Recovered or Perfected: The Discourse of Chemistry in the Nineteenth-Century Revival of Stained Glass in Britain and France

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The science of chemistry revitalized the art of stained glass in the nineteenth century. Chemists played a critical role in nineteenth-century stained glass studios across Europe.[1] They resuscitated neglected techniques and invented new materials.[2] For example, the chemist Georges Bontemps (1799–1883), who worked in both France and England, was renowned for having recovered the process of manufacturing the flashed red glass used in medieval windows. Chemists also provided the art with its modern palette, developing new shades of coloured glass and enamel paint. However, while scholars have documented the vital technical function science served, the essential role chemistry played in the discourse surrounding the revival remains unexamined. Focusing on France and Britain, this article examines the ways in which different texts produced by the stained glass revival — public essays, private communications, technical manuals, and critical accounts — drew on and evoked chemistry. Though these examples often address different audiences, they form part of the same wider discourse, and their comparison illumines general developments in this period.

The first half of the article describes how chemistry was deployed to imagine two distinct versions of nineteenth-century stained glass, which either departed from or looked back to historical styles. Advocates for each of these approaches employed chemistry as a means to mediate the relationship between the revived art and its past, and thereby to make the case for their particular vision of modern stained glass. The second half of the article charts the diverging responses in France and Britain to this intertwining of art and science. A chronological overview suggests that as the century progressed the contribution of chemistry to the medium was disavowed in France and embraced in Britain. This article thus demonstrates that in this period of historical and nationalistic revival, modern chemistry

[1] The author offers warm thanks to Dr Gareth Atkins and Dr Jasmine Allen who provided a unique occasion to explore the many facets of British nineteenth-century stained glass as well as invaluable commentary on this article.
[2] See Isabelle Lecocq and Jacques Barlet, *Techniques du vitrail au XIX^e^ siècle: Forum pour la conservation et la restauration des vitraux, Namur, 14–16 juin 2007* (Namur: Institut du patrimoine wallon, 2007); and Élisabeth Pillet, *Le Vitrail à Paris au XIX^e^ siècle: Entretenir, conserver, restaurer* (Rennes: Presses universitaires de Rennes, 2010).

was a critical means by which stained glass practitioners and commentators defined the direction this revived art would take and the place it would have in the broader artistic culture.

Looking in both directions in the first half of the nineteenth century

Nineteenth-century stained glass practitioners and theorists in both Britain and France were divided over the form that the revived art should take. In broad strokes, this debate concerned whether or not modern windows should embrace the visual qualities of oil painting. In Britain the Cambridge Camden Society and the Ecclesiologists asserted from the 1840s onwards that late eighteenth-century stained glass, such as the 'Reynolds' window (1779–85) of New College Chapel in Oxford, had abandoned the essential characteristics of the art by embracing oil painting's pictorial effects. They argued that modern glass should return to the example set by ancient windows and embrace the medium's specific material qualities, especially translucency.[3] In France this argument was framed by the terms *vitrail tableau* and *vitrail archéologique*. The former employed modern enamels to achieve subtle shading and atmospheric perspective. The latter revived historical models, favouring in particular the medieval mosaic style, which assembled monochromatically painted glass pieces in a complex lead network.[4] This argument was thus a disagreement about the relationship between the revived art and its past: should nineteenth-century stained glass be a reincarnation of or an evolution from medieval tradition? The following discussion traces the ways that chemistry was evoked in this discourse as a means of defining the revitalized art's relationship with its past.

On one hand, proponents of a new modern form of stained glass cited chemistry as the knife that cut the art loose from historical precedent. This camp claimed that there was no need for a revival because nothing had been lost: chemistry thereby offered not a means to reclaim the past but to depart from it. One of the most vocal advocates of this view was Alexandre Brongniart (1770–1847), director of the Manufacture national de Sèvres, who established one of the first nineteenth-century French stained glass

[3] Scholarship has often overlooked British painted glass that sought to imitate oil painting. See Jasmine Allen, 'Stained Glass and the Culture of the Spectacle, 1780–1862', *Visual Culture in Britain*, 13 (2012), 1–23 (pp. 10–13); and also, Jim Cheshire, *Stained Glass and the Victorian Gothic Revival* (Manchester: Manchester University Press, 2004).

[4] Jean-François Luneau, 'Vitrail archéologique, vitrail-tableau', *Revue de l'Art*, 124 (1999), 67–78; and Nicole Blondel, Martine Callias Bey, and Véronique Chaussée, 'Le Vitrail archéologique: Fidélité ou trahison du Moyen Âge?', *Annales de Bretagne et des Pays de l'Ouest*, 93 (1986), 377–81 (pp. 377–78).

studios.[5] Sèvres was founded by the French crown in the early eighteenth century to uncover the secrets of Chinese porcelain — chemical analysis and technical experimentation were built into the manufactory's foundation. In such a context, it is unsurprising that chemistry and technical analysis were central pillars of Brongniart's project to re-establish the stained glass tradition in France.[6] However, the continual references to science in Brongniart's writings go beyond a practical account of the manufactory's use of chemistry and begin to articulate a modern vision for glass.

