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RESEARCH ARTICLE

How the Glaishers pictured snowflakes

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Abstract

The Glaisher snowflakes (1855) are amongst the most recognizable images of snow crystals produced in the nineteenth century. Made with the intent of compiling a comprehensive record of snow crystal forms, they also appeared in a variety of print publications, from popular magazines to scientific textbooks, and briefly circulated through various scientific and artistic societies. In a time when reliable images of these small, transparent, ephemeral objects were few and far between, the Glaisher snowflakes were widely praised for both their beauty and their fidelity to nature. But their origin has so far been little examined. This article sheds light on how James and Cecilia Glaisher went about making them, and invites readers to see them through three interconnected perspectives: as products of a domestic environment, as products of a husband-and-wife collaboration, and as products of iterative image making.

In early 1855, James Glaisher (1809–1903) and his wife Cecilia (1828–92) observed and illustrated over 150 snow crystals.[1] Over the following decade, these drawings appeared in a variety of print publications, from popular magazines to scientific textbooks, and briefly circulated through various scientific and artistic societies. They even made their way onto the seal of the Royal Microscopical Society (1866), which to this day sports a snowflake logo.[2] The Glaisher snowflakes were widely praised at the time for both their beauty and their fidelity to nature.[3] But despite their popularity, their origin has been little examined. Throughout the history of snowflake science, observers struggled to visualize these small, ephemeral objects, making the Glaishers' achievement all the more remarkable. Key to this achievement was their collaboration, working alongside one another

[1] In precise terms, a snowflake is an agglomeration of individual snow crystals. The Glaishers recognized this distinction, exclusively referring to the objects they drew as 'crystals' or 'figures'. However, the term 'snowflake' also was and continues to be used more generally to refer to both individual and agglomerations of crystals. As terminology is not of central importance to my argument, nor to the Glaishers' arguments, I have chosen to use these terms interchangeably for the sake of variety.

[2] Gerard L'Estrange Turner, 'The snowflake emblem of the Royal Microscopical Society', *Proceedings of the Royal Microscopical Society* (1979) 14, pp. 175–8.

[3] Despite James's name appearing as the single author on all the publications related to these images, this article considers the images as a collaborative effort, referring to them as 'theirs' (i.e. the Glaishers' snowflakes); first names are used to distinguish between the pair when necessary.

from their south London home. This article sheds light on how the Glaishers went about making their drawings, and what this can tell us about the nature of domestic science and the art of working with 'barely visible' objects.[4]

At the time when the drawings were made, James was superintendent of the Magnetic and Meteorological Department at the Royal Observatory at Greenwich, a post he held from 1840 to 1874. At the Observatory, he focused primarily on standardizing instruments and collections of meteorological observations, which he did through a large network of observers across Britain. However, it was perhaps his activities outside the Observatory which most defined his career. He was closely involved in a variety of societies, including the British Meteorological Society (which he co-founded in 1850) and the Photographic Society (which he presided over between 1869 and 1892). He would later gain fame as a balloonist, when he and Henry Coxwell (1819–1900) made twenty-eight free ascents for the British Association for the Advancement of Science (BAAS) – recently dramatized for the big screen in *The Aeronauts* (2019).[5]

On 31 December 1843 he married Cecilia Belville, daughter of John Henry Belville (*c.*1795–1856), assistant astronomer at the Observatory. Little is known about Cecilia, aged fifteen at the time.[6] During the 1850s she became adept at photographic printing, a technique she likely picked up through her husband's contacts at the Observatory, and by witnessing photographic experiments at the home of their friend, the astronomer John Lee (1783–1866). A book co-authored with the naturalist Edward Newman (1801–76) featuring her photographic prints of ferns was planned in the mid-1850s but was eventually abandoned. Around the same time, an extended publication on snow crystals was also in the works, but ultimately remained unfinished (Figure 1).[7] Unfortunately, little is recorded of her activities after this intense period of fern and snowflake studies.

The pair published a set of eighty-eight black-and-white vignettes and sixty-three larger colour prints of snowflakes, observed between January and March of 1855.[8] These were featured in the fifth annual report of the Council of the British Meteorological Society (henceforth 'BMS report'), accompanied by a discussion of their value to meteorological science. Like most studies of snowflakes by the mid-nineteenth century, this discussion focused mainly on how each crystal shape was likely formed, based on the conditions under which it was observed. James's stated motivation for producing the images was that they would serve as a much-needed reference for meteorologists: a 'collection of snow crystals as observed, and accurately recorded, would be an interesting feature in meteorological investigation'.[9] The discussion did not deviate much from established knowledge about snow crystals. Like other observers before him, James

[4] Omar W. Nasim, *Observing by Hand: Sketching the Nebulae in the Nineteenth Century*, Chicago: University of Chicago Press, 2013.

[5] H.P. Hollis and J. Tucker, 'Glaisher, James (1809–1903), astronomer and meteorologist', *Oxford Dictionary of National Biography Online* (2012); John L. Hunt, 'James Glaisher FRS (1809–1903) astronomer, meteorologist and pioneer of weather forecasting: "a venturesome Victorian"', *Quarterly Journal of the Royal Astronomical Society* (1996) 37, pp. 315–47.

[6] Except for the fact that she had her first painting lesson two years earlier. Hunt, op. cit. (5), p. 336.

[7] Caroline Marten, 'Glaisher [née Belville], Cecilia Louisa (1828–1892), photographer', *Oxford Dictionary of National Biography Online* (2012).

[8] The previous year, the pair had observed some twenty to thirty crystals as well, but their drawings were far less elaborate. James Glaisher, 'Photogenic drawings of snow crystals, as seen in January 1854', in British Association for the Advancement of Science, *Report of the Meeting of the British Association for the Advancement of Science. Notices and Abstracts of Miscellaneous Communications to the Sections*, London: John Murray, 1855, p. 30.

[9] James Glaisher, 'Snow crystals', *Illustrated London News*, 24 February 1855, p. 191. Charles Smallwood (1812–73), a Canadian meteorologist, also produced snowflake drawings of his own, which look remarkably like the Glaishers', although they received much less publicity. See Frances E. Chickering, *Cloud Crystals: A Snow-Flake Album*, New York: Appleton, 1864, p. 17. Smallwood's drawings likely pre-date those of the

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Figure 1. Mock-up of images for an extended publication on snow crystals. FM Glaisher (C) 5/1/2 and 5/1/10. © The Fitzwilliam Museum, Cambridge.

believed that these objects were formed from the same two primary or base figures: a six-branched star, or a thin hexagonal plate. As the crystals fell through the sky they grew branches, prisms, and other increasingly complex shapes, always obeying the 'laws governing the crystallization of water' (by growing at sixty-degree angles to one another).[10] 'Perfect' crystals displayed a 'higher order' of branching, or had straight, sharp edges, as opposed to rounded, 'arborescent' edges.[11] These were all relatively uncontroversial statements to make on the topic – indeed, James acknowledged that the work served as a continuation of that of previous snowflake observers, from Aristotle to William Scoresby Jr (1789–1857).[12] What was new about the Glaishers' work was not their theory of snow crystal morphology, but rather the number and quality of their illustrations. It was the largest and most elaborate collection of snow crystal images published in over a century, becoming for a few decades the default point of reference for European and North American scientists and non-scientists alike.[13]

The images were first exhibited at a meeting of the British Meteorological Society on 27 March 1855, but quickly gained fame both within and outside the British

Glaishers, a matter of pride amongst some Canadian commentators. William Hales Hingston, 'The climate of Canada', in John Douglas Borthwick (ed.), *The British-American Reader*, Montreal: R. & A. Miller, 1860, p. 129.

[10] James Glaisher, 'On the severe weather at the beginning of the year, and on snow and snow-crystals', in British Meteorological Society, *Report of the Council of the British Meteorological Society: Read at the Fifth Annual General Meeting*, London: Meteorological Society, 1855, pp. 16–30, 18.

[11] Glaisher, op. cit. (10), p. 20; James Glaisher, 'Snow crystals', *Illustrated London News*, 17 February 1855, p. 154.

[12] Glaisher, op. cit. (10), p. 29.

