a financial advance from the Committee, did meteorological observations at high altitudes become practicable in Britain. The son of a naval officer, Coxwell was at this time in the second decade of his career as an aeronaut; others called him a "balloonatic." Coxwell occupied a world in which Victorian entertainers staked their livelihoods on their perceptions and anticipations of what the public wanted at a given moment. Like many aeronauts, he practiced more than one trade, offering his balloon for hire at the Crystal Palace during the summer and deploying his mechanical skills as a dentist in Tottenham during the winter. Coxwell earned recognition in the 1850s as the promoter of military ballooning and war-signaling and as the advisor on a proposal to explore Australia in a balloon. With the help of his family, local townspeople, and fellow artisans, Coxwell built the biggest balloon in Britain, which he appropriately named the Mammoth. It had a capacity of over 90,000 cubic feet. In his letters to Glaisher during the summer of 1862, Coxwell described the progress of the balloon manufacture. Coxwell employed all the available seamstresses in Tottenham, a net-maker, a basket-maker, and a valve-maker. A large schoolroom was engaged for pattern-forming and for oiling the cloth. In June 1862, Coxwell announced in a local newspaper that he was "perfectly ready for the experiments in which the British Association was about to engage."
Coxwell’s participation was crucial to the success of the ascents. He not only built a balloon, he controlled its movements so that Glaisher could take observations at different heights, and he served as a witness of the experiments. Scientific ballooning required “two different kinds of men,” explained Coxwell,

“the observer, who is intent and devoted to his instruments, and the pilot, who in new fields of aerial exploration must . . . have studied and grasped the requirements of the [British] Association and of the Meteorologist, so as to be able to place the said observer in the most favorable positions as to height, quick or slow movement in a vertical or horizontal direction, and above all, to ensure safety . . . so that the balloon, the instruments, and—far more than either—the life of the Meteorologist, should be considered and preserved.”

By differentiating his work from Glaisher’s in his numerous press reports and popular lectures, Coxwell helped to define the boundaries between “scientific” and “unscientific” ways of seeing, by suggesting, for example, what scientific observation was not. If attaining great heights was desirable to gentlemen of science because it enabled them to verify meteorological observations at great altitudes, high ascents were important for Coxwell because they attracted attention, set him apart from other aeronauts as a specialist in “scientific” ascents, and demonstrated his skills as an artisan and navigator. In a letter to Glaisher in April 1863, Coxwell showed that he understood that it was important to differentiate between scientific ascents and popular ascents: “It seems to me that the British Association ascents should be kept distinct from those merely undertaken for popularity or adventure, indeed some difficulty presents itself in combining them.” Concerned that his rising popularity as a dashing aeronaut might jeopardize his relation to the British Association, Coxwell asked Glaisher in 1863 if a high ascent made by him would “be thought an act of bravado on my part, or merely the fulfillment of a public contract?” Coxwell conceded that scientific ascents and ascents of pleasure did not “blend well.” He assured Glaisher that he refused to make “high ascents” with others “for mere popularity,” although there is no evidence that Glaisher asked him for this concession. Coxwell volunteered that “Others are willing to pay for a similar high ascent, but I have told them I can only undertake such experiments in conjunction with you yourself, as their testimony would be useless to science.”

Glaisher wanted to go as high as possible to gather information in unexplored regions of the sky, but to win acceptance for the idea that scientific balloon ascents were a worthwhile investment of public funds for scientific research, he had to demonstrate that his high ascents with Coxwell were “explorations,” not “stunts.” For Glaisher and the Balloon Committee, the balloon represented a new “faculty” of vision that would make possible the collection of meteorological observations in two dimensions. Like a geological survey, the project aimed at producing a map of atmospheric strata. The primary objects of observation for the scientific balloon ascensions were first, to determine the temperature of the air and its hygrometrical states at different elevations; second, to verify observations made on mountains (“to

21 Coxwell to Glaisher, 7 April 1863, RAS MSS Glaisher 2.
22 Coxwell to Glaisher, 27 August 1863, RAS MSS Glaisher 2.
23 Coxwell to Glaisher, 22 September 1862, RAS MSS Glaisher 2.
ascertain whether [they are] true or not’); and third, to investigate the distribution of water in clouds. The secondary goals were to compare the performance of different hygrometers and dewpoint thermometers and of aneroid and mercurial barometers (a special interest of Glaisher’s), and to make observations on electricity, ozone, sound, magnetism, physiology, solar radiation, clouds, air currents, the solar spectrum, and the chemical composition of the air.24

The figure of Glaisher as an isolated observer in a floating observatory gave graphic expression to the Victorian idea of the astronomer as a solitary observer in a remote watchtower, but the image is not straightforward, for scientific ballooning, like Victorian meteorology and astronomy, was by nature a public enterprise, involving diverse social encounters. Several men of science asked Glaisher to perform experiments in their special fields of interest, including electricity, physiology, magnetism, and solar physics. His employer, George Airy, for example, asked him to make magnetic determinations. In a letter to Glaisher in May 1864, Airy declared, “If you shall have any more Balloon Ascents, I much wish that you could give all your energies to Magnetic Determinations. . . . These determinations would be, at present, far more important than any addition to meteorological determinations.”25 Although Glaisher made many attempts to obtain the time of the vibration of a horizontal magnet, this proved to be difficult in an unsteady balloon.26 He was able, however, to record numerous physiological observations at different altitudes, and he frequently registered his and Coxwell’s number of pulse-beats per minute. As his published tables and reports show, Glaisher, in fact, gave most of his energies to the generation of meteorological tables and charts.27 Throughout the ascent, he made meteorological observations with his instruments nearly every half minute, recording them in a notebook at the center of a board fixed across the balloon car (Figure 2). His published tables provide insight into many types of observation, including descriptions of hardships related to travel: “Feet very cold, our boots covered with ice”; “Mr. Coxwell pants for breath”; “Experienced a difficulty in reading the instruments; Lost myself, could not see to read the instruments”; “sand out”; “beautiful sea of cloud everywhere; dropped paper, visible two minutes”; “ice on wet-bulb and connecting thread”; “Mr. Coxwell’s pulse 90”; “Fine echo from balloon”; “valve twice opened”; “deep blue sky”; “gun heard”; “I do not think Aspirated Wet-Bulb is correct.” Like the exploits of mountain explorers, Glaisher’s balloon ascents for the British Association were a place where science and spectatorship met in a context of adventure.