Throughout his public and private writings, Brongniart asserted that chemistry offered not a way back but rather a path forward for stained glass. In the published essay 'Essai sur les couleurs vitrifiables obtenues des oxydes métalliques et fixées par la fusion sur les différents corps vitreux' (Essay on vitrifiable colours obtained from metal oxides and fusible with various vitreous materials) (1801), he dismissed historical recipes as unworkable and lauded Sèvres's new analytical approach to developing vitreous materials.[7] He claimed not only that the art's past did *not* hold any secrets, but also that *only* the application of chemical laws could develop the materials necessary for modern practice. Indicatively, he writes in an 1825 letter to Louis-Étienne Héricart-Ferrand, vicomte de Thury (1776–1854), Director of Public Works: 'It is an undertaking worthy of the king to promote experiments [...] to re-establish an art, not lost but neglected; an art that advances in chemistry will gradually bring to perfection.'[8] In a pamphlet published in 1828, *Mémoire sur la peinture sur verre et sur son introduction dans la manufacture de porcelaine de Sèvres* (Report on glass painting and its introduction to the Sèvres porcelain manufactory), Brongniart lays out three types of glass painting, the second of which 'includes true glass painting, an art little known to the ancients, and elevated already to a high degree of perfection since the knowledge and expertise of modern

5 Hervé Cabezas, 'Les sept verrières anglaises commandées par le Comte de Chabrol pour deux églises de Paris (1825–1828) et leur influence sur la création française de vitraux', *Bulletin de la Société de l'histoire de l'art français*, 1998, 235–72.

6 A chemist, Louis-Rémy Robert (1810–1882), headed the stained glass studio beginning in 1838. The Sèvres Archives are filled with documents recording experiments to develop enamel colours and refine silver staining.

7 Alexandre Brongniart, 'Essai sur les couleurs vitrifiables obtenues des oxydes métalliques et fixées par la fusion sur les différents corps vitreux', *Journal des mines*, 12 (1801–02), 58–80 (p. 69); and Brongniart, *Mémoire sur la peinture sur verre et sur son introduction dans la manufacture de porcelaine de Sèvres* (Paris: Selligue, 1829).

8 'Il est digne de Roi de faire les essais [...] pour le rétablissement d'un art, non pas perdu mais négligé et que les progrès actuels de la chimie doivent successivement perfectionne.' Letter, 22 February 1825, Sèvres, Archives de la manufacture de Sèvres, PB 22, laisse 2, dossier 4. All translations from the French are the author's own.

chemistry has come to its aid'.[9] Linking Sèvres's scientific approach to a particular style of glass, he argued that modern chemistry obviated the medieval need for the mosaic-style assembly of small glass pieces.[10] Under his direction, Sèvres produced windows such as two panels now in the Louvre Museum, *Vitrail de la Renaissance* (1834–38) and *Vitrail illustrant le règne de Francois 1er* (1839–47), which employ large panes of glass covered in vitrifiable paint and make little attempt to align the contours of the designs with the leadlines. According to Brongniart, chemistry offered new artistic possibilities that allowed nineteenth-century stained glass to move beyond medieval precedent and towards a modern *vitrail tableau* style.

Two British manuals from the 1830s similarly refer to modern science as a means of leaving the medieval past behind. The British statistician, writer, and amateur economist G. R. Porter (1792–1852) published *A Treatise on the Progressive Improvement and Present State of the Manufacture of Porcelain and Glass* (1832) as part of the generalist Cabinet Cyclopædia series.[11] This exhaustive manual covers all the vitreous arts, including porcelain, glass-blowing, and the production of scientific glass instruments, and is unusual among early British glass manuals for its scientific perspective and language. Like Brongniart, whom he greatly admired, Porter asserted the dubious nature of historical recipes and the importance of modern chemical experimentation (p. 76). The manual notes the advances science has offered stained glass, in particular by developing different colours for staining and painting (p. 274). In his view, modern stained glass should capitalize on these innovations, and, though he did not make stained glass himself, he advocated that artists should prioritize painting over the lead-glass matrix:

> The method of staining and burning [...] on the surface of the glass having been found far more beautiful, admitting of greater variety of tints, as well as of those delicate shadings which were manifestly unattainable by even the most laborious composition in mosaic work. (p. 290)

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9 'La seconde classe renferme la véritable peinture sur verre, art à peine connu des anciens, et poussé déja à un haut degré de perfection depuis que les connaissances de la chimie moderne sont venues l'aider' (*Mémoire*, p. 14).

10 In a letter published in the *Constitutionnel*, Brongniart states, 'All the vitrifiable colours due to modern chemistry, such as blues of various tones, the greens produced from chromium, the red-browns, and above all the purples, violets, and pinks produced from gold, were totally unknown to [the ancients].' Alexandre Brongniart, 'Arts industriels, peinture sur verre', *Constitutionnel*, 25 October 1838, p. 8.

11 G. R. Porter, *Treatise on the Progressive Improvement and Present State of the Manufacture of Porcelain and Glass*, Cabinet Cyclopædia (London: Longman, 1832).