[13] The previous record belonged to Jan Engelman, who drew over four hundred. Jan Engelman, *Het Regt Gebruik der Natuurbeschouwingen, Geschetst in eene Verhandeling over de Sneeuwfiguuren*, Haarlem: Izaak van der Vinne, 1747.

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meteorological community.[14] The well-known physicist John Tyndall (1820–93) wrote to James a few months later requesting a spare copy of his 'beautiful snow-crystals'.[15] Thomas Pearsall, of the London Mechanics' Institution, asked whether he could exhibit some of the prints at an upcoming meeting of the Society of Arts.[16] They also quickly made their way into popular journals. Between 1855 and 1857, the *Illustrated London News* (*ILN*) ran three short articles attributed to James. The first appeared on 17 February 1855, and featured a few small drawings from the last week of January to 13 February. A week later, another article appeared in the *ILN*, this one displaying eight highly magnified crystals. Two more articles eventually appeared in *The Art Journal* (1857, reproduced in 1872) and *Leisure Hour* (1872).[17] Readers were often encouraged in these articles to observe their own snowflakes. Several of them did, with the second *ILN* article already featuring some crystals drawn by correspondents, including a Mrs King of Greenwich, a 'gentleman from Huntingdon' and the wire manufacturer and polymath Thomas Glazebrook Rylands (1818–1900). Besides periodicals, the images were also reproduced in various books, from titles such as Edward Belcher's *The Last of the Arctic Voyages* (1855) and Israel Perkins Warren's *Snowflakes: A Chapter from the Book of Nature* (1863), to more specialist publications such as John F.W. Herschel's *Meteorology from the Encyclopædia Britannica* (1862) and John Tyndall's *Heat Considered as a Mode of Motion* (1865), and even as late as A.E.H. Tutton's *The Natural History of Ice and Snow* (1927).[18]

Consequently, there are many contexts in which one could analyse the Glaisher snowflakes. In what follows, I invite readers to understand them in three interconnected ways. First and foremost, these images should be seen as products of a domestic environment: not just in the sense that they were made at home, but that they embodied the value of doing science at home. Looking at domestic spaces in Britain is especially pertinent in the nineteenth century, a time of proliferating scientific institutions and increasing professionalization, which scholars have traditionally associated with a shift of scientific work out of private and into public spaces.[19] Examining other nineteenth-century case studies of domestic science, scholars have shown how homes were important spaces for carrying out routine observations, popularizing science and imbuing scientific work

[14] This lecture was later published in the BMS report of May, but a summary was given in James Glaisher, 'On the late severe weather, as compared with that of 1814; and on the crystals of snow, observed during its continuance', *Gardeners' Chronicle and Agricultural Gazette*, 14 April 1855, p. 243.

[15] Letter from John Tyndall to James Glaisher, n.d., Cecilia Glaisher: Snow crystals, Fitzwilliam Museum, Cambridge (subsequently FM), Glaisher (C) 1/4.

[16] Letter from Society of Arts, Manufacturers and Commerce to James Glaisher, 13 March 1855, FM Glaisher (C) 1/6.

[17] James Glaisher, 'On the crystals of snow as applied to the purposes of design', *The Art Journal*, March 1857, pp. 73–6; 125–8; Glaisher, 'On the crystals of snow as applied to the purposes of design', in Frederick Edward Hulme, James Glaisher, Samuel Joseph Mackie and Robert Hunt, *Art-Studies from Nature, as Applied to Design: For the Use of Architects, Designers, and Manufacturers*, London: Virtue & Co., 1872, pp. 135–75; Glaisher, 'On snow crystals', *Leisure Hour* (1872) 1049, pp. 72–9.

[18] Edward Belcher, *The Last of the Arctic Voyages; a Narrative of the Expedition in H.M.S. Assistance*, London: Lovell Reeve, 1855; Israel Perkins Warren, *Snowflakes: A Chapter from the Book of Nature*, Boston, MA: American Tract Society, 1863; John F.W. Herschel, *Meteorology from the Encyclopædia Britannica*, 2nd edn, Edinburgh: Adam and Charles Black, 1862; John Tyndall, *Heat Considered as a Mode of Motion*, 2nd edn, London: Longman, Green, Longman, Roberts & Green, 1865; A.E.H. Tutton, *The Natural History of Ice and Snow: Illustrated from the Alps*, London: Kegan Paul, Trench, Trubner & Co. Ltd., 1927.

[19] Alix Cooper, 'Homes and households', in Katharine Park and Lorraine Daston (eds.), *The Cambridge History of Science*, vol. 3: *Early Modern Science*, Cambridge: Cambridge University Press, 2006, pp. 224–37, 224; Donald L. Opitz, 'Domestic space', in Bernard Lightman (ed.), *A Companion to the History of Science*, Chichester: John Wiley & Sons, 2016, pp. 252–67, 254. This framing has been complicated by scholars who emphasize the continued importance of homes and households. See Donald L. Opitz, Staffan Bergwik and Brigitte van Tiggelen (eds.), *Domesticity in the Making of Modern Science*, London: Palgrave Macmillan, 2016.

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with familial and moral virtues.[20] Although I focus less on the reception of the images, such themes can still be recognized in certain aspects of their making.

Perhaps the most prominent theme in the domestic history of science is the importance of family and household members – particularly women – in contributing to scientific work. As Londa Schiebinger noted in *The Mind Has No Sex?* (1989), when it came to working in science, 'Women had few options in the nineteenth century'. Often barred from universities and scientific societies, many had to rely on family members for ties to the scientific world, working as 'invisible assistants' to their husbands, sons, or brothers. In so doing, they became increasingly 'hidden from view within the domestic sanctuary'.[21] Much work has since been done to uncover women's contributions to the history of science, and the 'domestic sanctuary' remains an important place to find them.[22] With respect to the Glaisher snowflakes, if we are to recognize their domestic character, we ought also to see them as products of a married couple's scientific collaboration. Theirs is a thus far little-examined entry in the repertoire of case studies involving the collaboration of married couples.[23] We often find these cases in the observational sciences such as astronomy, botany or meteorology, which require extended periods of time for observing and often rely greatly on artistic labour and skill.[24] For our purposes, one such couple, John (1804–81) and Elizabeth Gould (1804–41), is particularly noteworthy. Two decades before the Glaishers sketched their first crystal, the Goulds gained widespread fame in both Britain and America for their ornithological lithographs, including the fifty bird prints in volume 3 of Darwin's *Voyage of the Beagle* (1839).[25] We will return to the Goulds a few more times, as they offer helpful comparisons and contrasts to the Glaishers' work. More generally, in her essay on married couples in nineteenth-century British science, Suzanne Le-May Sheffield identifies three kinds of collaboration 'between art and science in marriage': productive, tenuous and parallel, representing a spectrum

[20] For routine observation see, for example, Simon Naylor, 'Thermometer screens and the geographies of uniformity in nineteenth-century meteorology', *Notes and Records: The Royal Society Journal of the History of Science* (2019) 73, pp. 203–21. For popularization see Sally Gregory Kohlstedt, 'Parlors, primers, and public schooling: education for science in nineteenth-century America', *Isis* (1990) 81(3), pp. 424–45; Melanie Keene, 'Familiar science in nineteenth-century Britain', *History of Science* (2014) 52 (1), pp. 53–71. Domestic virtues may range from the humble (see James Cash, *Where There's a Will There's a Way! Or, Science in the Cottage*, London: Robert Hardwicke, 1873), to the familial (Staffan Bergwik, 'An assemblage of science and home: the gendered lifestyle of Svante Arrhenius and early twentieth-century physical chemistry', *Isis* (2014) 105(2), pp. 265–91), to the aristocratic or gentlemanly (Simon Schaffer, 'Physics laboratories and the Victorian country house', in Crosbie Smith and Jon Agar (eds.), *Making Space for Science: Territorial Themes in the Shaping of Knowledge*, Basingstoke: Macmillan Press, 1998, pp. 149–80, esp. p. 168), to the evangelical (Donald L. Opitz, '"This house is a temple of research": country-house centres for late Victorian science', in David Clifford *et al.* (eds.), *Repositioning Victorian Sciences: Shifting Centres in Nineteenth-Century Thinking*, London: Anthem Press, 2006, pp. 143–54).

[21] Londa Schiebinger, *The Mind Has No Sex? Women in the Origins of Modern Science*, Cambridge, MA: Harvard University Press, 1989, pp. 261–4.

