15 The Scientist’s Social Network: Reimagining Crystallographic Diagrams Ahead of the 1951 Festival Pattern Group Collaboration

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In 1951, just six years after the end of the Second World War, the national exhibition, the Festival of Britain, opened across the United Kingdom. Its epicenter was on London’s South Bank, where futuristic constructions such as the flying-saucer-shaped Dome of Discovery accompanied exhibitions celebrating British achievements in industry, the arts, and science. At the time of its launch, the country was still recovering from World War II, and the Festival set out to raise the spirits of the British populace and jumpstart the postwar economy. Today, the Festival looms large in the historical memory of British design in the period as future-facing: embodying qualities of the “contemporary” or “Festival” style—which is associated with color and light contours and reflecting aspects of contemporary science. One project in particular has come to symbolize, and is perhaps partly responsible for, this last point: the Festival Pattern Group (FPG) project for the Festival. The FPG was a discipline-boundary-crossing venture that brought together collaborators from industrial design and the science of X-ray crystallography to produce pattern designs derived from the atomic and molecular structures of the physical world.

The FPG, which was organized by the quasi-governmental body the Council of Industrial Design (CoID), was an ambitious effort bringing together twenty-eight manufacturers from industries ranging from glass to textiles to wallpaper. They worked with a scientific consultant, the crystallographer Helen Megaw, who had originally proposed the idea to translate crystal structures into pattern design, and who provided crystallography diagrams to the FPG manufacturer’s designers. The group produced prototypes for dozens of pattern designs derived from diagrams emanating from X-ray crystallography, including dress fabric printed with a pattern based on a crystallographer’s diagram of the structure of the protein methaemoglobin, and a wallpaper pattern based on the structure of boric acid (Figs. 15.1 and 15.2). These crystallography-derived designs were on show throughout the 1951 Festival. They were incorporated, for instance, into the design of some science exhibits. Their true home, however, was the Regatta Restaurant on London’s South Bank. There, the carpets, curtains, cutlery, and even waitresses’ collars bore patterns based on

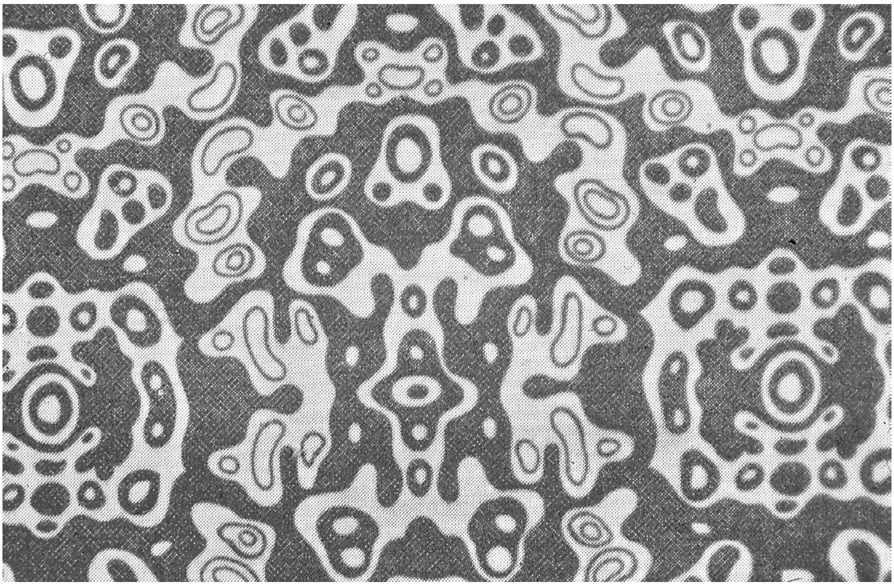

Fig. 15.1 Printed dress fabric with pattern based on an X-ray crystallography diagram of horse methaemoglobin, produced as part of the Festival Pattern Group project. Designed by S. M. Slade for British Celanese Ltd., 1949–1951. © The Design Council Slide Collection at Manchester Metropolitan University Special Collections.

the sub-microscopic structures of substancessfrom minerals to biological mattermstudied at the time by X-ray crystallographers (Fig. 15.3).

Despite its debut at such a high-profile event, however, the FPG was a short-lived endeavor. Most of the group's prototypes were never commercially produced, so they did not ultimately contribute to the Festival's economic goals, and they are unlikely to have had a wide-ranging influence on design at the time.[1] But the story of the FPG, particularly of how the project was catalyzed, illuminates a topic that has seen little in-depth research: how postwar British industrial design cultures engaged with science. In doing so, it presents an opportunity to hone approaches for generating richer understandings of interactions between design and science disciplines, both in the past and the present.