William Cooper (active 1831–50), a Scottish glass manufacturer and painter, similarly rejected the notion that stained glass was a lost art in his 1835 *Glazier's Manual*.[12] Referring to glass painting, he writes that the idea that such expertise had been lost

> is a very mistaken notion, for not only are the colours now employed as brilliant and durable as those of the ancients, but others have been added, which they most probably did not know how to produce, or at least did not use.[13]

Chemistry, once again freed from the need to redevelop old techniques, offered the opportunity to develop new ones: 'Modern ingenuity has superseded this clumsy expedient [of joining individual pieces with lead], and every colour used in painting can now be introduced into one entire sheet' (Cooper, p. 18). Like Brongniart and Porter, Cooper claimed that 'modern ingenuity' improved the art form, offering new artistic possibilities which he tried to realize through his own technical experimentation with glass staining and painting (Rush-Bambrough, pp. 89–122).

Such authors, then, evoked chemistry not as a tool of revival but of departure. Specifically, science offered stained glass a modern vitreous rainbow. Newly freed from its lead constraints, they insisted, the medium could now take advantage of the pictorial possibilities afforded by science.

Authors and scientists, on the other hand, who argued that modern stained glass should revive historical styles, presented chemistry as a means to reclaim the art's lost past. Claiming to discern a break between ancient and nineteenth-century glass, they offered science as the bridge across this rupture. The French author and architect Jean-Baptiste-Antoine Lassus (1807–1857), in his article 'Peinture sur verre' (1844), for example, noted the differences between ancient and modern glass, observing that the recent material was too homogeneous and transparent.[14] He suggested that technical investigation could help redevelop ancient procedures and materials. These experiments, in turn, would allow modern glass to reproduce medieval-style windows in which the lead and glass pieces were essential pictorial elements.

Michel Eugène Chevreul (1786–1889), a chemist and the director of dyes at the Manufacture nationale de Gobelins, similarly cast chemistry as

[12] Sally Rush presents an exhaustive account of William Cooper, illustrating his critical contributions as a glass painter. See Sally Rush-Bambrough, 'Glass Painting in Scotland, 1830–70' (unpublished doctoral thesis, University of Glasgow, 2001), pp. 89–122.
[13] William Cooper, *The Crown Glass Cutter and Glazier's Manual* (Edinburgh: Oliver & Boyd; London: Simpkin, Marshall, 1835), p. 99.
[14] Jean-Baptiste-Antoine Lassus, 'Peinture sur verre', *Annales archéologiques*, 1 (1844), 16–21 (pp. 19–20).

the means of returning to medieval glass forms. He attributed the beauty of Gothic windows to 'their simple design with delineated, discrete parts', and 'their assemblage of coloured parts […] which employs contrasting colours both among the glass pieces and between them and their opaque framing'.[15] Chemistry offered the means to recover these essential pictorial elements in the nineteenth century. In 1863 he published the results of his chemical analysis of ancient glass.[16] According to Chevreul, medieval windows maintained their superiority over nineteenth-century works because of the irregular thickness and chemical composition of ancient glass:

> The second fault [of modern glass] is chemical. It stems from the composition of ancient glass itself, which is not at all equivalent to a *colourless glass* with a *principal colourant* […]; ancient glass contains a great deal of intermediate iron oxide which colours it green, independently of oxides of cobalt, manganese, etc.[17]

To reclaim the brilliancy of ancient materials he argued that modern glass must be altered according to the results of chemical analyses (pp. 665–66). For Chevreul, chemistry offered a way to return to a lost material source, which, in turn, could be used to revive stained glass according to medieval models.

Chevreul's counterpart in Britain was the barrister and stained glass historian Charles Winston (1814–1864).[18] Winston similarly presented chemistry as the means by which modern glass could return to the lost model of medieval windows and their masterful use of transparent glass and lead. In his report on windows exhibited at the 1851 Great Exhibition, Winston

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[15] 'A ce qu'ils présentent un dessin très-simple […]' and 'A ce qu'ils offrent un ensemble de parties colorées, […] qui sont en même temps vivement contrastées, non-seulement entre elles, mais encore avec les parties opaques qui les circonscrivent.' Chevreul, *Mémoire sur l'influence que deux couleurs peuvent avoir l'une sur l'autre quand on les voit simultanément* (Paris: Académie des sciences, 1828), p. 56.

[16] M. E. Chevreul, 'Chimie appliquée aux beaux-arts: Mémoire sur les vitraux peints', *Comtes rendus hebdomadaires des séances de l'Académie des sciences*, 57 (1863), 655–66; 'Chimie appliquée aux beaux-arts: Appendice au Mémoire sur les vitraux peints et observations sur la diffusion de la matière', 682–85.

[17] 'Le second défaut est chimique. Il tient à la composition du verre ancient même, qui n'est point équivalente à du *verre incolore* plus un *principe colorant* […]; le verre ancien contient beaucoup d'oxyde de fer intermédiaire qui le colore en vert, indépendamment des oyxdes de cobalt, manganese, etc' (p. 665, emphases in original).