[22] For a useful introduction see Cooper, op. cit. (19). See also below.

[23] See, for example, Helena M. Pycior, Nancy G. Slack and Pnina G. Abir-Am (eds.), *Creative Couples in the Sciences*, New Brunswick, NJ: Rutgers University Press, 1996; Deborah E. Harkness, 'Managing an experimental household: the Dees of Mortlake and the practice of natural philosophy', *Isis* (1997) 88(2), pp. 247–62; Suzanne Le-May Sheffield, 'Gendered collaborations: marrying art and science', in Ann B. Shteir and Bernard V. Lightman (eds.), *Figuring It Out: Science, Gender, and Visual Culture*, Lebanon, NH: Dartmouth College Press, 2006, pp. 240–64; Annette Lykknes, Donald L. Opitz and Brigitte van Tiggelen (eds.), *For Better or for Worse? Collaborative Couples in the Sciences*, Basel: Springer Basel, 2012. Most recently in this journal see Christoffer Basse Eriksen and Xinyi Wen, 'Colouring flowers: books, art, and experiment in the household of Margery and Henry Power', *BJHS* (2023) 56(1), pp. 21–43.

[24] Opitz, op. cit. (19), p. 254.

[25] Janet Bell Garber, 'John and Elizabeth Gould: ornithologists and scientific illustrators, 1829–1841', in Pycior, Slack and Abir-Am, op. cit. (23), pp. 87–97.

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from successful partnerships to difficult ones.[26] Although I follow her call to examine the nature of working partnerships, as we will see, the case of the Glaisher snowflakes complicates the dichotomy of a straightforward collaboration between an artistic wife and a scientific husband.

A recent addition to the literature on married couples in science and their domestic collaboration by Christoffer Basse Eriksen and Xinyi Wen featured in this journal pointed out that even if a spouse's knowledge was confined to the household, it could still have a significant impact outside it, for example by shaping visual conventions.[27] This emphasis on visual contributions reminds us that practices of visualization and image making have featured prominently in much of the history of domestic science, particularly husband–wife collaborations. The collaborative nature of the Glaisher images is particularly evident when we focus on the way in which the pair made them: the labour involved, the techniques employed, the priorities considered. To identify their domestic and collaborative nature, it is therefore also necessary to view them in a third way: not just as images, but as the products of a series of image-making steps. Regarding the study of 'barely visible' objects in particular, which are 'not strictly invisible, nor … simply visible', I have found Omar Nasim's attention to the labour of observation particularly helpful, as it directs our attention to the interplay between conceptual and material labour (involving eyes, minds and hands).[28]

Dividing the labour

To unpack how the Glaisher snowflakes were made, it is necessary to view them as the product of what Nasim calls 'procedures of observation': routine gestures and inscriptions that help make an observer familiar with an object (in this case multiple objects), and communicate their way of visualizing it to different publics.[29] In reconstructing procedure it is useful to start with James's own account, which focuses on the means of collecting and studying these crystals rather than the ways of drawing them. He describes leaving a piece of yellow plate glass – two square feet in surface area and half an inch thick – outside on his windowsill to cool overnight. The next morning, he would lay the glass on his windowsill parallel to the ground, allowing flakes to fall on it. Due to its low temperature, crystals would get stuck to the glass and remain intact long enough for James – seated inside the room at the open window – to make sketches and record observations in his journal, 'with comparative comfort, and at my leisure'.[30] With the crystals collected, he would use a magnifying glass – in his case a Coddington lens – to study them in more detail.[31] Alternatively, he recommends that those who do not have access to a piece of plate glass to use a coarse cloth or other dark insulating material, like fur.[32]

Having looked closely at a branch or several branches of a particular crystal, he would then sketch it on a piece of paper. This is where James's account largely stops. We can infer the following steps from archival materials held at the Fitzwilliam Museum in Cambridge, including many snowflake-related notes, letters, drawings and publications, donated by the pair's son in 1928.[33] For example, it had been common knowledge for a

[26] Le-May Sheffield, op. cit. (23), p. 242.
[27] Eriksen and Wen, op. cit. (23), pp. 1–3.
[28] Nasim, op. cit. (4), p. 5.
[29] Nasim, op. cit. (4), pp. 4, 38, 43.
[30] Glaisher, op. cit. (11), p. 154.
[31] In the *Leisure Hour* article (1872) he mentions using a microscope, but not what kind. The magnification power required would also not have been high. Glaisher, 'On snow crystals', op. cit. (17), p. 78.
[32] Glaisher, 'On snow crystals', op. cit. (17), p. 78.
[33] Caroline Marten, '"Photographed from nature by Mrs Glaisher": the fern photographs by Cecilia Louisa Glaisher', MA thesis, the London Institute, 2002, p. 38 n. 130.

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long time that snow crystals generally exhibited sixfold symmetry. James therefore saved a considerable amount of time by only sketching one branch, leaving his wife to complete the rest of the branches. The sketches he made were likely to have been passed directly to Cecilia, who subsequently completed the crystals by drawing the remaining branches. These were then copied out even larger on better paper and coloured in, creating in essence negatives of the crystals, from which prints could be made for exhibition and engraving. This division – of James doing the sketching and Cecilia creating more complete illustrations based on those sketches – is mirrored in the work of John and Elizabeth Gould two decades earlier, with the latter basing her watercolours on her husband's initial drawings and stuffed specimens. Her illustrations, too, were 'praised for their beauty as well as for their accuracy'.[34] The key difference here is that Cecilia could not rely on taxidermy, or any other physical reference for these objects (a fact that underlies much of the history of studying snowflakes and other fleeting phenomena).[35] Her husband's brief observations were all that the pair could base their images on, making the meaning of 'accuracy' in their case highly contingent on James's memory, his initial sketches, and the pair's communication. As we will see, the paucity of visual reference material in part dictated how the pair collaborated, placing a greater emphasis on communication and entailing that Cecilia was by no means a passive copyist.

So far, the account given by James focuses on his role in the making of these prints. Mentions of Cecilia's role are few and far between, usually limited to a single sentence stating that the final drawings were 'executed' by her, 'from rough sketches of my own'.[36] The wording here echoes the wording found in Darwin's *Zoology of the Beagle*, in which he refers to the bird illustrations as being based on 'sketches made by Mr. Gould himself, and executed on stone by Mrs. Gould'.[37] Both statements attribute creative agency to James/John, with Cecilia/Elizabeth being left with the more passive role of carrying out the design.[38] A slightly different formulation is provided by a former colleague of James's, William Marriott, in a commemorative article on the occasion of James's death. In it, Marriott states that James 'carefully examined the snow, and made a number of rough sketches of various forms, which Mrs. Glaisher redrew under his supervision'.[39] This account no longer implies a clear separation, but suggests a greater degree of interaction between the pair, with Cecilia being able to rework James's sketches, and James having a more active role in the redrawing process. Here we see the division of labour start to become more complex.

Further insight can be gleaned from the pair's snowflake-related correspondence. The letters they received seem to suggest that Cecilia did more than just execute her husband's drawings. Although most of the dozen letters that survive are addressed to James, one is addressed to her. It was sent by the journalist and art critic James Dafforne (1804–80), representing *The Art Journal*, dated 3 January 1857. Written in anticipation of an article on

[34] Garber, op. cit. (25), p. 87.

[35] For more on the difficulty of illustrating fleeting (atmospheric) phenomena see, for example, Fiona Amery, 'Capturing the northern lights: standardizing the practice of auroral photography during the Second International Polar Year, 1932–1933', *Historical Studies in the Natural Sciences* (2022) 52(2), pp. 147–89.

[36] Glaisher, op. cit. (10), p. 17.

[37] Charles Darwin and John Gould, *The Zoology of the Voyage of H.M.S. Beagle*, vol. 3, London: Smith, Elder and Co., 1841, p. i.

[38] I rely here on the contemporary meaning of 'execute' as 'carrying out the design for (a product of art or skill)'. This interpretation acknowledges the skill that went into Cecilia's or Elizabeth's work, but implies that the final 'design' was fixed. *Oxford English Dictionary*, s.v. 'execute, v.', September 2023, at https://doi.org/10.1093/OED/4173223006 (accessed 16 October 2023).