**SCIENTIFIC OBSERVATION IN THE PUBLIC EYE**

Making scientific observations in the higher regions in a balloon involved managing risks—not only risk of death, injury, and broken instruments, but risk to public reputation. Glaisher and the British Association wanted to cultivate the public’s interest in science, but in so doing, they had to explain what counted as “science.” To max-

25 Airy to Glaisher, 14 May 1864, RAS MSS Glaisher 2.
Figure 2. "The Instruments of Mr. Glaisher Arranged in the Car." Pictured are dry and wet bulb thermometers (1), Daniell's hygrometer (2), a mercurial barometer (3), blackened bulb thermometers (4), an aneroid barometer (5), Regnault's hygrometer connected with the aspirator, silver conical shields for protecting the dry thermometer from solar rays, water-vessel for the wet-bulb thermometer, a compass, a watch or chronometer, a bottle of ether for the hygrometer, a lens to read the instruments, the aspirator to be worked by the foot, a magnet, an opera glass, and a pair of scissors for cutting the strings. (Woodcut in James Glaisher, ed., Travels in the Air [Philadelphia: J. B. Lippincott, 1871], p. 39).

imize the benefits of the British Association's grant, Glaisher made several ascents with Coxwell and other paying passengers from Mill Hill, Hendon, and from the Crystal Palace in the London suburb of Sydenham, where Coxwell advertised balloon ascents for public hire. Coxwell described these ascents as "semi-scientific": "Our journeys for two to three years were not confined to strictly private voyages to excessive elevations, but embraced many instructive trips on festive occasions." In "public" ascents, as Glaisher called them, he not only was watched by a larger crowd than at British Association meetings, he had to share the balloon car, or flying laboratory, with other paying passengers, and to make observations at comparatively low altitudes. For these ascents, he reduced the number of instruments he transported and attached them to a board hung over the side of the balloon car to reduce the errors in the temperature readings caused by excess body heat.

Like the waterworks and life-size models of extinct "monsters" at the Crystal Palace, Glaisher and his instruments were always objects of exhibition, viewed with

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curiosity by witnesses near and far. His audience consisted of distinct but overlapping groups: members of the British Association, volunteer observers in Glaisher’s far-flung meteorological network, spectators at the ascents, and paying passengers in the balloon. As the coordinator of a national volunteer meteorological network, Glaisher had practical reasons for making balloon ascensions a public stage on which to popularize the utility of meteorological work. His work required the assistance of many observers stationed at scattered points across the country, who collected observations and helped him measure his altitude in the balloon. Glaisher employed newspapers to popularize his need for assistance from terrestrial observers. On the day of each ascent, the Daily Telegraph published Glaisher’s “invitation” to “gentlemen possessed of any instruments” to take observations on temperature, humidity, and air pressure on the ground every ten minutes and to note the angles of azimuth and the height of the balloon with surveying instruments. One reader wrote to Glaisher on 8 May 1863 that he had “hurried home to get my theodolite” to record the coordinates of the balloon’s position. Others responded, not with observations, but with requests: an electrical philosopher named P. Rowell, for example, lobbied Glaisher to test his unusual theory of evaporation. Glaisher’s project of drawing others into his national meteorological network promised to achieve one of meteorology’s special aims: to establish and coordinate a system for assimilating empirical contributions from many scattered observers.

Although being in the public eye offered many advantages, Glaisher discovered that his connection with the world of London entertainment and public exhibitions presented special risks. Aeronauts who sought to advance the “science of aeronautics” by diversifying the balloon’s capabilities and social applications lamented that balloons never escaped the public eye. One complained, “How much the subject differs from other sciences in the impossibility of keeping it concealed from public observation during its progress into maturity, and of forming it into a system before it engages popular attention in an imperfect state; and this would appear to be one of the greatest difficulties with which it has had to contend.” Glaisher and Coxwell’s ascents inevitably generated publicity and drew large crowds. The British Association encouraged its members to attend Glaisher’s scientific ascents from Wolverhampton and from Wolverton. The London and Northwestern Railway announced “Special Trains Consequent on Balloon Ascent from Wolverton on Friday,

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31 From an undated Daily Telegraph article, RAS MSS Glaisher 4.2. Newspaper accounts of Glaisher and Coxwell’s ascents are published in Coxwell, Life, (cit. n. 1), Vol. II.


33 For Glaisher’s correspondents, see, for example, Rowell to Glaisher, RAS MSS Glaisher 1, folio 2. The special need for many observers in Victorian meteorology was eloquently addressed by John Ruskin, an early member of the short-lived London Meteorological Society, in “Remarks upon the Present State of Meteorological Science,” Transactions of the Meteorological Society, 1839, 1, rpt. Symons’s Monthly Meteorological Magazine, 1870, pp. 33–39. Ruskin, a passionate student of atmospheric forms in nature, stated that in contrast to practitioners in fields such as astronomy and chemistry, where persons such as Galileo, Newton, and Davy might achieve individual fame, “the meteorologist is impotent if alone; his observations are useless, for they are made upon a point, while the speculations to be derived from them must be on space” (p. 33).

34 Turnor, Astra Castra (cit. n. 17), p. viii.
June 26th, 1863.”

Even when Glaisher and Coxwell ascended from Wolverhampton in what Coxwell called “strictly private” ascents, therefore, they attracted onlookers and curious crowds. In a world where entertainers competed for public patronage, Glaisher upstaged other attractions. A passenger who ascended with Coxwell and Glaisher from the grounds of the Crystal Palace reported afterward that “all who were not engaged in scientific observation, were in ecstasies with the beauty of the scene. Mr. Glaisher was busily at work.” Another commented on Glaisher’s “busy work” in the balloon, where he sat “armed with a host of abstruse instruments.”

The difference between “busy work” and “ecstasies” in a balloon was a vital issue in mid-nineteenth-century Britain, where it became closely connected with battles over the definition of science and the morality of entertainment. Glaisher's disciplined measurements in the air were anomalous in an age of balloonacy. The analogues of “balloon experiences” in 1860s London were panoramas and “moving picture” shows that combined instruction and amusement. Panoramas were urban and landscape scenes, often from a bird’s-eye perspective, painted onto canvas or cylinders that enclosed spectators in a full circle for an all-embracing view. Re-worked onto canvas for public display at the Colosseum, the Yorkshire land surveyor Thomas Hornor’s “imitation London,” based on two thousand sketches Hornor made with the aid of a telescope from his perch in a makeshift shack that he called his “Observatory” atop the cross of St. Paul’s Cathedral (then the highest point in London), was a major metropolitan sensation in the 1830s (Figure 3). Panoramas express the Victorian fascination with “grand perspective” painting with characteristic elements of aesthetic realism, physical scale, and pursuit of illusion. “Moving picture” entertainments, such as the cyclorama and the Eidophusikon, added motion and variety to conventional panoramas. The Eidophusikon, an innovative stage design that, like the balloon, was invented and introduced to England by the French in the 1780s, provided the model for later mimetic devices such as the Diorama, which produced dynamic effects of storms and battles through the skillful manipulation of light, sound, and screens. Vertical dioramas of aerial journeys, such as the pantomime Harlequin and Old Gammer Gurton, which opened in Drury Lane in 1836, satisfied the Victorian taste for panoramas in motion, just as views from a balloon appealed to Victorians’ interest in sensations of travel.