On the surface, the FPG can look like a neat interdisciplinary union one that is in keeping with the historical memory of a generalized modernist interest in science in the design culture of postwar Britain. Several British designers in the period, such as textile designer Lucienne Day, deployed natural or quasi-scientific forms. And in the US, which might inflect the popular memory of British design, several now-iconic objects designed in the period reflect so-called atomic or molecular forms—including George Nelson's "Ball Clock" and Ray and Charles Eames's wire "Hang-it-all" wall-mounted hooks with spherical finials. But to explain postwar design through recourse to science as an element of 1950s "period style" can yield an incomplete or even misleading historical

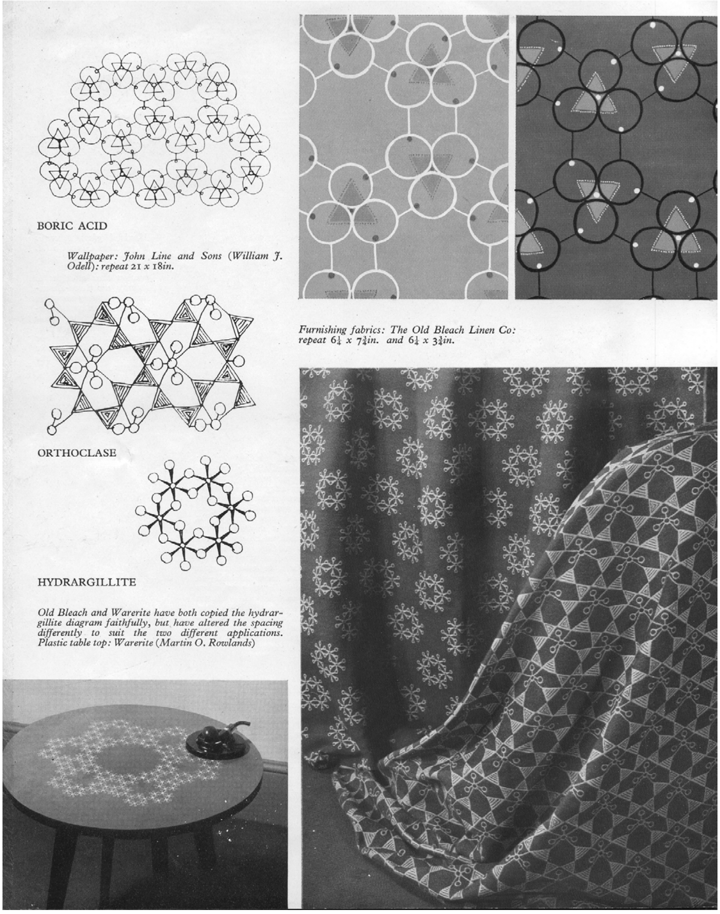

Fig. 15.2 Images of FPG textiles, wallpaper, and plastic laminate, alongside reproductions of crystal structure diagram drawings provided to the group's designers by Dr. Helen Megaw. Mark Hartland Thomas, The Souvenir Book of Crystal Designs (London: Council of Industrial Design, 1951), 9 © Design Council Archive by permission of the University of Brighton Design Archives.

narrative. Such an imagination of the past pictures the history of design as a progression of styles aligned with particular eras, while excluding consideration of numerous social, material, political, cultural and other historical contingencies. This approach fails to illuminate questions about how the "science" got into "design," and why designers might have been interested in contemporaneous developments in scientific fields in the first place. But, the notion of period style sets the tone for many historical accounts of postwar British science-inflected industrial design, such as the so-called atomic furnishings bearing wire forms and ball-feet or finials produced in the period.

A more nuanced picture of exchange between design and science fields emerges upon close examination of the cross-disciplinary dialogues that took place in the time

ABOVE: *The interior of the Regatta Restaurant, South Bank. Here can be seen the general effect of some of the materials and designs used in combination*

BELOW: *Settees upholstered in PVC coated fabric. Imperial Chemical Industries Ltd, Leathercloth Division (Fabric designer: C. Garnier). At the Exhibition of Science, South Kensington*

MEMBERS OF
THE FESTIVAL PATTERN GROUP

Barlow & Jones Ltd
E. Brain & Co Ltd
British Celanese Ltd
Carter & Co Ltd
Chance Bros Ltd
Dobroyd Ltd
Dunlop Rubber Co Ltd
Elkington & Co Ltd
General Electric Co Ltd
A. C. Gill Ltd
Goodearl Bros Ltd
C. A. Harvey & Co (London) Ltd
Imperial Chemical Industries Ltd
(Leathercloth Division)
Arnold Lever (London) Ltd
John Line & Sons Ltd
London Typographical Designers Ltd
Old Bleach Linen Co Ltd
R.H. & S.L. Plant Ltd
Spicers Ltd
Stevens & Williams Ltd
James Templeton & Co Ltd
Vanners & Fennell Bros Ltd
Vernons Industries Ltd
Warerite Ltd
Warner & Sons Ltd
Josiah Wedgwood & Sons Ltd
Wood Bros Glass Co Ltd
A linoleum manufacturing company
Addresses of members may be had upon application to Mr Hartland Thomas, at the Council of Industrial Design.

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Fig. 15.3 Photographs of the interior of the Regatta restaurant and Exhibition of Science at the 1951 Festival of Britain featured in Mark Hartland Thomas, The Souvenir Book of Crystal Designs (London: Council of Industrial Design, 1951), 16 © Design Council Archive by permission of the University of Brighton Design Archives.

leading up to the FPG's formation. A detailed, critical view of interdisciplinary relationships can be generated through looking at networks of practitioners and the ideas, objects, and images that moved among them. Network models, which have their roots in the sociology of science, can aid research on cross-field collaboration because they are based on the idea that institutions and objects are constituted by and embedded in the circulation of ideas, people, practices, and things. This chapter looks at the cross-disciplinary exchange leading up to the FPG collaboration through the lens of networks (in this case, zeroing in on what were literally social and professional networks). Although this historical account does not adopt a sociology of science methodology, such as actor-network-theory, it draws upon an approach to descriptions of entities or events as, in sociologist John Law's words, "heterogeneous set of bits and pieces each with its own inclinations" (Law 1992: 386). As Glenn Adamson, Giorgio Riello, and Sarah Teasley write, from the perspective of design history, network models can illuminate "how knowledge (of any form, from a decorative pattern or method of weaving to an industrial technique or piece of proprietary software) is transmitted across cultures" (Teasley, Riello, and Adamson, 2011: 4). Where historical relationships between science and design are concerned, such an approach allows researchers to push beyond the identification of parallels between the production of two fields to more complex empirical understandings of the transmission and translations of knowledge between them. Relationships between fields are not only about finding common ground; they are also about networks of people, institutions, ideas, and objects, and how their differing backgrounds and inclinations shape their encounters.