[39] William Marriott, 'Some account of the meteorological work of the late James Glaisher F.R.S.', *Quarterly Journal of the Royal Astronomical Society* (1904) 30(129), pp. 1–28, 10.

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snowflakes appearing in the journal later that year (under James's name), the letter implies that Cecilia was involved in the negotiations regarding the article's publication, and served as a contact point for the editors. We can infer that Cecilia proposed a set of crystals to be engraved for the publication, a proposition that 'Mr [Samuel Carter] Hall', the journal's editor-in-chief, 'gladly meets'. Dafforne also suggests that 'an interesting and useful paper may be written on the causes: this, we can talk over when I next have the pleasure of seeing either you or Mr Glaisher'.[40] Such a paper on the causes of snow crystal growth was eventually included. This, and the egalitarian phrasing of 'either you or Mr Glaisher', suggest that Cecilia's role as a public contact point was not trivial.

The collection of correspondence also contains a draft letter penned by Cecilia dated 18 March 1857 requesting historical texts on snow crystal formation.[41] The recipient is unknown, but could be the polymath Thomas Rylands mentioned earlier, who had been in correspondence with the Glaishers about his own snowflake drawings.[42] Cecilia writes to her unknown recipient asking for references to snow crystals in antiquity, and how far those antique forms are in accordance with 'ours'. The final line contains a noteworthy edit: '~~My~~ Our historical ~~sketch~~ introduction to the subject will be however very brief'.[43] Her having crossed out 'my' is telling, as it hints at both Cecilia's leading role in putting together the 'historical introduction' and her acknowledgement (voluntary or otherwise) that it was a shared endeavour. A separate note containing several historical publications on snow in Cecilia's hand confirms that she collected names of previous snowflake observers, most likely for this introduction.[44] Without reading too much into this minor edit, it is clear that Cecilia was closely involved in the research and composition of the publications that appeared under James's name. Her likely recipient, Rylands, definitely recognized Cecilia's contribution. Writing to James in February 1856, he concluded his letter with the following: 'Pray name me kindly to Mrs Glaisher to whom a good share of our acknowledgements are due'.[45]

Given the lack of written evidence of the pair's collaboration, their sketches and illustrations offer the biggest insight into their 'procedure'. These can be found on dozens of scraps of paper, of varying types, qualities and sizes. The irregularity of the scraps, the number of crossed-out drawings and the blotches of ink and paint all suggest a degree of thriftiness, and tell us that these sketches were by no means intended to look refined or publishable. Indeed, this thriftiness is consistent with James's other work: he used scrap paper from the Observatory to draft his writings for the *Illustrated London Almanack*, and he similarly used discarded skeleton forms to help with the organization of calculations.[46] We know that some of the snow sketches were James's from his observation account. But alongside the irregular and single-branched crystals we find many complete, six-sided ones, some with circular guiding lines, as well as several blotches of paint and ink. This confirms not only that Cecilia used drawing aids, like a rule and a compass, for the completion of her drawings, but also that the pair worked on the same scraps of paper, virtually alongside one another.

Some sketches are accompanied by short and often hastily written annotations. These mostly refer to details of the crystal which are particularly noteworthy: 'pinnacles … to the nucleus very elaborate'; 'Here pinnacles tightly all the way down'. They could also

[40] Letter from *The Art Journal* to Cecilia Glaisher, 3 January 1857, FM Glaisher (C) 1/9.

[41] Draft letter from Cecilia Glaisher, 18 March 1857, FM Glaisher (C) 1/10.

[42] Thomas Glazebrook Rylands, *Observations on the Snows and Snow Crystals of the Winter 1854–55, Made at Warrington, Lancashire*, Liverpool: T. Brakell, 1855.

[43] FM Glaisher (C) 1/10, 1v.

[44] Note, list of previous authors of snow crystal studies, n.d., FM Glaisher (C) 1/2.

[45] Letter from Thomas G. Rylands to James Glaisher, 10 February 1856, FM Glaisher (C) 1/7.

[46] I thank Daniel Belteki for bringing this to my attention.

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Figure 2. Selection of snow crystal sketches, with annotations. FM Glaisher (C) 2/12. Photograph by the author, reproduced with the kind permission of the Fitzwilliam Museum.

provide contextual information: 'not common'; 'This fell double'.[47] But some are also instructional: 'Nucleus much smaller', 'a little larger [on] the shaft'; 'prism 2 much too long' (see Figure 2).[48] The former two kinds of annotation were likely memory aids, serving alongside James's journal as a record of the conditions in which the crystal was seen, and highlighting features worth mentioning in an accompanying text.[49] Indeed, almost every piece of paper with crystals on it is labelled with the date and the ambient air temperature, two crucial data points for James's analysis.[50] The instructional annotations, however, demonstrate the pair's communication. Alongside the many abandoned, crossed-out or otherwise unfinished sketches, these annotations show how the crystals went through a process of iteration between James's initial sketch and Cecilia's finished pen-and-ink drawing. They evidence a degree of back-and-forth between the pair – corroborating Marriott's comment that Cecilia 'redrew [crystals] under his supervision'. It is material evidence of the pair's 'four-eyed' sight, a notion Lorraine Daston and Peter Galison use to highlight how natural-history illustration often required the collaboration of an observer and an illustrator.[51]

[47] FM Glaisher (C) 2/12, 2/16, 2/23.
[48] FM Glaisher (C) 2/29, 2/30.
[49] It is unknown whether the journal has been preserved – it is not in the Fitzwilliam collection.
[50] Glaisher, op. cit. (10), p. 29.
[51] Lorraine Daston and Peter Galison, *Objectivity*, 4th edn, New York: Zone Books, 2018, pp. 84–98.

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Figure 3. Strips with photographic copies of snow crystals. Detail from RGO/6/677, f. 197. Reproduced by kind permission of the Syndics of Cambridge University Library.

What makes this kind of four-eyed sight noteworthy is that both pairs of eyes were situated alongside one another, at home. It is worth reflecting on the importance of this domestic context. As superintendent of the Magnetic and Meteorological Department of the Royal Greenwich Observatory, James spent a considerable period of time during the 1850s working on developing self-registering meteorological instruments. Letters exchanged between him and the Astronomer Royal, George Airy (1801–92), in the years preceding the snowflake observations reveal his tenacity in the search for finding reliable methods and chemical solutions for recording these measurements, sometimes acting in direct defiance of his sceptical boss.[52] Intersecting with this search for reliable photographic solutions was James's interest in snowflakes. We see this clearly in Figure 3, which shows some strips of crystal drawings that were used to test different chemical solutions. These particular strips are kept amongst the Observatory's papers, not in the Fitzwilliam collection, although the latter does include a similar set of strips without the labelling. It begs the question to what extent James saw the work of observing and visualizing snow crystals at home as an extension of his work for the Observatory. Did his home serve as an alternative space to the Observatory for carrying out scientific activities, and if so, what benefits could it provide?

This question becomes ever more pertinent when we consider the difficulties of James's relationship with his superior. Airy ran a tight ship at the Observatory, implementing a strict division and regulation of labour.[53] James had experienced this regulation

[52] Magnetic Instruments & Photographic Registration 1849 to 1854, Royal Greenwich Observatory Archives, Airy Papers, RGO/6/677, Cambridge University Library, Cambridge, ff. 189–292; Magnetic Instruments & Photographic Registration 1855 to 1861, RGO/6/678, ff. 337–72.

[53] Daniel Belteki, '"The grand strategy of an observatory": George Airy's vision for the division of astronomical labour among observatories during the nineteenth century', *Notes and Records: The Royal Society Journal of the History of Science* (2023) 77(1), pp. 135–51, 135–6.