Earlier we saw that the British Association sought to make its practices public and visible, but drawing the public into structured engagement with science by way of

35 Advertisement for special trains on deposit in RAS MSS, Glaisher 5.
37 On “panorama” and London shows, see Altick, Shows of London (cit. n. 5), esp. pp. 128–210. In 1821, extensive repairs began on the dome of the Cathedral. For this purpose, a scaffolding was set up. Hornor received permission from the dean and chapter to make the top of the dome his second home for one year. On the making and public display of Hornor’s panorama, see Altick, pp. 141–149. On the iconographic characteristics of the panoramic image in eighteenth- and nineteenth-century European painting, see, for example, John Sweetman, The Panoramic Image (Southampton, Hampshire, England: John Hansard Gallery, The University, Southampton, 1981).
39 On the “Eidophusikon,” see Altick, Shows of London (cit. n. 5), p. 165; on Victorian vertical dioramas, see Altick, p. 178. Glaisher once commented on the dynamic effect of balloon travel where “all the motion seemed transferred to the landscape itself, which appeared when looking one way to be rising and coming toward us, and when looking the other as receding from us,” quoted in Glaisher, Travels (cit. n. 12), p. 62. Glaisher recognized analogies between meteorology and painting: with “the power of the painter,” he could make the “scenes” he “witnessed reappear mentally in all their details, so vividly” that he could reproduce them on canvas; Glaisher, Travels (cit. n. 12), p. 68.
scientific ballooning posed special risks in an age increasingly critical of “balloonacy.” The 1850s and 1860s witnessed numerous attacks on ballooning and other theatrical entertainments; it was an era of rising middle-class demands for the reorganization of labor and leisure and for the establishment of improving, or “rational,” recreation for the working classes.40 Metropolitan newspapers published several letters at this time from concerned readers who criticized the public’s taste for ballooning and other dangerous amusements, and graphic caricaturists satirized balloon sports in prints (Figure 4). The urban explorer, social reformer, and author Henry Mayhew, for example, blasted the public’s taste for sensational balloon experiences, writing in the Illustrated London News in 1852, the year of Welsh’s ascents for the British Association, that ballooning should be a “dignified delight,” not an opportu-
nity for "mental dram-drinking" and "depraved rage for excitement." Social criticism of "mental dram-drinking" in balloons paralleled the rise of the "moral management" movement in mid-nineteenth century Britain discussed by Elaine Showalter in connection with Victorian mental asylum reform. The well-known physician, medical photographer, and superintendent of the Female Lunatic Asylum in Surrey, Hugh Diamond, in fact, linked "dram-drinking," or intemperance, with the onset of lunacy in one of his female psychiatric patients who had a history of adding whiskey to her teapot. Diamond himself was visited by a "balloonatic" in 1852. In that year, the London Times reported that the aeronaut Charles Green (Welsh's aeronaut for the scientific ascents in that year) made a “surprise descent” at Diamond’s asylum, where the patients helped Green anchor the balloon. A reader who wrote to the Times under the name “Anti-Gas” suggested that the patients had

42 On risks and caricatures of ballooning from 1800 to 1865, see Turnor, Astra Castra (cit. n. 17). On the moral and social dangers of ballooning, see Mayhew, “In the Clouds” (cit. n. 6); “Dram-drinking” and lunacy as discussed by Hugh Diamond, quoted in Sander Gilman, ed., The Face of Madness: Hugh W. Diamond and the Origin of Psychiatric Photography (New York: Brunner and Mazel, 1976), p. 70.
merely “spied a brother” and that aeronauts like Green were, like “lunatics,” a risk to themselves and to society.43

Other attacks were even more damaging, for crowds frequently mobbed balloons before aeronauts could even ascend. During the period from 1830 to 1870, crowds mobbed and destroyed balloons in several incidents, including famous riots at Cremorne Gardens and the Surrey Zoological Gardens.44 Brief, episodic violence by laboring classes raised concerns among “respectable” members of Victorian society, the “privileged classes,” about maintaining order and social stability in a city in which increasingly specific social differentiation was associated with increasingly demarcated spatial segregation.45 The years 1859–1866, spanning the era of the Balloon Committee’s researches, saw a succession of collective demonstrations, bread riots, and street skirmishes in the East End and in Hyde Park, site of the 1851 Great Exhibition. Balloon ascents, as magnets that attracted heterogeneous audiences (although not the poorest class of “roughs,” who could not afford to pay the entrance fee to London pleasure gardens), were vulnerable to riots and skirmishes. They sparked fears among Londoners already worried about the deeper social problems of urbanization, industrialization, and overcrowding. Social disorders at balloon ascents were frightening because they confused these boundaries. Riots at balloon ascents, including one in 1864 when, as we will see, crowds mobbed and destroyed Coxwell’s balloon, showed how little control aeronauts had over their spectacles and audiences and how fast a privately owned balloon could become public property.

Glaisher and other men of science were not averse to publicity, nor, as we have seen, to all forms of public exhibition. To increase the resources of science and to make science itself a cultural resource, gentlemen of science sought to make knowledge-producing practices public and visible. Like other objects of public interest, they could never be certain who was in their audience. Their challenge was to intervene in the mechanisms by which others determined the meaning of their experiments. Why? Because gentlemen of science encountered risks of various...

43 “Descent at a Lunatic Asylum,” Times (London, 10 Sept. 1851); reply by “Anti-Gas,” in Times (London, 12 Sept. 1851). Many “surprise descents” occurred not only into the streets and on rooftops around the Crystal Palace and pleasure gardens but also outside London into meadows and rural properties. The writer, showman, and traveler Albert Smith satirized them in his poem, “A Flying Visit”; the Weekly Chronicle in 1841 published a letter from a woman whose balloon party was denied shelter at a house after making a “surprise” descent, see Turnor, Astra Castra (cit. n. 17), p. 188.

44 “Late Riot at Cremorne Gardens,” Times (London, 9 July 1863). The 1838 balloon riot at Surrey Gardens is discussed in Altick, Shows of London (cit. n. 5), p. 323; and Delgado, Victorian Entertainment (cit. n. 2), p. 40. Park officials resorted to a spontaneous eruption of the “modelled panorama” of Mt. Vesuvius to divert the attention of outraged spectators, who stoned the balloon, tried to drown guards, and threw rocks at the glass lion house until order was restored.

kinds when they opened their research to public examination or, as here, performed experiments in the public eye.46 The reputations of men of science and the status of the knowledge they produced were not determined by them alone. Going as high as possible to collect meteorological data inevitably implicated Glaisher in the world of balloon “stunts”; Victorians watched to see how high Coxwell’s balloon, the biggest in the British Isles, could go. Coxwell’s career, as he himself pronounced, was a “matter of public property.”47 Victorian precision seemed at odds with Victorian “balloony.” In a context in which scientific ballooning and public exhibitions were inextricably linked through their connection to Victorian pleasure gardens, what was the difference between a “vertical exploration” and a balloon stunt; between scientific observation and “mere adventure-seeking”? Glaisher and the members of the Balloon Committee, like other men of science, never fully controlled what people watched, nor could they anticipate how spectators would behave if the ascent did not go off as planned.