[18] For further discussion of Winston's contributions, see Sarah Brown, 'Charles Winston (1814–64) and Stained Glass Restoration in the 19th Century', *British Archaeological Association Conference Transactions*, 19 (1997), 107–17 ; and Stanley Shepherd, 'A. W. N. Pugin and the Making of Medieval-Type Glass', *Journal of Stained Glass*, 21 (1997), 1–10.

asserted that chemical analysis illustrated the critical differences between ancient and modern materials:

> We are strongly impressed […] that the difference in effect between such ancient and modern glass does not depend on the state of the surface, but on the composition of the material, and this opinion has been much strengthened by the result of some chemical experiments recently made.[19]

According to Winston, his chemist, Mr Medlock, planned to analyse a sequence of cobalt glass samples to produce 'a most valuable chain in the history of the manufacture'.[20] Here, chemistry becomes the writer of history, tracing the medium's lineage through the ages. This material history revealed, according to Winston, the 'non-identity of modern glass with ancient [samples]' (p. 181). Only chemical analysis had the power to restore the lost character of medieval glass and materially link modern glass once again to its forefathers. Winston cast chemistry as the tool that simultaneously revealed historical difference and overcame it.

Winston collaborated with the British glass manufacturers Powell & Sons, who crafted windows with samples produced by Winston and Medlock's chemical experiments.[21] The success of this scientifically achieved modern-medieval glass was noted, among others, by the British glass manufacturer Apsley Pellatt (1791–1863).[22] Citing Winston's achievements, Pellatt states in his account of the 1862 International Exhibition:

> If the colours in these windows equal the best of the ancient, of which there is little doubt, it is owing to the various specimens he caused to be analysed, and the synthetic experiments he

[19] [Charles Winston], 'Glass Painting', in *Reports by the Juries on the Subjects in the Thirty Classes into which the Exhibition was Divided* (London: Clowes, 1852), pp. 533–35 (p. 535).

[20] Charles Winston, 'On a Revived Manufacture of Coloured Glass Used in Ancient Windows', in *Memoirs Illustrative of the Art of Glass-Painting* (London: Murray, 1865), pp. 175–85 (p. 183) (first read at the Ordinary Meeting of the Royal Institute of British Architects, 14 June 1852).

[21] Winston was not alone in his efforts. A. W. N. Pugin (1812–1852) and John Hardman (1812–1867) worked with James Hartley (1810–1886) in the late 1840s and 50s to analyse and reproduce medieval ruby and white glass; while William Edward Chance (1842–1923) with the assistance of Georges Bontemps and George Wood (active 1870–80) began to produce consistent ruby glass in the 1870s. See Stanley A. Shepherd, *The Stained Glass of A. W. N. Pugin* (Reading: Spire, 2009); and Tony Benyon, 'The Development of Antique and Other Glasses Used in 19th- and 20th-Century Stained Glass', *Journal of Stained Glass*, 29 (2005), 184–98.

[22] Pellatt's account reflects an intimate knowledge of glass manufacturing and the chemistry involved. See Apsley Pellatt, 'Class XXXIV: Glass', in *Reports by the Juries on the Subjects in the Thirty-Six Classes into which the Exhibition was Divided* (London: Spicer, 1863), pp. 1–8.

> made, which enabled him to reproduce the glass, and furnish the recipes gratuitously to the glass-maker. (p. 2)

Pellatt maintained that such experiments gave British glass a stronger material connection to its past than that produced elsewhere in Europe. The chemically achieved 'true-identity' of modern British glass and its medieval ancestors, as Winston might phrase it, forms the basis of Pellatt's claim that Britain had greater authority in the revivalist movement sweeping Europe. As a tool of revival, chemistry thus also fed into revivalism's nationalistic undercurrents.

Artists, scientists, and critics used chemistry, then, to imagine modern stained glass as an art that could look either forwards or backwards. They cast chemistry simultaneously as the modern marvel which distanced the medium's new incarnation from its past, projecting it into an artistic future, or, alternatively, as an analytical bridge that could reach back in time and link current production to its medieval heritage. Accounts of chemistry's role in the revival must consider not only its technical use but also this discursive function, which constructed conflicting relationships between the medium and its past.

Diverging paths

Having established that chemistry not only technically facilitated the revival of stained glass, but also helped to imagine the form this revived art should take, this next section delineates how the medium's relationship to chemistry fared differently on either side of the Channel as the century progressed. An analysis of practical manuals and critical accounts suggests that chemistry's role was increasingly sidelined in France but embraced in Britain. Although there is not space to present a fully worked-out explanation here, we might briefly relate these diverging approaches to the different contexts surrounding stained glass on either side of the Channel: French long-standing discomfort with the relationship between industry and the fine arts, in which stained glass occupied a precarious position throughout the nineteenth century; and, alternatively, British national pride in their industrial advancements in the glass arts and their eventual acceptance of stained glass into the 'Fine Arts' category.[23] It is hoped that sketching the broad contours of these developments based on the consulted source base

[23] For a broader discussion of the dynamics between art and industry, see Jasmine Allen, *Windows for the World: Nineteenth-Century Stained Glass and the International Exhibitions, 1851–1900* (Manchester: Manchester University Press, 2018), pp. 22–37, and in particular, p. 25; and Patricia Mainardi, *Art and Politics of the Second Empire: The Universal Expositions of 1855 and 1867* (New Haven: Yale University Press, 1987), p. 42.