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directly on several occasions. In 1840, upon being appointed superintendent, he would use an idle telescope outside working hours to search for planets, pursuing his long-standing interest in astronomy. According to one of James's biographers, Airy forbade this kind of unauthorized activity, preventing him from using Observatory instruments for astronomical observations. A few years later, and at Airy's request, James produced an article about his department for the *ILN*, which appeared under his own name. Airy objected to this on the basis that he should bear ultimate authority over statements related to the institution, and requested that James's name be removed.[54] Evidently, James faced certain kinds of restraint at the Observatory, in terms of both his passion projects and authorship for work related to the institution (or done during regular working hours). With this in mind, his home offered a space free from these restraints, allowing him to make his observations at his 'leisure' with the aid of his wife. Rather than thinking about the home as a marginalized scientific space, for James working at home had an emancipatory effect.[55]

This article mainly looks at the collaboration between James and Cecilia, but there were, of course, others involved in the production of the Glaisher snowflakes. An important figure in this regard is Alfred Deacon, who engraved the images. Thanking him at the end of the BMS report, James noted that Deacon 'rendered every justice to my original drawings', and that his interest in the subject helped the 'artistic illustration of my labours' (note: *my* labours, not *our* labours).[56] The only other extant record of Deacon's work is an invoice detailing the cost of engraving the illustrations, which amounted to £32 15*s* 8*d*, about one-sixth of James's annual salary as superintendent.[57] Crucially, the invoice is addressed not only to James, listed as the secretary of the British Meteorological Society, but also to Henry Perigal, his friend and treasurer of said society. The society had in fact 'resolved upon engraving the whole of [the crystals]', in addition to covering the cost of printing in colour (£23). About a dozen members covered half of the total cost, such that 'the finest set of engravings of snow crystals ever issued was published by the Society at a cost to itself of scarcely £30'.[58] The Goulds, similarly, produced their first Himalayan bird illustrations with support from the Zoological Society and its paid subscribers.[59] The fact that the Glaisher prints were financed partly by the British Meteorological Society and partly by its members was wholly omitted from the papers and popular articles which appeared under James's name, which were designed to present them as the products of an individual, leisurely pursuit. This ultimately reminds us that we should not assume that work done at home is always entirely domestic in nature; rather, we see how the Glaishers took advantage of both the domestic and institutional aspects of their work.

Magnifying and reconstructing

Taking into account the division of labour, we start to understand the complexity of picturing a snowflake: it needs to be captured, examined, sketched, annotated, drawn,

[54] Hunt, op. cit. (5), p. 320.

[55] In this I am echoing Donald Opitz, Staffan Bergwik and Brigitte van Tiggelen, 'Introduction: domesticity and the historiography of science', in Opitz, Bergwik and Van Tiggelen, op. cit. (19), pp. 1–15.

[56] Invoice from Alfred Deacon to James Glaisher and Henry Perigal, 26 November 1855, FM Glaisher (C) 1/14; Glaisher, op. cit. (10), pp. 29–30.

[57] At the time when he made his snowflake observations James's annual salary was £200 plus £40 for housing. See Graham Dolan, 'Pay 1836–1871', *The Royal Observatory Greenwich*, n.d., at www.royalobservatorygreenwich.org/articles.php?article=945 (accessed 10 August 2022).

[58] George James Symons, 'The history of the English meteorological societies, 1823 to 1880, being the address delivered at the Annual General Meeting, January 19th, 1881', *Quarterly Journal of the Royal Meteorological Society* (1881) 7(38), pp. 65–98, 91.

[59] Garber, op. cit. (25), p. 87.

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redrawn, copied, engraved and published. Zooming in on the middle part of this process, this section deals with the practices involved in making and remaking the image on a page, highlighting how the crystals were magnified and reconstructed. Both are fundamental aspects of picturing microscopic objects. The crystals that James observed ranged from about two to twelve millimetres in diameter; the images that the Glaishers produced range from this 'natural size' to twenty-six centimetres. In the process of magnifying figures, the Glaishers had to make decisions about what to include, what to make 'invisible', and how to fix missing or broken features. This section focuses on visualization practices, but, as will become clear, the pair's collaboration and domestic context of their work also help us understand the considerations that went into producing the images.

The key difficulty in making very complex but small shapes larger is that minor details need to be amplified and preserved at a larger scale. A one-millimetre branch becomes half a centimetre long – you now have five times as much space to fill. The Glaishers were clearly aware of this. Amongst the pair's sketches we occasionally find comments about the natural size of a particular crystal, often with the implication that the drawing has been made to approximate it, but that details have been simplified in the process. A note titled 'Drawn from nature. Feb: 20th', containing nine small but evenly sized crystals, reads, 'as near the natural size as I can sketch them. Number 4 was very beautiful – [a thin?] transparent lamina of ice? With delicate [lines] more so than my drawing. No. 1 … was the most common form … and varied in size as did all of them'.[60] A passage in James's second *ILN* article is also telling:

> The insufficiency of the draughtsman to represent with his pencil the overwhelming mass of intricate detail, unfolded by the aid of a good lens, is no little matter of regret to the observer, who would record for the general benefit an appropriate idea even of the real structure of these beautiful formations.

Ironically, he adds that his Coddington lens 'discloses as much of the crystalline formation of these bodies as is commensurate with my power of representing accurately'.[61] James therefore seems to have had an ambiguous relationship with the difficulties of magnifying a crystal. On the one hand, the beauty of its complexity would inevitably be lost in the process of drawing such a crystal, given that his drawing skills limited his ability to capture its likeness. On the other hand, the tools he had at his disposal also limited how much of the object he could see, ultimately reducing the amount of detail he had to capture. Magnifying an object, in sum, was not just affected by a lens refracting light or the drawing skill of the observer, but a combination of both.

Then there is the question of how to contextualize a drawing's size. In the 'Drawn from nature' note above, we read that the crystals all varied in size, but the drawings were all equal in diameter. Similarly, the images in the BMS report appeared only in two sizes, without indication of relative scale. To understand why such an important feature of a snow crystal was relegated to its accompanying text, we must consider who these drawings were made for. As mentioned earlier, the images appeared in newspapers soon after they were made. These publications were designed to elicit awe and to encourage readers from a wide general audience to make their own observations. Conversely, James's report in March was tailored to the members of the British Meteorological Society, whom he hoped to convince of the scientific value of systematic snowflake observations. Two years later, the same images appeared in *The Art Journal*, alongside an article that explicitly encouraged industrial designers to draw inspiration from them.

[60] FM Glaisher (C) 2/2, original emphasis.
[61] Glaisher, op. cit. (9), p. 191.

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The *Art Journal* article is a testament to how malleable the Glaisher snowflakes were in terms of their scientific and artistic applicability. Whereas in the BMS report they served the purpose of illustrating morphological properties, in the *Art Journal* piece they were displayed as intriguing patterns for artists and designers to emulate. Crucially, James underlines the need for artists and designers to understand the morphological processes of crystal formation, allowing them to create new designs rather than copying old ones. In that sense, the combination of scientific and artistic value is fundamental to these images. There is also evidence to suggest that these images were made with such a dual utility in mind. On the back of one of her painted snow crystals, Cecilia wrote, 'In regard to the application of these figures there is much to be said'.[62] Given her artistic talents and recent work on producing prints of ferns, this comment may allude to the decorative value she saw in them. Similarly, the editor of the *Art Journal* piece introduces it by stating, 'In the course of his examination of these snow crystals it occurred to Mr. Glaisher that they would furnish novel and most beautiful suggestions for the ornamental designer'.[63] Indeed, amongst the pair's letters we find suggestions to display the prints to members of the Society of Arts, as an example of nature photography, or to use them as decorations for a chess board.[64] The pair also produced several colour drawings of mosaics and tiling using crystal patterns, likely in preparation for the *Art Journal* piece, which highlights tile work as a particularly interesting area for snowflake designs to be incorporated in. It is fair to assume that the Glaishers were aware that a wider audience beyond the meteorological community would find interest and value in the images.

With this in mind, we can start to see how the Glaishers balanced scientific and artistic interests in making their images. For instance, drawing crystals to a consistent size diminishes the amount of contextual information about relative sizes, but emphasizes their differences in form. With James prioritizing representative form over eye-catching symmetries, information about size or magnification was relegated to the text. This is not to say that the Glaishers were not working with different scales at all. Amongst their sketches and notes we can find many instances of a larger crystal or branch accompanied by a much smaller sketch of the same image, the latter serving as a scale reference. But such references were only used during the sketching stage, being subsequently left out of the final published form. This tells us that during the process of magnification scientific and aesthetic considerations could be emphasized at different stages.