Directing people’s attention to his observation practices in the balloon became central to Glaisher’s efforts to imbricate balloon ascensions in the world of science, not mere entertainment. Few Victorians accompanied Glaisher in the balloon, however, so few actually saw what he did in the air. To see science at work, Glaisher asked witnesses to look not at the balloon, but at his observations with instruments in the balloon. Just as balloon ascents provided occasions for gentlemen of science to demonstrate how one ought to comport oneself in a scientific “public” as a witness of a scientific experiment, lectures and writings were a means for Glaisher, in words and pictures, to exhibit right observation in a balloon and turn curiosity about balloons into an interest in science.48 From 1862 through at least the 1870s, Glaisher propagandized his observations in a balloon to diverse audiences, or “publics.” In addition to addressing men of science at British Association meetings, he spoke at schools, churches, mechanics institutes, and the YMCA. He also wrote about his scientific experiments in Coxwell’s balloon in Good Words, an illustrated six-penny monthly addressed to middle-class readers that mixed serial fiction and short essays with Christian topics, with a circulation in the 1860s around 80,000; and in an article, “Aeronautics,” published in the Encyclopedia Britannica.49 He urged scientists

46 The risks of public experiment are discussed in A. D. Orange, “The Idols of the Theatre: The British Association and Its Early Critics,” Annals of Science, 1975, 32:277–294; and Secord, “Extraordinary Experiment” (cit. n. 5). See also Devorkin, Race to the Stratosphere (cit. n. 2).
48 The use of illustrated texts to demonstrate right observation practices with new instruments of seeing, such as the microscope and the telescope, has roots in a longer tradition in the history of science. See, for example, Michael Aaron Dennis, “Graphic Understanding: Instruments and Interpretation in Robert Hooke’s Micrographia,” Science in Context, 1989, 3(2):309–364. and Shapin and Schaffer, Leviathan and the Air Pump (cit. n. 30).
and members of the general reading public to view his ascents as a successful demonstration of the balloon's scientific utility; it was “unnecessary to justify further the attempt to make the Balloon a philosophical instrument” instead of a “toy, fit only to be exhibited” or a “vehicle for carrying into the higher regions of the air excursionists desirous of excitement, mere seekers after adventure.”

Victorian astronomy provided the primary model for Glaisher’s ideas on meteorological observation at great heights above the Earth. To Glaisher, the balloon car of the Mammoth and the Magnetic and Meteorological Department at the Royal Observatory seemed rather alike. Like his employer, George Airy, Glaisher had strict ideas about what counted as reliable meteorological observation. Discipline, punctuality, faithful note-taking, and accurate observation were major constituents of his observation regime both at the Royal Observatory and in the balloon car. He explained in *Travels in the Air*, as on numerous public occasions, that he sat “as calmly [in the balloon car] as in his observing room” at Greenwich. The atmosphere was a “great laboratory” for discovery, not just a vantage point for picturesque views. He outlined a project of looking in a balloon that was “self-possessed” and “accurate”; that entailed “rapid note-taking”; and that “exchanged conjectures” for “instrumental facts.” He pondered on the “extraordinary power” of his mind and emotions, taut with the knowledge that only a few moments could be devoted “to note down all appearances and all circumstances at these extreme positions; and if not so rapidly gleaned, they are lost for ever.” In such situations, every “appearance of the most trivial kind” was noticed; the eye became keener, the brain more active. Although he emphasized that he was a “calm” traveler, Glaisher expressed anxiety about missing observations, saying he felt “anxious” when at every instant he “might be failing to observe very important phenomena.” Unafraid to float thousands of feet above the Earth in a basket, he felt “condemned by the fear of not being ready when the moment came to observe a phenomenon which perhaps no eye had contemplated before.” Glaisher challenged “those philosophers [whom he did not name] who think that observations in the higher regions can be made . . . by the first observer that comes.” For three months prior to his first ascent with Coxwell, Glaisher prepared the instruments and practiced making observations in a limited space: “I . . . considered how best to group them on a board such as would have to serve me for a table in the car of the great balloon; so that when the day for the ascent came, I was able to imagine that I was not making my aerial debut” (Figure 5).

The mid-Victorian “gospel of work” provided a framework for seeing success at making accurate meteorological observations in a balloon as a model for social virtues in a developing society. During the 1840s and 1850s, the British debated how best to achieve the secure moral order needed to achieve the kind of economic growth that they demanded, and these debates inspired an outpouring of writings on the national and social character, a body of literature that appealed directly to working-class laborers, artisans, mechanics, and middle-class men of business. The Leeds physician and social reformer, Samuel Smiles, author of *Self-Help* (1859),

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51 For an exposition of Glaisher's regime of observation in another context, see, for example, his instructions to meteorological observers in his network, in Glaisher, "On the Corrections To Be Applied to the Monthly Means of Meteorological Observations Taken At Any Hour, To Convert Them To Mean Monthly Values," *Philosophical Transactions*, 1848:125–139.
Figure 5. "Mr. Glaisher in the Car." Coxwell is shown on the left, reading a compass; Glaisher is pictured on the right, seated before his instruments, his hand poised to take notes. (Woodcut in James Glaisher, ed., Travels in the Air [Philadelphia: J. B. Lippincott, 1871], p. 23).

Brown, and one “profound geologist, in the person of a baker,” whom Sir Roderick Murchison had discovered in Scotland. Attention to details and accurate note-taking were crucial: “The practice of writing down thoughts and facts for the purpose of holding them fast and preventing their escape into the dim region of forgetfulness, has been much resorted to by thoughtful and studious men.” The creed of the careful observer of humble phenomena shines through Smiles’s writings. He insisted that the “intelligent eye of the careful observer” gave “apparently trivial phenomena their value,” for “so trifling a matter as the sight of seaweed floating past his ship, enabled Columbus to quell the mutiny which arose amongst his sailors at not discovering land . . . There is nothing so small that should remain forgotten; and no fact, however trivial, but may prove useful in some way or other if carefully interpreted.” The “repetition of little acts” built individual character and improved “the character of the nation.” Accuracy of observation was the mark of a well-trained man: “Too little attention is paid to this highly important quality of accuracy,” he declared, adding that an eminent man of science had confessed to Smiles that “It is astonishing how few people I have met within the course of my experience, who can define a fact accurately.”

In their emphasis on the importance of these characteristics—accuracy of observation, repetition of small acts, attention to detail, method, punctuality, diligence, perseverance in difficult situations, and devotion to duty—Glaisher’s expositions on meteorological practice in the 1860s amplified the values of self-help that Smiles made famous. In a lecture delivered to young working-class men at the YMCA in September 1862, “Scientific Experiments in Balloons,” Glaisher presented his regime of accurate note-taking in a balloon as a moral object lesson for life. Remark ing that he felt the YMCA wanted him to apply the lessons he had learned in the balloon to their general experiences, Glaisher told his youthful male audience that the exclusion from their vocabulary of two words, “impossible” and “impracticable,” would enable them to overcome difficulties in their everyday lives. It was his power of “concentrating his thoughts” on his work and of excluding “vagrant” thoughts that had enabled him to add to the general store of knowledge. He advised young men to pursue their education after they left school, to make “accurate observations,” and to train themselves to “conquer difficulties” in life—through the study of mathematics, for example. Not a “single stray” or “foreign” thought should enter their minds. As a superintendent of a vast network of meteorological observers enlisted to record ephemeral weather phenomena, Glaisher could well appreciate the importance of self-motivated persons willing to record data that, to others, appeared trivial. Glaisher encouraged diligent and accurate note-taking; he told the young men that at high altitudes, it required the “exercise of a strong will to take any observations at all.” He proclaimed that “on this self-help, self-education, self-training, much of the character of every man is dependent, and prepares him to overcome difficulties which he must encounter in life, and to which he would inevitably succumb if always dependent on others.”