This history of the FPG explores the project's germination within boundary-crossing constellations of figures from science, architecture, design, and art circles, and the varied interests and aesthetic ideologies that guided their cross-disciplinary exchange.[2] It traces the circulation of Helen Megaw's proposal for a crystallography-inspired pattern design project and accompanying diagrams (which eventually spurred the FPG's establishment) within postwar design networks in the late 1940s. It pushes past the notion of a generalized interest in science among postwar designers in the period (after all, not all designers were keen to engage with science). I focus on the conditions of the interactions between people and diagrams at the center of the story, and the aesthetic, ideological, and even institutional impetuses of those who gravitated to Megaw's diagrams and her proposal for a project uniting crystallography and design.

In this story, the crystallographic diagram acts as a "trading zone," that is, as a catalyst and meeting place for cross-cultural exchange (Long 2011: 8). It is a meeting place where we do not always see the clear connections or shared ideas that might be expected when it comes to the topic of relationships between science and another field. Practitioners from science and design involved in the exchanges leading up to the FPG's collaboration did not necessarily gravitate toward the prospect of crystallography diagrams as a basis for pattern designs for the same reasons. Each person in the network highlighted below, including Helen Megaw herself, saw the crystallographer's diagrams through his or her own frame of reference. The emphasis here is not on shared ideas and ambitions across disciplines, but on the different ideas—animated largely by the formal qualities of the crystallographer's diagram—that drove engagement with science by those in the design field. Therefore, rather than focusing on the FPG's prototypes themselves, which have been written about elsewhere (Jackson 2008; McGill 2007; Schoeser 2001), I explore the dynamics of both overlapping and divergent interests of people from different fields in the period preceding the FPG's interdisciplinary collaboration. In tracing Megaw's proposal's reception across design networks, it is necessary to touch on a number of events and areas of art and design practices in postwar Britain, several of which are subject areas that historians have studied in their own right. Rather than going into depth on the histories of each area, I create a slice across them, indicating ways in which they are interwoven. In the above ways, this account of the FPG's history reframes the story, centering on what historians, designers, and scientists who study or participate in relationships between design and science can learn from the FPG when it comes to reflecting critically on cross-field exchange.

Visualizing the Invisible

In the postwar period, Britain was a hotbed of cutting-edge research in X-ray crystallography, a technique which had been developed in the early 1910s. Although the study of crystals and their internal structures had existed long before the twentieth century, the application of X-rays to crystallography opened up dramatic new possibilities for deep investigations of matter at the smallest scale. Scientists working in the field in the postwar era elucidated the underlying structures of materials, including naturally occurring crystalline substances such as minerals, as well as synthetic polymers, and laboratory-grown crystals of organic materials, such as proteins like DNA. X-ray crystallography was used in physics, chemistry, and biology.

A crystal is made up of a regular arrangement of atoms that repeats in three dimensions. X-ray crystallography involves a set of specific techniques centered on directing X-rays through crystals, most commonly to generate data about the structures of their atoms. In the early- to mid-twentieth century, data about this scale of matter that could not be observed visually was generated by sending X-rays through a crystal, which diffract off the atoms inside, leaving a trace on a photographic plate. The resulting "diffraction photograph," usually a complex arrangement of dots and dashes, required much interpretation in order to visualize the atomic structure that had produced it. And because X-ray crystallographers were envisioning information about matter at scales that had not been visualized before, and certainly could not be *seen*, they developed a visual language to interpret and represent this new vision of nature, drawing in part upon existing conventions for representing chemical and crystal structures through diagrams and three-dimensional models. The diagrams at the heart of the FPG collaboration are artifacts of this visual language.

Born in Dublin in 1907, Helen Megaw practiced within a culture of X-ray crystallography that was defined, in part, by the techniques described above, in which hand-drawn diagrams and three-dimensional modeling were key parts of many research processes. She specialized in mineral structures, conducting research on ice early in her career (which resulted in an Antarctic Island, Megaw Island, being named after her). She went on to undertake innovative research on minerals with ferroelectric properties, which have applications in electronics, and on the structure of feldspar minerals (Glazer 2009). Megaw was one of several female X-ray crystallographers in the period—such as scientists Dorothy Hodgkin, Kathleen Lonsdale, and Rosalind Franklin—who were producing leading research that had resonance beyond the field. Although the number of women in crystallography was not high in absolute terms (Julian 1990), early- to mid-twentieth-century crystallography is remembered in part for its relative openness to women compared with other physical sciences at the time. This is often attributed to the progressive attitudes of gatekeepers, such as crystallographer and leftist activist J.D. Bernal, along with a culture of progressive politics in the field. Megaw had done her PhD at Cambridge with Bernal, and later joined his laboratory at Birkbeck College in London before moving to the Cavendish Laboratory in Cambridge in the late 1940s as their first female scientist (Crowther 1974). She has been less visible in histories of X-ray crystallography than her colleagues Hodgkin and Lonsdale, however, who have been the subjects of biographies. There is consequently room for historical research into Megaw's role in twentieth-century crystallography, which this account does little to fill, although, as I show below, aspects of her scientific practice play a role in the history of the FPG.