— much of which is technical and largely untapped — may offer signposts for future research.

An analysis of three editions of the French stained glass manual *Nouveau manuel complet de la peinture sur verre, sur porcelaine et sur émail* provides a useful overview of how chemistry's role in technical descriptions evolved in France. The three editions appeared in 1844, 1866, and 1883 as part of the encyclopedic Roret series, which covered everything from the painting of buildings to the production of mustard. While the *Nouveau manuel* was intended for a broad audience, the three editions were evidently used by practitioners and were commonly found in stained glass studios.[24] Their changing language and organization offer insight into the general perception of the métier, as well as the expertise and background expected of the stained glass artist.

The 1844 edition demonstrates chemistry's centrality to stained glass in the early days of the French revival. It was written by the little-known chemist M.-E.-F. Reboulleau (active 1839–47) who helped produce the first *vitrail archéologique* in France. For Reboulleau, chemistry ensured the art's revitalization: 'The immense conquests that chemistry has made in the last fifty years promises assured success for this work. Contemporary glass painting is almost entirely a modern creation.'[25] The 1844 edition's organization and language reflect the degree to which chemistry structured Reboulleau's approach to the medium. The first chapter, 'The Nature and Composition of Enamels', presents an in-depth discussion of the chemistry of glass-painting materials, while descriptions of techniques for painting and firing glass do not appear until the second half of the text. The reader thus passes through chemical explanations to reach practical instruction — an understanding of chemistry precedes physical practice. The most striking integration of chemistry is perhaps in the manual's recipes, which describe enamels not by parts-per-weight of components, but rather by the number of atoms of each constituent element (pp. 62–86). This confusing system is followed by a section titled 'Atomic Calculus of Enamels', which demonstrates how to convert enamel recipes in parts-per-weight into atoms and to determine enamel recipes directly from elemental combinations. Reboulleau thoughtfully provides six pages of tables for *easy* conversion between atoms and parts-per-weight for each substance. He believed his readers would generate new enamel recipes from their chemical formulae. The 1844 text casts stained glass as a distinctly modern medium built on

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[24] Michel Hérold, 'Les Manuels de vitriers et de peintres sur verre (1828–1843), ou Le Bibliothèque de Bouvard et Pécuchet', in *Le Vitrail et les traités du Moyen Âge à nos jours*, ed. by Karine Boulanger and Michel Hérold (Berne: Lang, 2008), pp. 243–57.

[25] 'D'ailleurs, les immenses conquètes que la chimie a faites depuis cinquante ans, promettaient à ce travail un succès plus assuré. La peinture sur verre d'aujourd'hui est donc presque entiérement de création moderne.' M.-E.-F. Reboulleau, *Nouveau manuel complet de la peinture sur verre* (Paris: Roret, 1844), p. 13.

relatively recently established chemical principles and suggests that the practitioner of this art was expected to be fully fluent in contemporary chemical terminology.

Twenty-two years later, the second edition shifts away from the technical language of chemistry.[26] The manual was revised by M.-Désiré Magnier (active 1860s), a graduate of the Parisian École polytechnique who worked on several of the Roret publications. Much of the content remained the same, but Magnier removed most of the references to chemistry from the main text. The atomic calculus for enamels, for example, is eliminated, and recipes are now provided only in parts-by-weight. Thanks to these changes, using the recipes no longer required chemical conversions but simply some measuring. Magnier also added a new section at the end of the book, which included the chapter, 'The Chemistry of Vitrifiable Colours'. This chapter, which absorbs some of the first edition's instructions for producing basic materials, begins with a rudimentary discussion of chemical symbols, equivalents, and formulae:

> To facilitate an understanding of the following material for those who are unfamiliar with chemistry, we must begin by explaining the meaning of certain letters and numbers, which will be referred to, and which otherwise would only be hieroglyphs for the uninitiated.[27]

The second edition thus not only removed chemistry from the main body of the manual but also assumed a reader whose interest in the science was an addendum to his practice of the art.[28]

The 1883 edition, rather than further editing out chemistry, simply ignores scientific content. The latest editor, Adolphe Romain (b.1843), another student of the École polytechnique (and workhorse of the Roret series), updated the descriptions of stained glass techniques, but left the content of 'The Chemistry of Vitrifiable Colours' unchanged.[29] For

[26] M.-D. Magnier and M.-E.-F. Reboulleau, *Nouveau manuel complet de la peinture sur verre* (Paris: Roret, 1866).

[27] 'Pour faciliter aux personnes étrangères à la chimie l'intelligence de ce qui va suivre, nous devons commencer par expliquer la signification de certaines lettres et de certaines chiffres, dont il sera fait usage et qui, sans cela, ne seraient pour elles que des hiéroglyphes dépourvus de sens' (Magnier and Reboulleau, pp. 326–27).

[28] While there is not enough space in this article to consider Georges Bontemps's *Guide du verrier*, it presents a tipping point between the chemical and artisanal and illustrates stained glass's liminal position in the middle of the century. The text is split between two audiences: the first section is directed towards the chemically informed reader, while the second adopts more practical language. Bontemps, *Guide du verrier* (Paris: Librarie du dictionnaire des arts et manufactures, 1868).