Another recognizable artefact of the Glaishers' magnification practices is the zoomed-in inset. Often, a small, six-branched crystal would be sketched alongside an enlarged version of one of its branches.[65] This branch would be more detailed, sometimes accompanied by a short annotation. For example, the crystal in Figure 4 is characterized by its distinctive eye-of-a-needle-shaped tips. A zoomed-in version of the branch is shown to the right of it, an arrow pointing to its centre. The annotation tells us that the central part of the branch (the 'eye') resembles part of another crystal they drew. The practice of using zoomed-in sketches to highlight important details of natural objects has a longer history, gaining particular prominence in the late sixteenth century amongst natural historians.[66] As scholars saw increasingly more detail through their magnifying lenses (and later microscopes), zooming in became a means of adding layers to drawings, incorporating multiple levels of seeing in the same image.[67] Yet, like the scale references, the

[62] FM Glaisher (C) 4/17.

[63] Glaisher in *The Art Journal*, op. cit. (17), p. 73.

[64] FM Glaisher (C) 1/6; letter from Henry Lee to James Glaisher, 15 February 1868, FM Glaisher (C) 1/11.

[65] FM Glaisher (C) 2/12; 2/16; 2/30

[66] Florike Egmond, *Eye for Detail: Images of Plants and Animals in Art and Science, 1500–1630*, London: Reaktion Books, 2017, p. 189.

[67] Egmond, op. cit. (66), pp. 197, 113.

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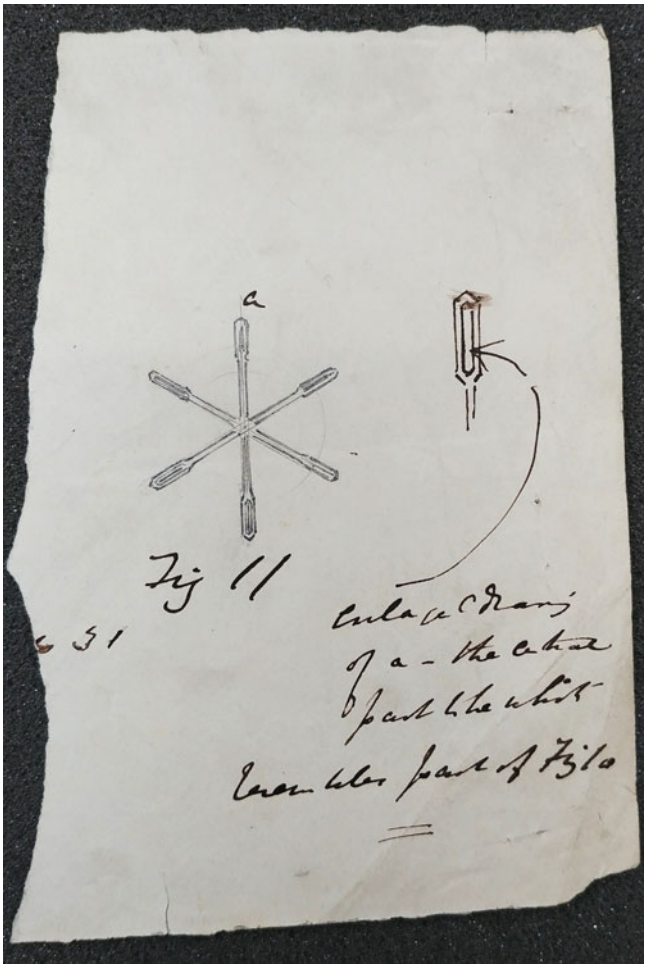

Figure 4. Sketch of a crystal with zoomed-in inset. FM Glaisher (C) 2/6, Fitzwilliam Museum, Cambridge. Photograph by the author, reproduced with the kind permission of the Fitzwilliam Museum.

zoomed-in insets did not make it to publication. In Nasim's words, they functioned instead as the 'scaffolding' to be removed from the final image, something to be rendered 'invisible'.[68]

Implicit in the act of magnifying an object like a snowflake is the act of copying it, since the object itself cannot be made larger.[69] In the process of copying, details are often lost. For example, on the back of the previously mentioned 'Drawn from nature' note, James wrote the following: 'The stars were of course most perfect in form, but which my pen fails faithfully to represent'.[70] Efforts to recover these details can be described as acts of reconstruction – of remaking the physical object on the page. Beyond simply copying what they saw onto the page as best they could, we see the pair using reconstruction as a way to tell a story regarding these objects.

The storytelling aspect of the Glaisher snowflakes is perhaps most visible in a little booklet made of three folded sheets of thick sketching paper, found amongst their

[68] Omar W. Nasim, 'Making invisible: the other side of visualization in science', forthcoming.

[69] For an exception to this rule see Fei Chen, Paul W. Tillberg and Edward S. Boyden, 'Expansion microscopy', *Science* (2015) 347(6221), pp. 543–8.

[70] FM Glaisher (C) 2/2, original emphasis.

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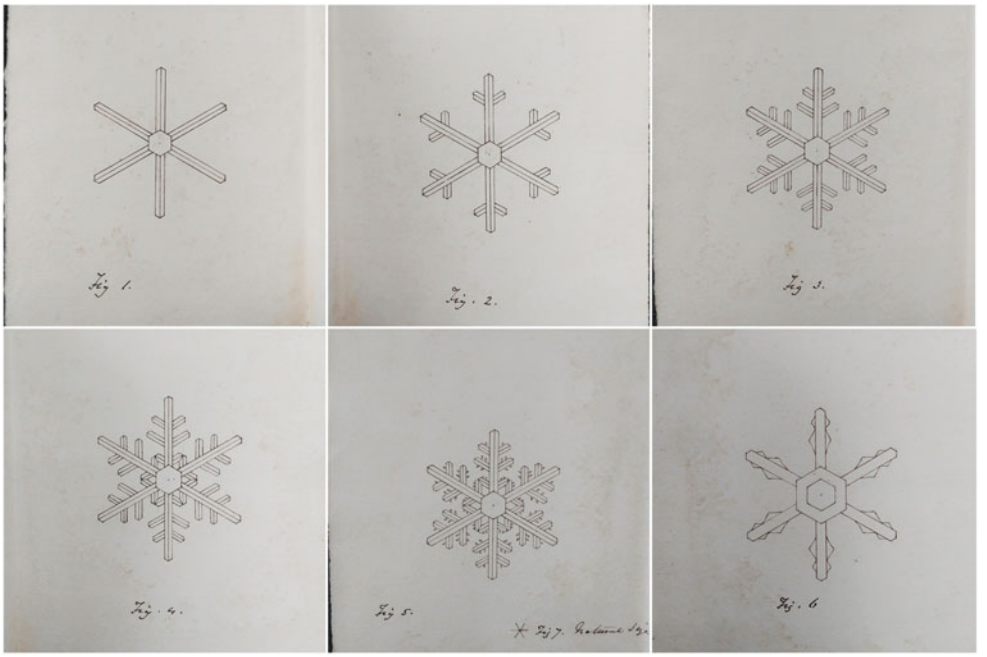

Figure 5. Booklet labelled 'Kepler in the museum'. FM Glaisher (C) 2/4. Photographs by the author, reproduced with the kind permission of the Fitzwilliam Museum.

sketches (Figure 5).[71] The front of the booklet reads, 'Kepler in the museum'. On each page, there is a simple graphite drawing of a snow crystal. There are six in total, all of the same crystal, becoming increasingly elaborate by growing extra branches, with the final drawing showing the crystal in an advanced stage of melting. A seventh sketch shows a very small asterisk-shape labelled 'natural size', giving the reader a reference to the real-world object this series of drawings was likely based on. It is an intriguing record: the Glaishers themselves do not refer to it, nor does the archive catalogue provide much information. Although likely not intended for publication, these sketches might have served a conceptual purpose in understanding crystal morphology, which is discussed in the BMS report. The inscription could corroborate this: Johannes Kepler's 1611 study of the snowflake – which Cecilia consulted for her 'historical introduction' – focused on the origins of its hexagonal symmetry.[72] However, the reference to Kepler may also be accidental, with Cecilia repurposing the booklet for keeping notes about her consultation of Kepler's book in the British 'Museum'.