The Crystal-gazers of Postwar Art and Design

As Megaw's diagrams circulated among postwar design communities, they sparked cross-disciplinary dialogues. In the process, the meaning of Megaw's crystallographic diagrams shifted as they were inserted into new contexts, encountering actors in fields outside of her own. They began their journey through the design world in 1946, when Megaw contacted the London design consultancy, the Design Research Unit (DRU), with a proposal: "I should like to ask designers of wallpapers and fabrics to look at the patterns made available by X-ray crystallography," she wrote, enclosing several crystallographic diagrams and recommending that they be used as a basis for pattern design (Megaw 1946a). Although it is not clear exactly which diagrams Megaw sent to the DRU, her letter mentions that they included some structures she researched. Fig. 15.4, which shows the atomic structure of the mineral afwillite drawn later by Megaw for the FPG, suggests what the diagrams received by the DRU may have looked like.

Megaw's diagrams and accompanying message reached members of a specific social network that connected scientists, design figures, and artists who shared a set of overlapping political and aesthetic interests, and in which members of the DRU were deeply embedded. Although they ultimately did not pursue her idea to design patterns based on the representations generated by X-ray crystallographers, the DRU's circle was sympathetic to the overture from an X-ray crystallographer. Their responses to Megaw's proposal and diagrams indicate what the members of this design consultancy might have seen in the diagrams emanating from X-ray crystallographic research that arrived at their studio in 1946. Many designers outside the network weren't interested in science, let alone in the inscrutable (to the non-expert) diagrams of the underlying crystal structures of materials. The reception of these diagrams, therefore, illuminates the aesthetic and political frameworks that shaped approaches to science by this particular constellation of figures from postwar design and fine art cultures.

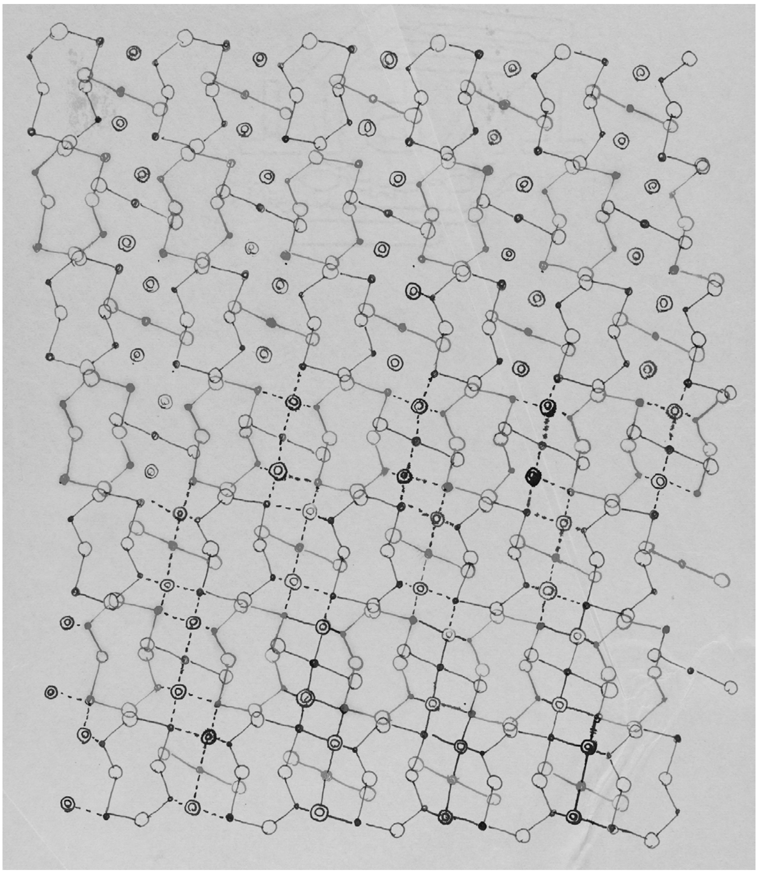

Fig. 15.4 Diagram of the mineral afwillite by Helen Megaw for the Festival Pattern Group, AAD 1977/3/429 © Colin Wilson, Estate of Helen Megaw / Victoria and Albert Museum, London.

Upon receiving Megaw's message and enclosed diagrams, the DRU's Marcus Brumwell was intrigued. "Your ideas about the beauty of shapes in nature is of course an absolutely first class one," he wrote, and set about making plans for her to discuss the proposal with the director of the DRU, Herbert Read (Brumwell 1946). When Megaw contacted the DRU, she had an inkling that they were open to dialogue with scientists. One of the DRU's founding aims was "to bring artists and designers into productive relation with scientists and technologists" (Cotton 2011: 29) in pursuit of their aims to reform and rebuild British industrial design after the war. And they had, in fact, originally contacted Megaw about working with them as a scientific consultant (at their friend Bernal's recommendation) before she sent them her proposal. Designer Misha Black, who would later play a role in the development of several FPG pattern designs as a designer of the Festival's Regatta restaurant, was a founding member of the DRU, along with the designer Milner Gray, and Brumwell, the head of an advertising agency. Its director, Read, was an art and design critic, poet, co-founder of the Institute of Contemporary Arts, and champion of British modernism.