Glaisher told his tales of “careful observation” and “busy work” in a balloon to

54 Smiles, Self-Help (cit. n. 53), pp. iv, 118, 132, 121, 270, 271. Also relevant here is Rev. J. G. Wood, Common Objects of the Microscope (London: George Routledge & Sons, 1861), p. 7. Wood stated that it was not the wealthiest, but the acute and patient, observer who made the most discoveries.

hungry listeners, and he was an eloquent and active propagandist. In 1871 he published a volume he edited, *Travels in the Air*, containing essays by himself and three French scientists, Camille Flammarion, Wilfrid de Fonvielle, and Gaston Tissandier, who also made scientific observations in balloons. The illustrated travel account appealed to the Victorian taste for topical news, pictorial entertainment, and tales of exploration, a taste that imperialist expansion, travel, public exhibitions, illustrated newspaper reports of military expeditions, and the flowering literature of social investigation both sharpened and exploited. In its promise of both instruction and amusement, *Travels in the Air* resembled a Victorian peepshow offering a glimpse into the interior of a flying lab.

In *Travels in the Air*, Glaisher defined knowledge as a certain type of “prospect” gained not just by altitude, but by right observation. “Ascents,” as we have seen, were a major contemporary attraction: Victorians ascended in balloons, climbed mountains, and scrambled to the top of tall buildings for bird’s-eye views of London. At Leicester Square, exhibition visitors climbed a series of staircases to look at Wyld’s “Great Globe,” a relief map made of six thousand plaster casts showing the world’s major geographical features in color and with texture. In 1851, it was the most popular attraction apart from the Crystal Palace itself. “The Ascent of Mont Blanc” at the Egyptian Hall, one of the biggest hits of the whole Victorian era, entertained audiences with dioramic pictures of alpine travel accompanied by a colorful, conversational narrative by the inveterate traveler, prolific writer, and playwright, Albert Smith, who gave up a medical career for the heady world of show business. He was also, briefly, an aeronaut, ascending in a balloon from Vauxhall Gardens in 1857 to shoot off fireworks over Pimlico, but he got caught in a thunderstorm and fell, with the balloon, into Belgrave Road, a misadventure that probably contributed to his decision to restrict his future ascents to Mont Blanc. For Glaisher, by contrast, a “prospect” was not just a grand vista, a topographical map, or a London show; the term defined meteorological observation practiced in a value system that combined punctuality, accurate observation, note-taking, and English manly character. Glaisher transported a system of correct observation practices into the air. Meteorological instruction alone did not guarantee success in scientific

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ascents, for balloon experience was crucial; nor was a background in aeronautics sufficient for scientific work, for even the best aeronauts, according to Glaisher, lacked the necessary general education to be competent observers.\textsuperscript{59} What, then, was the nature of scientific “observation” in a balloon?

Glaisher’s account of his accurate observations is best seen against the backdrop of other Victorian accounts of scenery viewed from the perspective of a balloon, for he had to work against these norms of seeing and description to distinguish himself as a scientific narrator—even though, as we shall see, his observations convey delight in “sight-seeing.” Victorian balloon travelers expressed excitement and wonder. Of the appeal of “aerial travel,” Coxwell explained that ballooning was popular because it combined amusement and instruction in a context of adventure:

\begin{quote}
Aerial travels admit of anecdotes having a gay as well as sombre colouring. The very act of getting away from this our planet, is often attended with exciting surroundings, especially when a lofty tower, a church steeple, or a row of trees, happens to come in dangerous proximity. Then again, the behavior of companions, no less than their motives for going up, affords ample scope for adventure, while as to the return to mother earth, something enlivening is almost sure to crop up, especially if one drags through a corn field, and has to settle with an exacting land-owner . . . not charitably disposed towards those who unawares and without invitation, drop in on him from the heavens.\textsuperscript{60}
\end{quote}

Balloon travel was lively, and balloonists strove to enliven. Coxwell, like Thomas Hornor, was a painter of scenes; like London showmen, he sold access to new optical, visual, and kinetic sensations. It reflected well on Coxwell’s powers as an engaging painter of images when Glaisher expressed delight in the mode of traveling or when, as Coxwell put it, Glaisher took pleasure in the “sight-seeing, scenery, and cloud-scapes, which from time to time presented themselves, irrespective of the philosophical uses to which [Glaisher’s] notes and deductions were to be turned subsequently, when they were studied and gone into his own systematic way.”\textsuperscript{61}

Glaisher enjoyed balloon travel, but unlike other patrons, the Balloon Committee paid Coxwell not to narrate, but to transport Glaisher as high as possible, high above the clouds and charming scenery below. Coxwell verified that his duty was to manage the balloon, not to point out “diverse” views from a balloon: “I could not reveal or allude to the diverse views in the balloon when Mr. Glaisher was intent on his observations, and when . . . he sat, to use his own metaphor, as if he were at the Royal Observatory.”\textsuperscript{62} Glaisher emphasized that although he himself might occasionally indulge in a picturesque view of clouds or city movements, he felt more “a part of the machine [the balloon] above than of the world below.” Aeronauts and “excursionists,” he declared, were too “eager to enjoy the privilege of movement, and the varied prospect in any direction” to make high ascents above the clouds, beyond sight of Earth, Glaisher explained. The balloon gave scientists “fresh territory” to explore, high above the Earth’s “visible scenery.” Even during his first ascent, when a most “magnificent view” opened before him, he reported that in light of his duties, he did not “note its peculiarities and beauty.”\textsuperscript{63}

\textsuperscript{59} Glaisher, \textit{Travels (cit. n. 12)}, p. 30.
\textsuperscript{60} Coxwell, \textit{Life, (cit. n. 1)}, Vol. II, pp. 5–6.
\textsuperscript{63} Glaisher, \textit{Travels (cit. n. 12)}, pp. 2, 5–6, 44.
seeking” balloon excursionist, Glaisher offered an image of himself as a calm observer, capable of resisting a beautiful view outside the balloon in order to make accurate scientific observations and produce meteorological charts and tables.

Glaisher maintained that balloon ascents offered an even better scientific “prospect” than alpine exploration, a research area that, as Bruce Hevly shows, had many parallels to scientific ballooning and that similarly attracted great Victorian scientific and popular interest. Glaisher thought that scientific observations made on mountains were frequently unreliable; unlike in recreational ballooning, however, the issue was not that mountain climbers were too distracted by the beautiful view to make repetitive observations on instruments, but that they were exhausted. Here again, the vital issue was not just altitude, but discipline and precision. Glaisher recalled that the French explorer De Saussure had been too tired to observe his instruments properly when he reached the top of the summit of Mont Blanc. De Saussure had admitted that he “was compelled to rest and pant as much, after regarding one of [his] instruments attentively, as after having mounted one of the steepest slopes,” Glaisher recalled. By contrast, Glaisher reported, a bit disingenuously in light of all of his misadventures, that a balloon carried him up “with speed and certainty at any number of feet per minute, with instruments complete and carefully prepared for observation.” Balloon ascents could be repeated on different days and at different times to evaluate constantly changing atmospheric conditions, whereas a single set of observations on a mountain was “of slight value” to science “except to appease curiosity.” A view gained in a balloon widened the “prospect” of science, and enabled scientists to exchange conjectures for “instrumental facts.”