Accidental or not, the juxtaposition of the sketches and the inscription alludes to an important aspect of picturing snowflakes: images can serve as the historical record of the development of a crystal, a development that at the time could not be studied any other way. Consider that it can take up to an hour for a single crystal to reach the ground, but less than a minute to melt and become unrecognizable. For many observers, the Glaishers included, the study of these objects occurred in that final minute, and yet their interest lay primarily in what happened during the preceding hour. M. Norton Wise uses snowflake morphology as an example where complex behaviour requires historical narratives to be

[71] FM Glaisher (C) 2/4.
[72] Johannes Kepler, *The Six-Cornered Snowflake* (tr. Colin Hardie), Oxford: Oxford University Press, 2014.

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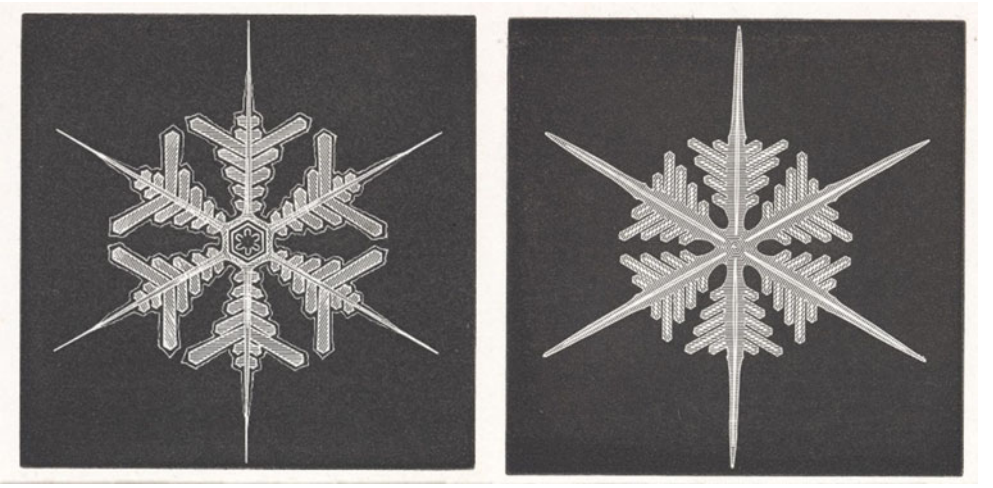

Figure 6. Snow crystals in stages of melting. FM Glaisher (C) 6/9/74; 6/9/78. © The Fitzwilliam Museum, Cambridge.

adequately explained: 'A snowflake is an historical object and its virtual history is its explanation'.[73] Picturing such an object in various stages of growth constituted the creation of a kind of 'natural-history museum'.[74] He made this observation in reference to snowflake photographs from the 1930s, as well as digital simulations of snow crystal growth made in the 1990s. But you do not need a camera or computer to create such kinds of natural-history museums – the Glaishers' booklet exemplifies this. The natural-history–museum approach that it embodies is an exercise in reconstruction: of using iterative images to reconstruct a snow crystal's growth and decay as a means of understanding its structure.

That the Glaishers thought to some extent in reconstructive terms about their snow crystals is also evident in the way the objects were represented. Writing in the *ILN*, James warns, 'for the benefit of the inexperienced, that the crystal, subjected to the warm influence of the proximity of the observer, not unfrequently alters in form before it sensibly begins to melt'.[75] In the BMS report, he describes how multiple crystals are depicted in states of transition, 'attributable to [his] close vicinity whilst observing them' (some examples are shown in Figure 6).[76] Nevertheless, he argues that 'it is not unnatural to suppose a reversal of the laws governing their first formation', given that the freezing of water obeys the 'law' of crystallization.[77] This was a contested view of ice crystal morphology at the time.[78] Yet James clearly recognized how iterative images portraying an object's decay could offer insight into the process of their formation.[79]

[73] M. Norton Wise, 'Science as (historical) narrative', *Erkenntnis* (2011) 75(3), pp. 349–76, 366.

[74] M. Norton Wise, 'Goethe was right: "the history of science is science itself"', in Alexander Blum, Kostas Gavroglu, Christian Joas and Jürgen Renn (eds.), *Shifting Paradigms: Thomas S. Kuhn and the History of Science*, Berlin: Max-Planck-Gesellschaft zur Förderung der Wissenschaften, 2016, pp. 347–59.

[75] Glaisher, op. cit. (9), p. 191.

[76] Glaisher, op. cit. (10), p. 23.

[77] Glaisher, op. cit. (10), pp. 26, 18.

[78] Rylands, for instance, was not convinced, something he made clear to James in their correspondence. FM Glaisher (C) 1/7. A decade earlier, a German snowflake observer noted that on the subject of the crystal form of ice there has been 'much discussion, doubt and dispute'. Georg Friedrich Schumacher, *Die Krystallisation des Eises: Aus vielen eigenen Beobachtungen dargestellt und mit fünf Kupfertafeln erläutert*, Leipzig: Mayer und Wigand, 1844, p. 27.

[79] Glaisher, op. cit. (10), p. 27.

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A snowflake being a small, transparent object, it can be difficult to capture its materiality on the page. James commented that they were sometimes so thin and transparent, he thought they 'exhibited no appearance of solidity' whatsoever.[80] A particularly difficult aspect of the crystal's materiality to reconstruct on the page was its brilliancy, or the way its microscopic facets reflected rays of light and made it shine. The Glaishers considered this a noteworthy optical phenomenon, and sought to preserve it in the final images. For instance, two of the crystals the pair observed were, according to James, 'highly crystalline, and in parts glistened with an intense brilliancy, an idea of which I have endeavoured to convey by leaving those portions white in the drawing'.[81] This was by then a well-known method of conveying reflections in pencil drawings.[82] But the statement 'leaving those portions white' tells only part of the story of replicating the brilliancy effect, an achievement largely creditable to Cecilia. Merely leaving them white in the sketch would have resulted in a dark patch once the drawings were copied photographically. This copying method first involved washing and soaking a sheet of paper in a common salt solution, before pinning it on a board to let dry. One side was then evenly coated in silver chloride, and once dry, the drawing to be copied – acting as the negative – would be placed on top of the treated sheet of paper, and left in sunlight. Exposure to sunlight turned silver salts into metallic silver, resulting in a positive copy of the original drawing on the treated paper. To make sure the brilliant areas of the crystal stayed white, Cecilia applied a layer of paint to specific areas of the negative before beginning the copying process. The areas covered in paint would block most of the sunlight, leaving the silver salts underneath unexposed.[83] The resulting prints showed crystals of various shades of grey, with some perfectly white highlights. These copies could subsequently be engraved, printed, (coloured – see below) and published. The original negative, on the other hand, still displayed the dark, black crystals with strikingly colourful highlights – stunning colour illustrations, considering that they served mainly to enable reproducible grey-and-white photographic copies (Figure 7).

Cecilia's use of colour in general is intriguing. Whereas the smaller vignette prints were in black and white, her larger crystals each featured colourful backgrounds, including black, green, ox-blood red, charcoal, dark green, brown, Prussian blue and cyan (Figure 8).[84] The colours serve a simple analytical purpose, namely to make comparison between crystals easier by designating different days of observation. But Caroline Marten, who has studied Cecilia's images of ferns and snowflakes, suggests that the colours may have also served an artistic purpose, namely to mimic other photographic processes popular at the time, such as the cyanotype photographs of Anna Atkins (1799–1871), or the iron-based processes of Robert Hunt (1807–87).[85] Relying on their audience's familiarity with photographic images, this may have helped strengthen the perception that these prints of snow crystals were also photographs 'taken from nature'.[86] As mentioned earlier, the Glaishers sought to balance scientific and artistic

[80] Glaisher, op. cit. (10), p. 18.

[81] Glaisher, op. cit. (10), p. 22.

[82] Meghan C. Doherty, 'Discovering the "true form": Hooke's *Micrographia* and the visual vocabulary of engraved portraits', *Notes and Records* (2012) 66(3), pp. 211–34.

[83] Golding Bird, Charles Brooke and John Wickham Legg, *The Elements of Natural Philosophy, or, an Introduction to the Study of the Physical Sciences*, London: John Churchill, 1860, p. 621.

[84] Colour names as described by Caroline Marten.

[85] Marten, op. cit. (33), pp. 60–3.