[29] Adolphe Romain, M.-D. Magnier, and M.-E.-F. Reboulleau, *Nouveau manuel complet de la peinture sur verre* (Paris: Roret, 1883).

example, the 'Table of Chemical Equivalents', introduced in the 1866 edition, remains the same, including the footnote about the number of known elements. This failure to revise the table stands out because there were, in fact, a number of elements discovered between 1866 and 1883. One might also note the glaring failure to update the formula for water in the description of hydrates, which is still written 'HO' (rather than H_2O). Either Romain did not know the actual formula, which was well established by this time (this is unlikely as he graduated from France's premier engineering school), or it was simply not an important enough error to correct. The trajectory of the three manuals suggests that knowledge of chemistry had gone from being a significant aspect of practising the art of stained glass to a peripheral, and almost obsolete, appendix.

A critical account of stained glass written in the late nineteenth century suggests that there was an explicit effort to sever the medium's links to chemistry in France. In his review of the 1889 Exposition universelle, Édouard Didron (1836–1902), stained glass artist and critic, disavowed the importance of science in the art's revival, claiming that the 'true' revival of stained glass was the result not of chemistry but of archaeology. To this end, he rewrote the history of the revival. First, Didron associated chemistry with Sèvres's stained glass and research on enamels. He suggested that Sèvres's reliance on chemistry unduly pushed stained glass towards the pictorial mode in the early days of the revival: 'In the hands of the chemists, uninitiated in questions of art, glass painting could only offer bad results. They distorted public taste by completely transforming glass into painting.'[30] Introducing the term '*peintre-chimiste*', Didron links chemistry explicitly with stained glass that resembles oil painting, a style to which he firmly objects:

> Nevertheless, their writings and the protection awarded to the chemist-painter in the first years of the nineteenth century had the beneficial result of restoring the forgotten art to favour. This advantageous reaction could not slow [the effort] to restore to stained glass the conditions central to its decorative function and the elements essential to its proper nature.[31]

[30] 'Entre les mains [...] de chimistes assez étrangers aux questions d'art, la peinture sur verre ne pouvait donner que de mauvais résultats. On faussait le goût public en assimilant d'une manière complète le vitrail au tableau.' Édouard Didron, 'Le Vitrail depuis cent ans et à l'exposition de 1889', *Revue des arts décoratifs*, 10 (1889), 39–48, 97–108, 137–54 (p. 46).

[31] 'Néanmoins, leurs écrits et la protection accordée aux peintres-chimistes des premières années du XIX^e siècle eurent ce bon résultat de remettre en faveur un art oublié. Une réaction salutaire ne pouvait tarder qui rendrait au vitrail les conditions indispensables à sa fonction décorative et les éléments essentiels de la physionomie qui lui est propre' (p. 47).

While Didron acknowledges that the *peintre-chimiste* had done important early work recovering stained glass techniques, the chemist's continued involvement would only hinder the future development of the art form.

Next, Didron distanced the revival's later productions from the scientific community. His account of the development of stained glass between 1847 and 1889 excludes any further mention of chemistry, even when chemists were actively and prominently involved in the projects he describes.[32] Didron instead claimed that after chemists' initial efforts during the Empire and Restoration, in the second half of the century, *peintres-verriers* restored the aesthetic potential of the art through their archaeological perspective. Steeped in medieval models, *peintres-verriers* recognized the 'primordial laws' of stained glass, adopting leadlines and glass pieces as primary pictorial elements. Didron thereby not only associated chemistry with the *vitrail-tableau* style, but also dissociated it from mosaic-style glass. By limiting chemistry's involvement to the first half of the century and the *vitrail-tableau* style, he attempted to confine chemistry's participation to a very specific, and early, moment in the revival. While there is not space to expand on the point, we might briefly conjecture that Didron's attempt to distance stained glass from chemistry in 1889 was related to his desire to elevate stained glass to the status of a fine art and downplay any 'taint' of industry (Allen, *Windows*, pp. 22–24).

By the end of the century, while chemists were certainly still active in French stained glass production, particularly in larger studios, their role in the discourse had been diminished. Rather than being openly acknowledged, as it was at the beginning of the revival, the involvement of chemistry was now suppressed, whether by removing it from practical instruction manuals or accounts of the recent history of the art.

On the other side of the Channel, by contrast, British manuals downplayed chemistry's importance for stained glass in the first part of the century. *The Decorative Painters' and Glaziers' Guide* (1828) by Nathaniel Whittock (1791–1860) is an example of an early instructional manual which demonstrates that British practitioners were not expected to have a knowledge of chemistry. While we might consider the text's lack of chemistry to be a result of Whittock's own background, which was neither in stained glass nor chemistry but rather in writing instructional books covering various trades for the layperson, the book is explicit about its aim that stained glass could be practised without any training in chemistry. The introduction dismisses the need for any such education:

[32] In his description of the 1847 restoration of the Sainte-Chapelle, for example, Didron does not acknowledge that the president of the commission, Chevreul, was a chemist, though he had carefully noted Brongniart's and Georges Bontemps's scientific professions earlier.