Coxwell’s own accounts of their scientific ascents directed others’ attention to Glaisher’s observation practices in the balloon, thereby shaping wider social perceptions of Glaisher as a disciplined observer. Coxwell, like Glaisher, had multiple, diverse audiences. It was standard practice for Victorian aeronauts to publish accounts of their balloon ascents in newspapers. Coxwell himself wrote several newspaper accounts about his ascents with Glaisher. The celebrity aeronaut also gave numerous public lectures. In a letter to Glaisher in January 1863, he boasted that he had delivered lectures both for “the working classes” and “for the elite”; long after his ascents with Glaisher, he popularized his work for the British Association in his illustrated, two-volume autobiography, *My Life and Balloon Experiences* (1887, 1889). Coxwell, who frequently was the sole witness of Glaisher’s ascents, helped construct Glaisher’s public image as a hero of precision by corroborating his stories of painstaking observation and, perhaps even more important, by emphasizing in his writings the difference between Glaisher and other, “unscientific,” patrons. According to Coxwell, the men did not discuss the dangers they surmounted: “it was [Glaisher’s] instruments about which he was most anxious.” In lectures, Coxwell

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65 On Coxwell’s audiences, see, for example, letter from Coxwell to Glaisher, 6 January 1863, RAS MSS Glaisher 2. See also Coxwell, *Life* (cit. n. 1). Coxwell remained a Victorian celebrity in the 1890s; see, for example, Harry How, “Illustrated Interview with Henry Coxwell,” *The Strand*, Jan.–June 1896, 2:123–131.

66 See, for example, Coxwell, *Life*, (cit. n. 1), Vol. II, p. 121, where he presents “An Unscientific But Graphic Description By a Voyager.”
expressed astonishment and admiration that “Mr. Glaisher kept on dotting down his observations.” He complimented Glaisher’s “personal bearing in the balloon car,” saying that the scientist’s “calm” and “self-possession” at altitudes of over five miles satisfied him that Glaisher had the “requisite qualifications” for his duties. He said that he knew of other scientific men who “had trembled in the car” at lower altitudes.

Even without specific knowledge of what Glaisher did with his “abstruse instruments,” audiences saw Glaisher as a man who did “busy work” in a balloon. His delicate tools for making precise observations were fragile and, indeed, often broke during rough descents, but they were a robust and powerful symbol of his intellectual identity as a man of science. Glaisher took with him many of the instruments he used at the Royal Observatory—thermometers, hygrometers, barometers, hermetically sealed glass tubes for collecting air “specimens,” a magnet, ozone papers, a compass— instruments that scientific explorers such as John Tyndall carried with them in alpine expeditions. Many of the instruments had to be altered or modified for the balloon. To ensure that the thermometers quickly gained the temperature of the air and that water vapor in the region of the wet bulb was carried off even when the balloon was moving slowly, Glaisher employed an aspirator worked by a cylindrical bellows, to produce a rapid, artificial current of air over the bulbs. A scale behind the barometer rendered it like a large thermometer and helped him to observe it easily. Having campaigned for years for more accurate, standardized meteorological instruments, he was especially interested in testing the designs of different instrument-makers at high altitudes. The instruments were attached to the table with strings that could be cut away, or they rested on stands screwed to the table. On approaching the earth, Glaisher rapidly removed all the instruments and placed them in a cushioned basket at his feet to protect them from breaking in rough landings.

Glaisher’s writings did more than simply document his research findings or spread his ideas to the public; they were the rhetorical means through which he shaped the public image of his ascents as science, not “mere amusement,” and through which he consolidated his position as a self-possessed and disciplined scientist among “mere adventure-seekers” and “balloonautics.” In the rising age of professional science, Glaisher’s accounts of scientific ballooning both exploited and transformed the image of the scientist as a neutral, detached observer who viewed the world from a unifying perspective on high.

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68 Glaisher superintended the repair of instruments that broke during their ascents, for despite his precautions, it was not uncommon for thermometers and other instruments to fall out of the balloon during rough descents. Glaisher used the newspapers to advertise for assistance in relocating them. On the calibration of instruments in Glaisher’s efforts to establish a nationwide network of meteorological observers, see, for example, Marriott, “Earliest Telegraphic Daily Meteorological Reports and Weather Maps,” Q. J. Roy. Meteorol. Soc., 1903, 29:123–131. As Judge of Philosophical Instruments at the 1851 Great Exhibition, Glaisher complained that the meteorological instruments were “toys”: he compared the nation’s barometers to elegant but useless furniture; quoted in Bennett, Science at the Great Exhibition (cit. n. 5), p. 8.

69 Glaisher, Travels (cit. n. 12), p. 41.

linked the political economy of the great Victorian astronomical observatories with the growth of meteorology and the social values of work and “rational” recreation. Like scientific experiments in balloons, right observation practices in a rigorous system of values would open the “prospect of a wider spread of science, and an increase of the sphere of its usefulness.”

PERSISTING PROBLEMS OF SCIENTIFIC BALLOONING

The remainder of our discussion considers the British Association’s lack of control over the balloon and its consequences for the project. By 1864, Glaisher and Coxwell’s collaboration had ended. Many problems endemic to scientific ballooning had surfaced. On the one hand, Glaisher had made a few discoveries; he had found, for example, that the decrease of temperature was irregular up to the highest altitudes, and that the differences in temperature at different altitudes were so immense that it was necessary to abandon the theory that temperature declined according to a law of one degree of temperature for every increase of 300 feet of elevation. On the other hand, success in what essentially was a meteorological survey depended on control over the vertical and horizontal movements of the balloon such that the observer could be placed at specific locations for making observations at will, and such control was not possible in Victorian balloons. In later years, Glaisher blamed the lack of mechanical control over the balloon in the wind for the demise of his experiments with Coxwell, suggesting that it would be far better for ascents to be made in France “or on a large continent” where observers had more time to make observations before they started drifting out to sea.71 Illustrations in Travels in the Air showing Glaisher and Coxwell’s balloon soaring peacefully over the Crystal Palace might suggest that ballooning was unproblematical in this period, but these images of balloon discovery and exploration tell only part of the story (Figure 6).

Even Glaisher and Coxwell’s first scientific ascent together, in July 1862, underlined the types of problems raised by their lack of control over the balloon’s horizontal movement. This ascent took place from a gasworks in Wolverhampton, a town north of Birmingham in central England, chosen because of its distance from the sea. Due to heavy winds, Glaisher was unable to secure his instruments in the car before the balloon ascended, and they had reached an altitude of 10,000 feet before his instruments were in working order. At roughly 25,000 feet, Glaisher felt sick and became unable to observe the instruments. Glaisher asked Coxwell to descend two miles and to reascend again to verify his results, but Coxwell refused, expressing uneasiness at their proximity to the sea. They therefore made a rapid descent and landed roughly in a meadow. In this and other cases, Glaisher tried to maximize the amount of observing time available to him before the balloon drifted over the sea, but it proved impossible to make observations for more than two or three hours.72

If drifting out to sea was a problem, so was the risk of ascending too high to breathe easily. Their historic high ascent in September 1862 illustrates their lack of control over the balloon’s vertical movements. On this occasion, the pair attained at least 30,000 feet, higher than any previous balloon ascent, and Glaisher was nearly killed in the service of meteorology. Glaisher recounted their mishap:

71 Glaisher, Travels (cit. n. 12), p. 93.
72 Glaisher, Travels (cit. n. 12), pp. 84, 93, 44, 47.
Up to this time I had taken observations with comfort, and experienced no difficulty in breathing, whilst Mr. Coxwell, in consequence of the exertions he had to make, had breathed with difficulty for some time. Having discharged sand, we ascended still higher; the aspirator became troublesome to work; and I also found a difficulty in seeing clearly. . . . I asked Mr. Coxwell to help me read the instruments. In consequence, however, of the rotary motion of the balloon, the valve-line had become entangled, and he had to leave the car and mount into the ring to readjust it.73

After falling unconscious, Glaisher reported, he lost all recollection of the next six minutes. Roused by Coxwell, he awoke when he heard the words “temperature and observation”: “I heard him say, ‘Do try; now do.’” The first things he claimed to see were his instruments: “Then the instruments became dimly visible.” “I have been insensible,” he reportedly told Coxwell, who replied: “You have, and I too, very nearly.” Back to work, Glaisher returned to his duties: “I then . . . took a pencil in my hand to begin observations.”74

73 Glaisher’s account was circulated among scientific and general audiences; see, for example, Report of the BAAS, 1862: 384; and Glaisher, Travels (cit. n. 12), pp. 48–65. It was reproduced in Coxwell, Life (cit. n. 1), pp. 130–137, and published verbatim in his obituary in the Daily Telegraph, February 1903, “Death of Mr. James Glaisher, Thrilling Balloon Ascent” (I thank Larry Schaaf for drawing my attention to this reference). Coxwell’s recollection of the event follows Glaisher’s in Coxwell, Life (cit. n. 1), pp. 137–144.

74 This account is in Glaisher, Report of the BAAS, 1862:384; and Glaisher, Travels (cit. n. 12), pp. 54–55.
It was not obvious in 1862, the era of “balloonacy,” that a balloon mishap would become one of the century’s most famous images of heroic scientific exploration, but, in fact, Glaisher and Coxwell became Victorian national heroes. The pair’s brush with death in the pursuit of accurate and unprecedented meteorological measurements was one of the era’s biggest sensations. Examination of contemporary reports suggests that it was not, in fact, Glaisher’s unconsciousness, but his self-possession at high altitudes that dominated Victorian discussions of his historic high ascent. Newspaper coverage of the incident highlighted Glaisher’s courage and discipline. The London Times praised Glaisher’s bravery in the “act of experimentalizing”: “The feats of a man of science give you a better guarantee for real courage [than a soldier] because they are solitary, deliberate, calm, and passive.”75 The Times emphasized Glaisher’s apparent resistance to fancy: where poetry “pointed to the sky” in “raptures,” the “material eye of science . . . simply reported a great trouble breathing.” Even Punch, which frequently poked fun at British Association scientists, joined in the general celebration of the pair. “Coxwell and Glaisher: A Song by a Schoolboy,” published in Punch, praised both men for their devotion to duty under adverse conditions: “One kept on reading at his glass, whilst he could see or stand / The other’s teeth let out the gas, when cold had numbed his hand.”76 Punch celebrated Glaisher and Coxwell as modern heroes whose odysseys required more courage than the deeds of ancient gods.

Glaisher’s own account of the event, reprinted and retold in a variety of scientific and popular contexts, played a large role in creating his heroic public image. “Mr. Glaisher Insensible at the Height of Seven Miles,” a lithograph in Glaisher’s illustrated travel account, Travels in the Air, dramatizes the scene that created a national sensation (Figure 7). The image depicts Glaisher, a dedicated observer, unconscious in the balloon car at his panel of meteorological instruments, his head thrown back against the basket. Coxwell is portrayed balanced perilously on the hoop pulling the valve line in a desperate attempt to release air from the balloon and to return safely to earth, using his teeth, he later testified, because his hands had frozen on the metal bar. Coxwell confirmed that he had roused Glaisher by uttering the words “temperature” and “observation” in the scientist’s ear.

Glaisher’s self-possession and devotion to his instruments at a dangerous moment captured the public’s imagination at a moment when Victorians emphasized the social values of self-discipline and hard work. The notion of bringing a person back from reverie through an appeal to his sense of duty (an important theme of Romantic literature) had new resonance in the 1860s, the age of rising middle-class demands for individual enterprise in the era of liberalism, free trade, and local initiatives. Glaisher soon discovered, however, that neither he nor other members of the British Association fully controlled public perceptions of themselves and their work. In 1864, Punch, having two years earlier praised Glaisher as a scientific hero, now parodied Glaisher’s observations by reproducing a table of data collected by an “aeronautical dog.”77 The popular Victorian humorist, Charles Bennett, proposed to

75 Times (London, 11 September, 1862).
Figure 7. “Mr. Glaisher Insensible at the Height of Seven Miles.” Coxwell is shown on the left, pulling the valve-line with his teeth. Glaisher is on the right, his head thrown back, his hand clutching his throat. Also shown are a cage of pigeons and Glaisher’s instruments. (Lithograph in James Glaisher, ed., Travels in the Air (Philadelphia: J. B. Lippincott, 1871), p. 55.)

take Glaisher to the moon, to give him “something else than wet bulbs, zeros, and short breath, to talk about to the British Association when they meet.”

Other attacks were more damaging. A crowd mobbed and burned Coxwell’s balloon in 1864. In a report of the Balloon Committee in 1865, William Sykes stated that “in consequence of the destruction of Mr. Coxwell’s great Balloon, not any high ascents have been made during 1864/5.” Sykes added that the object had been to “have ascents in the largest balloon that Coxwell could make.” The riot in which a crowd destroyed Coxwell’s balloon took place on 11 July 1864 at a Foresters’ Fete in Leicester. According to Coxwell in a letter published in the Times on 12 July

79 Sykes to Glaisher, 6 September 1865. RAS MSS, Glaisher 1.
1864, the anger of a “mob” was aroused when a “gentleman, reported to be a provincial aeronaut, gave it out that the balloon then present was not my largest and newest balloon, but a small one.”

Faced with “a sea of clamouring spectators to the number of 50,000 persons,” Coxwell was unable to make a safe departure, although “everybody” demanded an “instantaneous ascent.” Coxwell threatened to let the gas out of the balloon unless the crowd exhibited some kind of order. After executing his threat, the crowd totally destroyed the balloon. Coxwell described in a local newspaper the chaos that followed: “While the work of demolition was proceeding, Sergeant Chapman led me away amid yelling and derision. My clothes were soon torn, and then the cry was raised, ‘rip him up,’ ‘knock him on the head,’ ‘finish him,’ etc., all of which would have inevitably been executed had I not followed the Inspector’s advice.” The crowd burned the car, which previously had been used for all of Coxwell’s ascents, including those with Glaisher; after the public bonfire, hundreds of people paraded the hoop through Leicester as others tore the balloon fabric to shreds and hawked the pieces in the street.