[86] For more on Cecilia, including her work on fern leaves, see Caroline Marten's online exhibition *Snow Leaves Ferns*, available at https://ceciliaglaisher.com (accessed 4 October 2023).

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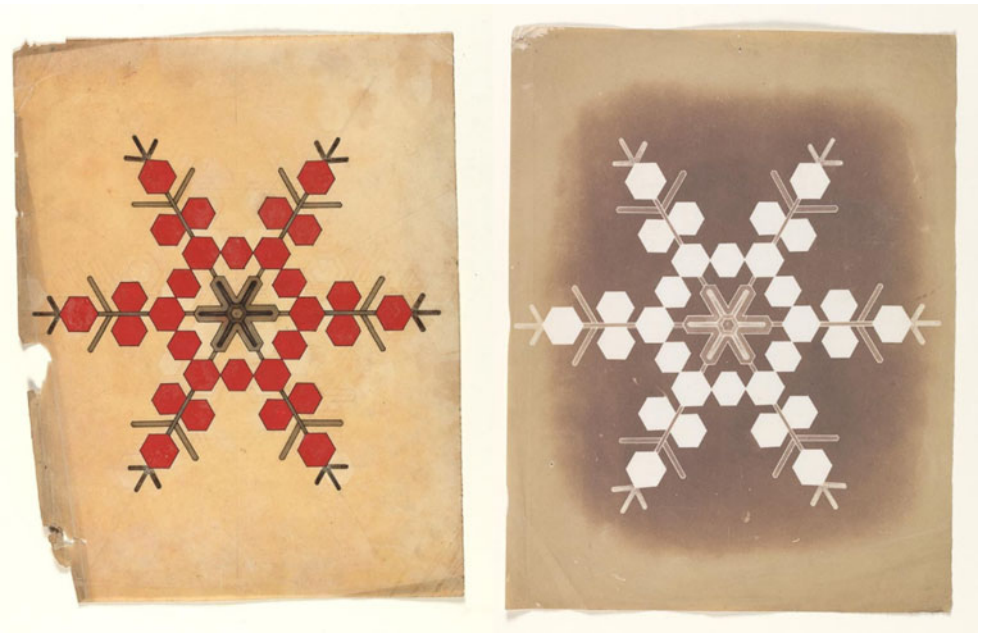

Figure 7. Black-and-red negative and its photographic positive. FM Glaisher (C) 3/7/52; 3/7/53. © The Fitzwilliam Museum, Cambridge.

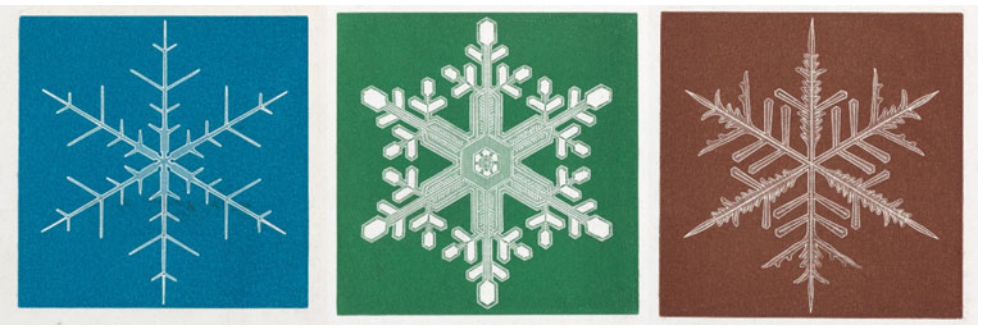

Figure 8. Coloured prints of snow crystals. FM Glaisher (C) 6/9/2; 6/9/35; 6/9/41. © The Fitzwilliam Museum, Cambridge.

considerations in their images. Including colour would have served much more an artistic purpose than a scientific one, given that it tells the viewer nothing new about the crystal's shape.[87] But by using the colours as indicators of specific days they gained analytical value. Given that the pair produced the images for a variety of audiences, it is unlikely that this dual benefit of colour was lost on them.

[87] For comparison, botanists in the eighteenth century often used colour in their illustrations for legibility reasons rather than taxonomic ones. See Kärin Nickelsen, *Draughtsmen, Botanists and Nature: The Construction of Eighteenth-Century Botanical Illustrations*, Bern: Springer Netherlands, 2006, Chapter 5.

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Conclusion

We might ask ourselves what motivated the Glaishers to observe and visualize these snowflakes at all? Answering this question is not as straightforward as it may seem. We saw that James's self-declared motivation lay in contributing to an area of meteorological knowledge that has 'languished for want of extended and continuous observations'.[88] By collecting a series of crystal forms at known temperatures, he believed he was enabling future meteorologists to uncover the mechanisms which produce these marvellous figures. With this in mind, it is worth pointing out that there is no record of James specifically having studied snowflakes prior to 1854, nor do we have evidence of continued studies after the four-week period of observations in 1855.[89] An extended volume on the subject never materialized, and both of the 1872 publications recycle material they had published almost twenty years earlier.[90] We should not forget the importance of the winter of 1854–5 being particularly 'severe', offering favourable conditions for an extended period of observing snow. Beyond this, we should also be aware that James liked writing articles for a general readership in publications such as the *ILN*, and carrying out snowflake observations at home would offer excellent material for them. It would also offer an additional opportunity to test photographic chemistry, alongside the testing he was doing at the Observatory (recall Figure 3). Undoubtedly, Cecilia's skill in drawing and copying, and experience working with ferns in a scientific and artistic context, enabled the picturing of these objects in the first place. But it can be argued that she was ultimately instrumental in allowing the drawings to reach such a wide audience at all.

Speculation about motivations aside, the three interconnected perspectives put forward in this article attest to the different historiographical insights these images offer. Focusing on their domestic origins helps us see the value that private homes offered during the 'reconfiguration' of scientific spaces in mid-nineteenth-century Britain.[91] James found an outlet at home to work on a passion project away from the surveillance of his superior, and leaned into the domestic character of the work in his non-specialist publications, encouraging readers to make their own observations at home. Working at home also directly enabled a close collaboration with his wife, whose contributions were formative for the pair's work. In her assessment of the Goulds' bird prints, Janet Bell Garber maintains that, 'For John Gould, art was a part of his science, and for Elizabeth, science was a part of her art'.[92] She portrays John as the meticulous ornithologist, who would have found success even without his wife, but who took advantage of her artistic talents. For all the similarities between the Glaishers and the Goulds, the case of the former suggests that a neat division between the scientific and artistic labour should not be taken for granted. Although James played a primary role in observing and Cecilia a primary role in illustrating, the divisions of labour and iterative drawing practices discussed above paint a picture of a more enmeshed collaboration.

[88] Glaisher, op. cit. (10), p. 29.

[89] He did, however, carry out experiments on the effect of snow on grass in early 1845. Illustrated London Almanack proof sheets by James Glaisher, Royal Society Archive (RSA), MS/910, f. 275. After the mid-1850s, he only recalls one occasion witnessing snow crystals during his balloon ascents, namely when he passed through a snowstorm at 14,000 feet on 26 June 1863. James Glaisher, *Travels in the Air*, London: Richard Bentley, 1871, p. 71.

[90] A mock-up for the extended volume is in the Fitzwilliam Collection (Figure 1). The only other reference to it is in the *Art Journal* piece.

[91] Bernard Lightman, 'Refashioning the spaces of London science: elite epistemes in the nineteenth century', in David N. Livingstone and Charles W.J. Withers (eds.), *Geographies of Nineteenth-Century Science*, Chicago and London: University of Chicago Press, 2011, pp. 25–50, 28–34.

[92] Garber, op. cit. (25), p. 97.

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This was doubly necessary given the ephemeral nature of snow crystals, which necessitated a high degree of communication between the pair about how to do justice to these objects. This communication becomes evident when we approach the images as products of an iterative visualization process, one which involved the making and remaking of these figures on the page. Paying attention to these visualization practices further helps us understand how scientific and artistic considerations are incorporated into images. In sum, it is through applying these different perspectives that the ambiguous nature of the Glaisher snowflakes comes to light: they are neither solely domestic nor institutional, neither artistic nor scientific. Case studies such as these therefore implore us to combine different historiographical approaches, and to recognize how they enrich one another.

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