The DRU's inclination toward current science reflects their sympathy with the sentiments of their friends from constructivist fine art practice at the time. The DRU members were bound through friendships and professional ties to a cross-disciplinary network of scientists, design figures, and artists that included Bernal and the "St Ives" circle of constructivist and abstract artists (so named because they had decamped to the Cornish coast from London during the war), which included Barbara Hepworth, Ben Nicholson, and Naum Gabo. Their associates in the St Ives circle positioned themselves within a British legacy of drawing upon nature in their work. But they also kept a keen eye on contemporary developments in science, harboring a fascination with new scientific practices of envisioning and understanding forms and patterns in nature beyond the visible. Writing in the 1944 book *This Changing World*, edited by Brumwell, Herbert Read proclaimed that "Science has taught us that underneath the shifting appearance of nature [. . .] there is a system of law" (Read 1945: 8). Scientific ideas animated the artists' own explorations of underlying "laws" of form. Many in the St Ives group were among the British avant-garde's enthusiastic readers of the biologist D'Arcy Wentworth Thompson's *On Growth and Form* (1917), a mathematical exploration of recurring morphologies across animate and inanimate nature.

For many in the circle linking the DRU and St Ives artists, interest in contemporary science went beyond the visual. It also extended to political concerns about the social role of science. They looked to contemporary scientific advances as a potential peaceful force, one that could help usher in an imagined social utopian future. As editor of *This Changing World*, Brumwell, a friend and supporter of the work of many St Ives constructivists, brought together contributors from a range of topics, including the sciences, to imagine their future shape in postwar Britain. He included an essay by Bernal (a member of the extended network described here who was a close friend of Brumwell's and Hepworth's), laying out the potential of science to contribute to the distribution of resources within a future socialist system: "the ends for which people are striving – food, work, security, and freedom – are gifts which science has put within reach of all" (Bernal 1945: 16). Members of this network, such as Hepworth, also expressed concerns about science's social role and the potential dangerous ramifications of the rapid development of scientific research that was estranged from other cultural realms. This issue hastened their intent to engage with science and scientists (Barlow 1996). As Barbara Hepworth wrote to her friend Margaret Gardiner, "the speed is out of proportion in the world of invention to the detriment of poetry and aesthetic vision ... I cannot see any hope of stopping this suicidal impulse unless Art & Science stand firm together" (Gardiner 1982: 28). A sense of the unbridled but "parallel" progress across science, the arts, and other areas underpins Brumwell's book as well (Brumwell 1945: 1). Within this circle, Megaw's proposal was appealing, because it forged an intersection and engagement between the work of contemporary scientists and the arts.

Visual qualities of crystallography diagrams also linked, on a symbolic level, to the socialist utopian political convictions of many associated with the St Ives circle. It is difficult to know exactly how deeply those in art and design fields who were active in this network engaged with scientific knowledge—and they certainly did not engage with crystallography as scientists would—but it is clear that Hepworth and Gabo, in particular, harbored an enthusiasm for crystal structure that was fed through their relationship with Bernal (Burstow 2014; Barlow 1996; Hammer and Lodder 1996). Art historian Robert Burstow writes about the reasons for their enthrallment to crystallography, arguing that geometric form, including that found in crystals, symbolized "order, precision, predictability, universality" for the constructivists, and thus the social utopian potential they saw in science (2014: 60).[3] Indeed, when Brumwell forwarded Megaw's diagrams and proposal to his friend Barbara Hepworth, she wholeheartedly encouraged what she called Megaw's "marvelous" idea ("why hasn't anybody thought of it before?," wrote the artist). Hepworth advised, "The main point seems to me to produce them [. . .] exactly as they really are. To me they are more beautiful than any man-made pattern" (Hepworth 1946). For Hepworth, the geometric structures found in Megaw's diagrams and proposal would have cut right to the heart of her explorations of form, but also to her political convictions and imagination for the future.

Whether it was crystallographic symbolism, the promise of uniting science and "art," or both, Brumwell perceived a resonance with the concerns of the constructivists in the patterns Megaw had drawn and sent to the DRU. He responded to her proposal by lending her his beloved copy of the 1937 book *Circle: International Survey of Constructive Art*, edited by Gabo, Nicholson, and the architect J.L. Martin. *Circle* articulates science's place in the ethos and ambitions of the constructivists, expressing both their enthusiasms and anxieties about contemporary trajectories of scientific research. Brumwell's interpretation of Megaw's proposal in light of the constructivist outlook on science is also revealed by his statement, in response to Megaw's proposal that, "The general idea is one which interests Herbert Read profoundly" (Brumwell 1946). Read shared with the circle of St Ives artists a preoccupation with natural forms—and with crystal structure and its associated symbolism for the St Ives constructivists. Read's novel *The Green Child*, for instance, has the protagonist travel to a subterranean utopian society in which crystals and "the science we call crystallography – the study of the forms, properties, and structure of crystals – was the most esteemed of all sciences," comprising the foundation for the civilization's very ideas of beauty and truth (Read 1935: 173). Megaw's proposal to import crystallographic forms into pattern design was aligned with Read's outlook. For him, the aesthetic frameworks of abstract art, associated with artists such as Hepworth and Gabo, extended to his vision for the future shape of industrial design—the area that Megaw's proposal for crystallographic wallpaper and textile patterns directly impinged upon. In his book *Art and Industry*, Read called for "new aesthetic standards for new methods of production" in industrial design derived from abstract artists' investigations of form (Read 1956: 9). Brumwell expressed his excitement to share

Megaw's ideas with Read, "the man to help us to fructify them" (Brumwell 1946), and Megaw was soon invited to write an essay for a DRU monograph edited by him.