The riot at Leicester shows Victorian aeronauts’ lack of control over the balloon on the ground. It raised questions about the safety of ballooning in the public eye and underlined the practical difficulties of fashioning ballooning into a “respectable” mechanical art. The destruction of Coxwell’s balloon in the Leicester riot marked the beginning of the end of relations between Glaisher and Coxwell. Glaisher, himself a London Forester, originally intervened on Coxwell’s behalf to help raise money from the Foresters for a new balloon. Later, however, he refused to ascend with Coxwell, even though Coxwell still had the biggest balloon in Britain. A friend of Glaisher, writing to him about a mutual acquaintance’s recent ascent in Coxwell’s new balloon, Research, which was even bigger than Mammoth, faulted their contemporary for “associating with Coxwell,” called Coxwell’s balloon “illgotten property,” and suggested that their associate was unaware of the circumstances surrounding “the way in which [Coxwell] obtained the money from Leicester.” In his reply, Glaisher explained that he declined to speak with Coxwell because “he has acted impertinently to me.” He felt “indebted to [Coxwell] for enabling me to make observations in the great altitudes,” believed Coxwell to be the “best Aeronaut still,” and “deeply regretted that a wanton mob destroyed his property and that events should have followed leading me to stop the experiments in which I was engaged.” However, although he said the British Association Balloon Committee blamed him for sacrificing knowledge “on account of private feeling” (“I am told that I ought to use the only balloon, which will give me the knowledge we seek in the higher regions”), this he declined to do.

At his death in 1903, Glaisher was remembered for his “thrilling balloon ascent” in 1862 when “he and Mr. Coxwell attained the greatest altitude ever yet reached”: an event that, according to this writer, “had the effect of leading the public to think of Mr. Glaisher rather as an aeronaut than in his true quality, that of a man of science.” In a context in which science and public spectacle were inextricably linked, Glaisher tried to control the representation of his ascents as science, not “mere amusement,” but as we have seen, he was not entirely successful at purging
ballooning of its connection with Victorian entertainment and social and moral disorder. Although Coxwell with ballast and skillful and energetic pulling on ropelines could control some of the balloon's up-and-down movements and avoid rough landings, he, like other aeronauts, could never fully control the balloon in the air or on the ground. Glaisher's claim in later years that it was no longer necessary for him to justify the balloon as a tool of scientific discovery therefore must be balanced against the knowledge that the British Association scientific balloon ascensions with a human observer were relatively short-lived. Only four years after Glaisher's first ascent, the Balloon Committee disbanded. His researches on the decline of temperature with increasing altitude were sufficiently important to him to make ascents in a French showman's "great Captive Balloon" in Ashburnham Park, Chelsea.83 On a calm day, he could regulate the balloon's movements at will and keep it stationary at any elevation up to 2,000 feet to make observations at different elevations. However, the "captive" balloon only allowed him to make observations in one dimension, instead of a panorama of observations at different coordinates. As he soon discovered, moreover, even the captive balloon was plagued by accidents: shortly after Glaisher began his low ascents from Chelsea, the balloon broke from its cable and soared to freedom, eventually landing at the foot of an oak tree.84

To find ballooning in the picture of British meteorological surveying in the 1870s, Victorians had to look at the images in Glaisher's travel book, Travels in the Air (see Figure 1). "Over London at Night," a lithograph that inscribes Glaisher and Coxwell's balloon's path and a graph of meteorological data over a nocturnal bird's-eye view of the metropolis, is a graphic expression of the deep—and, as we have seen, persistently troubled—connection between precision measurement and public exhibitions. Although Glaisher argued that his ascents were in the domain of "science," not "mere amusement," he did not, as we have seen, fully succeed at dissociating ballooning from its negative associations with Victorian entertainment while preserving its allure as an object of public interest. Science and showmanship in the 1860s were, as I have argued, still powerfully connected, and scientists could not control the effects of popularity. That Glaisher felt compelled to gesture repeatedly to his success at proving the philosophical value of the balloon in later years suggests not that he had actually proved it, but that people still needed to be convinced.

CONCLUSIONS

Although the aim of the Balloon Committee was to collect empirical facts, it was observation and its troubles that became the object of public notice. In this paper I have examined Glaisher's and the British Association's efforts in the early 1860s to validate the balloon as a tool of discovery. When the British Association launched systematic scientific investigations of the earth's atmosphere by observers in balloons, the balloon itself was an object of public exhibition, a fixture of pleasure gardens, and a vehicle for transporting adventure-seekers on fantastic voyages into the higher air. Glaisher transported science into the air, but in so doing he had to strike an elusive balance between science and show. Like other scientists in mobile field stations, Glaisher carried with him into his expeditions not only instruments

83 Glaisher, Travels (cit. n. 12), p. 87.
but a system for making reliable observations, a system rooted in the networks of geomagnetism and meteorology developing around the Royal Observatory at Greenwich and the British Association. The balloon was not, however, easy to accommodate within Victorian science. Many hurdles had to be overcome before scientific balloon ascents could even get off the ground. Even when the balloon was aloft, it proved difficult to direct. Transforming the balloon into a vehicle for making precision measurements involved taking many risks. In addition to the risks of death, injury, broken instruments, and the hardships associated with fatigue and weather, there were risks to public reputation and safety in a social milieu in which Victorian spectators frequently ridiculed aeronauts and sometimes mobbed and burned balloons.

Earlier I suggested that to consolidate his moral authority as a scientific observer in a context in which science was connected to the world of showmanship, Glaisher had to distance himself from the Victorian tropes of the "balloonatic" and the "mere adventure-seeker." Now we have seen that Glaisher's struggle to establish the balloon as a philosophical instrument tested the definition and meaning of "scientific observation" in front of thousands of eyewitneses. "Popular culture" was not simply a pool into which men of science diffused knowledge; it was a resource for their ideas and a competitive field in which scientists had to work against—or redirect—stereotypes of discoverers and explorers to fashion a credible identity for themselves. In his writings and lectures, Glaisher navigated the perils of self-promotion, taking advantage of the public speaking opportunities that his fame opened to him to promote meteorological education and the gospel of work, while differentiating his disciplined regime of balloon observation from the "prospects" of aeronauts, of "mere adventure-seekers," and of mountain explorers. Directing people's attention to his disciplined observation practices with instruments in the balloon became central to Glaisher's efforts to explain what counted as "science" in a balloon. To encourage a connection between ballooning and Victorian precision, Glaisher articulated a new type of "balloon experience," one that produced data, not thrills. Just as balloon ascents themselves provided occasions for gentlemen of science to demonstrate how one ought to comport oneself as a member of the "scientific public" during an experiment, Glaisher used his lectures and writings for scientific and general audiences to communicate, in words and pictures, how a man of science made scientific observations in a balloon.

Further study of the cultural meaning of scientific field expeditions promises to yield more insights into the intellectual development of Victorian science and its moral and visual dimensions. The relations among science, visual arts, and values in mid-Victorian ballooning are best considered in the context of the public dimension of scientific experiment. To understand these relations in different contexts and historical settings, we must look beyond the walls of the observatory and the

laboratory to the places where science and public exhibition met. Appraising the intellectual and moral value of Victorian discovery in balloons compels us to confront the social impact of a variety of intellectual and cultural forces at work in the 1850s and 1860s—forces associated, for example, with the growing appeal of meteorology, the changing public sphere of science, the spatial segregation of classes, debates over public morals and entertainment, the cultural meaning of science, and the rise of science professionalism.