> It was deemed a sufficient reason for publishing a complete compendium of information on the Art of Staining Glass, in a plain, practical, and familiar style, so that the workman, whose mind and time have been too much occupied by his business to attain a knowledge of even the terms used in chemistry and experimental philosophy, may yet understand the true and least expensive method of performing many of the highest chemical experiments in dissolving and precipitating metals for the purpose of producing colours for staining glass.[33]

He continues, 'It is for this reason that all scientific or technical terms that might by possibility be misunderstood by the reader, have been sedulously avoided' (p. iv). Whittock treats chemistry as a useful but external aspect of stained glass and, instead, encourages hands-on practice and embraces non-technical language for the general practitioner.

Echoes of this tendency to keep chemistry at arm's length in descriptions of the art continue into the middle of the century. For example, the language employed in Cooper's *Crown Glass Cutter and Glazier's Manual* (1835), which was directed at glaziers, illustrates that those who pursued the art form were still not expected to have a scientific background (pp. ix–x). As Sally Rush has illustrated, Cooper was intimately familiar with both the mechanics and chemistry of glass and employed his technical background to great effect in the perfection of glass staining. However, his manual assiduously avoids chemical descriptions and uses non-technical language to describe both processes and materials. Similarly, William T. Gillinder (1823–1871), who was a successful British-American glass manufacturer and published *Treatise on the Art of Glass Making* in 1851, anticipated a reader without a background in chemistry. He provides recipes in weight percentages and his sparse efforts to break compositions down into their component parts are unusable. For example, his descriptions of baryta or heavy spar, 'Similar to Lime in all its leading properties. Its composition is — Sulphuric Acid, 40; Baryta 78; total 118', provide no units to clarify the numbers' meaning. Nor do these numbers describe actual chemical compositions based on atomic number or atomic weight.[34] As a glass manufacturer, Gillinder was very likely familiar with basic chemistry and his dubious chemical descriptions are thus particularly odd. He makes no attempt to ground his descriptions in a scientific framework and proceeds as if factual chemical knowledge is unnecessary for his reader. The two manuals reflect an enduring ambivalence to chemistry's role in the practice of stained glass in the first part of the century.

[33] Nathaniel Whittock, *The Decorative Painters' and Glaziers' Guide* (London: Hinton, 1828), pp. iii–iv.
[34] William Gillinder, *Treatise on the Art of Glass Making* (Birmingham: Gillinder, 1851), p. 22.

However, in the 1850s, while chemistry remained relatively marginal to British stained glass manuals compared to French examples, it also began to appear regularly elsewhere in British stained glass discourse. As noted in the first half of this article, Winston, who commissioned chemical analysis of ancient glass, cast the revitalization of stained glass as an entirely scientific process:

> For the operation was a regular chemical one from beginning to end, requiring pure chemical knowledge, and a great deal of it too, to carry it out; and a branch of chemistry, by the bye, on which comparatively little is known.[35]

His assertion of chemistry's participation in the revival presents a shift in British accounts of stained glass, which began to discuss more generally chemistry's importance. For example, Charles Tomlinson (1808–1897), a compiler of scientific encyclopedias and no glass practitioner, published an article in 1857 on the state of vitreous painting in England. He argued that glass painters should be either better informed about chemistry or work more closely with chemists: 'The chief reason why those branches of Art which depend so much for their success on chemical operations are beset with so many difficulties, is that the artists are not chemists.' He continues: 'Our object in writing this article [is] to insist on the important truth, that the difficulties which beset the art of painting in vitrifiable colours are chiefly due to the absence of chemical knowledge.'[36] Tomlinson's descriptions of the art recall Reboulleau's and Brongniart's language from earlier French texts.

By the end of the century, chemistry had become a lauded and embraced aspect of British glass practice. Three glassmakers, Harry James Powell (1853–1922), Henry Chance (1794–1876), and Henry Graham Harris (dates unknown) published *Principles of Glass-Making* (1883) as part of the Technological Handbooks series produced by the Society of Arts, which was intended to prepare students for technical examination. Powell's introduction echoes language from the beginning of the revival in France, in particular from Brongniart's writings:

> A practical knowledge of the manufacture of glass is generally acquired through apprenticeship, and the study of hereditary recipes. There is danger that the proficiency, which may be thus attained, will be based on a groundwork of 'rule of thumb' rather than of science. The want has often been felt of a work illustrating the present condition of the manufacture,

35 *Memoirs*, p. 11, from a letter dated 20 April 1856.
36 Charles Tomlinson, 'On Enamel-Painting', *Art Journal*, 19 (1857), 120–21, 219–20, 375–76 (p. 375).

> and at the same time defining the principles upon which experience has proved the several processes to be based.[37]

The manual soundly rejects the ‘rule of thumb’ and embraces a scientific framework as a central facet of the art. It presents in-depth chemical analyses of glass and accurate chemical formulae for materials, as well as a description of the chemical differences between ancient and modern coloured glass. In particular, the section on ‘glass mosaic or stained and painted glass’ weaves together art and science, moving among the chemical composition of fusible glass for enamels, aesthetic judgements on different window styles, and a discussion of the historical development of stained glass taken from Winston (Powell, Chance, and Harris, pp. 90–100). The comparison between *Principles* and the third edition of the *Nouveau manuel*, both published in 1883, is striking. While the French text tacked on out-of-date chemistry, the British guide fully integrated the latest chemical analysis into its discussion of the art. Indeed, in its approach to scientific content, *Principles* is closer to Reboulleau’s 1844 edition of the *Nouveau manuel*. By the end of the century, France and Britain had switched positions: French discourse detached chemistry from the art, while British accounts embraced science and indeed various technological developments which aided the stained glass industry.