Megaw's impetus for proposing a cross-disciplinary pattern design project was in many ways distinct from that of her interlocutors in the DRU who were so enthusiastic about the proposal. Although she was closely associated with Bernal, it is not clear whether she shared the socialist utopian views of the milieu described above, or the modernist concerns about form and abstraction that would have driven the DRU's interest in her diagrams. Megaw's writing on the subject suggests that she was driven by an abiding interest in the aesthetic qualities of crystallography diagrams, which was embedded in both her scientific practice, and, as I explain below, her personal engagement with decorative art and amateur craft. The visualization of crystalline structures through diagrams was a vital element of her scientific work, aiding her research on the structures of minerals. In the process of drawing diagrams for the purposes of her scientific research, Megaw was attuned to the aesthetic qualities of the patterns that emerged. In her initial letter to the DRU, Megaw wrote, "I am constantly being impressed by the beauty of the designs which crop up in the course of the [scientific] work without any attempt of the worker to secure anything more than clarity and accuracy" (Megaw 1946a). One of Megaw's fundamental aspirations in proposing the use of crystallographic diagrams in pattern design was to communicate publicly about this aspect of X-ray crystallography practice. As she later wrote in an essay, "Pattern in Crystallography," for the (ultimately abandoned) book project by the DRU, "It is hoped that [the structures elucidated by crystallographers] may suggest to designers ways in which to broadcast to a wider public some of the aesthetic pleasure found in the subject by crystallographers themselves" (Megaw 1946b).

Megaw's proposal to the DRU was not the first time she had pursued the decorative applications of crystallography diagrams. Her ongoing engagement with pattern design through amateur craft frequently drew upon her scientific practices of representation. As Lesley Jackson writes, Megaw had once given her friend, the X-ray crystallographer Dorothy Hodgkin, a linen cushion embroidered with the structure of aluminum hydroxide, and she had made Christmas cards with the same crystal structure (Jackson 2008). During retirement, when Megaw discovered the plant *Perovskia*, its leaves also found their way onto her Christmas cards (Glazer 2002). Megaw exhibited a wider knowledge of pattern design as well. In her letter to the DRU, she invoked the nineteenth-century arts and crafts designer William Morris, who devised wallpaper patterns based on repeated motifs drawn from nature. She suggested that textiles with patterns derived from crystallography diagrams should be named after the substance represented, "just as the William Morris patterns were called after their constituent flowers" (Megaw 1946). Her allusion to Morris points to the Victorian slant of Megaw's reference points for design, in contrast to the modernist outlook of the DRU.

In circulating her diagrams to the DRU, however, she tapped into an existing network bound by an already-porous boundary between crystallography and design, and where crystalline structure—of the kind she presented in her diagrams—was a fulcrum for cross-field relationships and exchange. But as Megaw's exchange with the DRU shows, this kind of exchange does not necessarily mean that scientific knowledge, in the form of the crystallographer's diagram, operated in design or art circles in the same—or even similar form—to the way it operated in scientific communities. What begins to emerge from Megaw's dialogue with the DRU's circle is the multivalent character the crystallographic diagram took on as it traveled through design networks before the establishment of the FPG. Between Megaw's dispatch of the diagram as a visual messenger of the "aesthetic pleasure" underpinning her scientific practice of visualizing structures of matter, and the DRU's studio, Megaw's proposal and diagrams become overlaid by the modernist aesthetic frameworks that shaped the DRU's outlook on science. The DRU's particular modernist frameworks do not, however, describe the outlook of postwar British design culture as a whole when it comes to engagement with contemporary science, and it was not the only one that played a role in the FPG story, as I explain below.

Mark Hartland Thomas's Crystalline Aesthetic

Megaw's diagrams resurfaced in the design world in 1949 when her colleague Kathleen Lonsdale presented images of them, along with Megaw's proposal that they be applied to pattern design, at a talk organized by the Society of Industrial Artists, a professional association for industrial and graphic designers. These diagrams caught the eye of Mark Hartland Thomas, the CoID's Chief Industrial Officer, a member of a Festival of Britain planning committee, and the person responsible for industrial design exhibits at the Festival. He wrote to Megaw after Lonsdale's lecture, eagerly asking if he could pursue their transformation into pattern design with manufacturers. Megaw agreed, and Hartland Thomas began assembling a group of manufacturers up to the task of producing patterns based on crystallographic diagrams, with the ambition of launching them at the Festival. Megaw became the group's official "Adviser on Crystal Structure Diagrams." Working closely with Megaw, Hartland Thomas was an enthusiastic steward of the project right up until its Festival debut.