Looking forward

By way of conclusion, I suggest that chemistry’s various paths through stained glass discourse might direct our attention to a facet of such accounts that anticipates current art historical interest in materiality. While in both Britain and France stained glass that rejected the pictorialism of oil painting was directly associated with medieval models, British advocates of this style appealed not only to archaeology but also to materiality.[38] Winston, for example, claimed that the distinct qualities of stained glass’s past materials, in particular ancient coloured glass, had historically determined its

37 Harry James Powell, Henry Chance, and H. G. Harris, *The Principles of Glass-Making* (London: Bell, 1883), p. 1.

38 While French writers such as Eugène Viollet-le-Duc had raised the importance of considering stained glass’s materiality, building on the earlier writings of Pugin and John Ruskin, British authors and artists focused increasingly on this issue in the latter part of the century. Francis Wilson Oliphant focuses, for example, explicitly on the material conditions of the art in his writings from the 1850s. See Eugène Viollet-le-Duc, ‘Vitrail’, in *Dictionnaire raisonné de l’architecture fran*çaise *du XI*[e] *au XVI*[e] *siècle*, 9 vols (Paris: Bance-Morel, 1854–68), IX (1868), 373–462; John Ruskin, *The Stones of Venice*, 3 vols (New York: National Library Association, 2009), II, 394–97; Francis Oliphant, ‘Thoughts on Stained Glass’, *Ecclesiologist*, n.s., 12 (1854), 33–36, and Oliphant, *A Plea for Stained Glass* (Oxford: Parker, 1855), pp. 41–42, 67.

design and produced particular styles.[39] He thereby concluded that modern windows, if they wished to be archaeological, should only emulate sixteenth-century examples, as the glass available was closest to that of this period. His appeal to return to previous styles, was, in fact, a call to restore the link between materiality and form. His use of chemistry to resurrect ancient glass offered not only the opportunity to reproduce medieval models, but also, and more importantly, the possibility to return to a medieval approach to design which embraced the art's material constraints: 'The material employed imposes upon the artist an obedience to certain conditions in the design and execution of the work.'[40] He encouraged British artists to produce new windows grounded in the 'brilliancy and transparency' of the glass and the structural supports of the lead. Severing mosaic design from the repetition of medieval motifs, Winston presented materiality as the defining design principle of modern glass. In turn, chemistry formed the technical basis of Winston's concern for stained glass's material qualities and provided a critical tool for further understanding and refining these materials. The shift from archaeology to materiality, which seems to have been a broad one in Britain, I would suggest, offered an opening to chemistry. Science became ever more embedded in the study and practice of stained glass as the British focus on the art's material qualities grew in the second half of the century.[41]

Grounding an art form's aesthetics in its specific material conditions is a remarkably modern position. Indeed, Winston's discourse anticipates recent art historical discussions of materiality and theoretical approaches such as 'new materialisms', which foreground the material qualities and histories of artworks.[42] One might explore in future research how current efforts to integrate the material nature of artworks into art historical

[39] [Winston], 'Glass Painting', p. 534. He reiterates this argument in *Memoirs*, p. 178.
[40] 'Glass Painting', pp. 531, 533. He also advocated that 'the surest means of effecting the true advancement of the art [is] the total relinquishment of all copies or imitations of ancient glass whatsoever, whether perfect or imperfect in themselves; and the substitution of a new and original style of glass painting, founded on the most perfect practice of the *Mosaic system*, and sufficiently comprehensive to include within itself designs of the most varied character'. Winston, *An Inquiry into the Difference of Style Observable in Ancient Glass Paintings*, 2 vols (Oxford: Parker, 1847), I, 284, emphasis in original.
[41] Stained glass's material construction was a central concern for the later Arts and Crafts Movement, as exemplified by the writings of William Morris, Christopher Whitworth Hall, and Somers Clarke. See Christopher Whitworth Hall, *Stained Glass Work* (New York: Appleton, 1905); and Somers Clarke, 'Stained Glass', in *Arts and Crafts Essays by Members of the Arts and Crafts Exhibition Society* (London: Rivington, Percival, 1893), pp. 98–105.
[42] See Diana Coole and Samantha Frost, 'Introducing the New Materialisms', in *New Materialisms: Ontology, Agency, and Politics*, ed. by Diana Coole and Samantha Frost (Durham, NC: Duke University Press, 2010), pp. 1–43.

analysis might look to this earlier moment as an example. Winston was, of course, not the sole writer to elevate the material conditions of stained glass, but his writings exemplify how extensively chemistry participated in this discourse. His case demonstrates that widening one's understanding of the role of chemistry in nineteenth-century stained glass beyond its technical function not only reveals the manner in which the revival employed science to mediate its relationship to tradition, but also illuminates the essential modernity of the revived art.