Hartland Thomas plays an important role in the networks crisscrossing science and design fields in the FPG's pre-history, but his own reasons for engaging with scientific subject matter are not immediately obvious. The CoID represented a different environment for the negotiation of scientific subject matter than that of the DRU. Bringing science and design together was not a particular aim of CoID-promoted design. And although the Festival celebrated British achievement in science, industry, and the arts, the merging of scientific form with industrial design *in individual objects* was not an overarching goal for the CoID for its industrial design exhibits. The idea to pilot such a collaboration between industrial design and science was actually so removed from the exhibition's aims that Hartland Thomas was initially worried that the FPG's use of scientific diagrams in pattern design might overstep his remit. Thomas, in fact, was concerned not to "give offence to my scientific colleagues" planning the Festival's science exhibits, as he later wrote, so he sought the approval of Ian Cox, Director of Science and Technology at the Festival, before embarking on the project (Hartland Thomas 1950). Given that such a close collaboration between science and design for the Festival was not an objective in its planning.and even seemed out of the ordinary to the Festival planner who organized itathe question of why Hartland Thomas so enthusiastically took on coordination of an elaborate cross-disciplinary collaboration, and how he reconciled the project's emphasis on scientific form with the institutional dictates of the CoID, is crucial to understanding the roots of the FPG collaboration.

Hartland Thomas had strong aesthetic convictions underpinning his response to crystallographers' representations of the underlying structures of matter, and his background as an architect committed to tenets of the modern movement is key to understanding his aesthetic outlook.[4] After the Second World War, Hartland Thomas belonged to a cadre of architects calling for the adoption of classical ideals of geometric proportion. This was a response to the postwar industrialization of architecture and the state planning of housing, which had sparked anxieties among architects about their authorial role, and the identity of the profession as an aesthetic endeavor (Neumann 1996). A rallying call to take up the commitment to geometric proportion came from Hartland Thomas two years after the end of the war, when he called for a new aesthetic based on ancient ideals of "Scale, Modulus, Proportion [. . .] Symmetry, and Balance" (Hartland Thomas 1947a: 37). This revived interest in the deployment of classical geometrical order in architectural design methods had antecedents in theories of continental modernist architecture, most closely identified with Le Corbusier. This interest in geometric order also reflects the legacy of the neoclassical Beaux-Arts tradition in architectural education in Britain that was still alive in the period when many postwar architects, including Hartland Thomas, were trained.

The crystallographic diagram aligned with many of the geometric ideals with which Hartland Thomas was preoccupied, such as symmetry and the repetition of modular elements. He highlighted these qualities in *The Souvenir Book of Crystal Designs*, an illustrated guide to the FPG sold at the Festival, lauding the diagrams Megaw provided for the project for having "the discipline of exact repetitive symmetry" (Hartland Thomas 1951: 2). Even before setting eyes on Megaw's diagrams, however, Hartland Thomas had identified a parallel to the tenets of a fundamental pillar of his aesthetic system, "modulus," in the structures of crystals. Just as a repetition of a crystal's single unit cell produces a larger crystalline structure in nature, modulus involved the election of a single "dimensional unit" as the basis for proportions throughout an individual building (Hartland Thomas 1947b: 79–80). In his 1947 book *Building Is Your Business*, Hartland Thomas identified the antecedents of his architectural ideal in nature, "at a much smaller scale in crystalline structures, and at a vastly larger scale in celestial geometry" (Hartland Thomas 1947b: 74).[5]

In addition to their appeal on the level of his aesthetic ideology, Hartland Thomas was also driven by an institutional interest in his enthusiasm for crystallographic diagrams and subsequent intent to organize the FPG collaboration. He saw in the crystallographic diagrams' aesthetic a practical purpose one linked with the institutional objectives of the CoID. The conventions of crystallographic diagrams offer a visual coherence across the representations of numerous structures. He admired this "remarkable family likeness" of crystallography diagrams, and throughout the FPG's working period, emphasized that this formal coherence should be maintained in the final designs (Hartland Thomas 1951: 5). In the FPG project, he deployed crystal structure diagrams in this way to create a visual identity across a collection of products from different industries. The FPG thus reflected the CoID's objective of forging stronger links with industry, intended to ensure widespread uptake of the tenets of "good design" that the Council promoted among manufacturers. In fact, the CoID's Director, Gordon Russell, saw the FPG's value primarily in its encouragement of stronger relationships across industries, rather than in the decorative use of crystallographic diagrams. He underplayed what he called "the decorative possibilities of the patterns themselves," while praising the project's potential for relationships between the FPG's industrial constituents: "It is this aspect of the matter making the project a sort of Design Centre that I think most important," he wrote (Russell 1950). The latter spoke more directly to the CoID's core aims than did the notion of adapting scientific forms to pattern design. Hartland Thomas, on the other hand, combined the two; he sought to unify the products of different industries using the crystallographic diagram as an aesthetic tool. This too mirrored aspects of Hartland Thomas' practice in architecture; two years after the Festival, he worked to standardize components across the building industry through an organization called the Modular Society, just as he sought to unify the products of different kinds of manufacturers in his administration of the FPG using the crystallographic diagram as an aesthetic instrument of standardization.

As a Festival planner, Hartland Thomas also responded to the FPG's potential to contribute to the Festival's drive to showcase British accomplishments. The Festival commemorated the 1851 Great Exhibition of a century earlier. Whereas the 1851 event was an explicit celebration of imperial power exhibiting objects from the British Empire, the 1951 Festival, set at the beginning of the empire's dissolution, was comparatively national-focused.[6] Since X-ray crystallography was, as Hartland Thomas wrote in the *Souvenir Book*, "particularly highly developed in Britain," that meant it contributed to the Festival's national narrative, and had in fact already been slated to be featured in the exhibition's science exhibits as a result (Hartland Thomas 1951: 6). As Jo Littler has pointed out, "the perpetuation of imperial narratives of discovery and the heroic adventurer discovering new lands" was palpable within the Festival's exhibition narrative despite its focus on Britain rather than the empire, "only now it resided in 'science'" (Littler 2006: 26).

As in the case of the DRU, Megaw's diagrams prompted Hartland Thomas to read into the scientific image of his own codes, meaning, and potential uses; they appealed to his aesthetic ideology as a modernist architect, and were deployed as tools to pursue the institutional goals he worked toward as a CoID officer and Festival planner.

He is thus a part of an extended network that cuts across design cultures of postwar Britain, through which the crystallographic diagram circulated, shifting in its significance and perceived potentiallaesthetically, conceptually, politicallyaas it moved through environments associated with varied modernisms. Tracing the circulation of Megaw's diagrams among design networks in the late 1940s, it is clear that there is no notion of a generalized preoccupation with science among design cultures of the period. There is no single way that scientific knowledge operated in postwar British industrial design circles. Artifacts of the crystallographer's visual language appealed to several contemporary cultures of practice (some of which did overlap). Their varied convictions included hopes for a social utopian future, institutional imperatives for the future of British industrial design, and classical ideals of proportion emanating from postwar architectural debates.

"Undisciplined" Dialogues

Within the networks of practitioners from different fields and disciplinary cultures who play roles in the FPG's backstory, the crystallographic diagram acted as a mobile "trading zone." The concept of the "trading zone"—which has been employed in anthropology and subsequently the history of science—refers to a site that allows for the exchange of knowledge between different cultures. These might be physical sitestcoffee shops, for instancecor symbolic ones. Historian Pamela O. Long, for instance, evokes the concept of the "trading zone" in research on how knowledge exchange between artisans and "learned men" affected the development of the "scientific revolution" in early modern Europe (as discussed in Lee Chichester's essay for this volume). Long describes the Vitruvian tradition in architecture as a symbolic "trading zone" between these groups (Long 2011). The story of the FPG's pre-history reveals the crystallographic diagram as a symbolic trading zone, as a site for communication and exchange between practitioners in different fields and between visual languages and the differing aesthetic, political, professional, and bureaucratic aims that drove them.

The FPG represents an opportunity to explore how scientific representations functioned outside the laboratoryT"in public""in cultures of practice associated with design production and policy, including that of the members of the DRU and of Hartland Thomas (as the modernist architect *and* as the CoID officer). Designers and artists represent particular *publics* for science. As such, this history of their involvement in cross-field dialogues preceding the establishment of the FPG undermines outdated notions of the passive reception of scientific knowledge by publics outside of scientific practice. A fuller picture of the reception and negotiation of scientific knowledge in public can only be achieved though understanding the audiences for scientific knowledge as "active consumer[s]" (O'Connor 2009: 335). An active public for science may be motivated by interests other than or in addition to gaining "accurate"nin a scientist's viewiunderstandings of a scientific subject. As historian of science Katherine Pandora writes, "Encounters with science in the everyday world can be multifarious, miscellaneous, overlapping, partial, and contradictory—in fact, *un*disciplined" (Pandora 2009: 347). The "trading zone" is an important site for such "undisciplined" encounters—one in which complex dynamics of agency between the approaches of different fields or cultures play out. This reality bubbles beneath Megaw's conversations with figures outside her immediate field. Although she initiated the dialogues recounted here and provided the diagrams and proposal at their center, her interlocutors negotiated crystallographic knowledge through the lens of their own interests and world views. This is an important point when it comes to how scientific knowledge, in the form of a diagram for instance, is received outside the walls of the laboratory in other fields. The knowledge signified by a representation in scientific practice can dissolve and be replaced by new sets of meanings in a non-scientific practice.

The story of the FPG offers an opportunity to develop more distinct understandings of the role and significance of science in practices and in institutional and intellectual cultures associated with postwar British design. These understandings move past the surface understandings of "style" to the aesthetic outlooks and ideologies, institutional objectives, and political frameworks that underpinned them. As this snapshot of the process demonstrates, there is much more to learn about the complex and varied ways in which scientific knowledge was negotiated within British industrial design of the period. Although this essay has focused on a cross-disciplinary exchange that took place in the past, the FPG story's potential resonance extends to the present. Today, notions of interdisciplinarity shape many efforts in arts and humanities research and the cultural sector that create or study links between science and design.[7] The current enthusiasm for interdisciplinarity has much positive potential for research that crosses discipline boundaries in productive ways. The impulse to celebrate interdisciplinary connections, collaboration, and exchange must not obscure the complex aspects of encounters between disciplines, however, such as those at the root of the FPG collaboration. Interrogating both moments of resonance *and* disjuncture can aid understandings of how disciplinary cultures shape cross-field interactions, as well as the values that underpin impulses towards cross-field exchange itself.

Notes

1. Paul Reilly, the CoID's information officer in the 1950s, remarked in reflections on the Festival twenty-five years later that the FPG can "hardly be said to have laid the foundations for a new school of design – indeed they barely survived the Festival year" (Reilly 1976: 61). As Lesley Jackson points out in her detailed history of the FPG, several factors may have contributed to the fact that many FPG prototypes were not commercially produced, including continued wartime materials shortages, and restrictions on the domestic furniture market (Jackson 2008).
2. Where other texts on the FPG have touched on the cross-disciplinary exchange before the FPG's formation as background to the topic, the focus has been weighted toward

description, leaving much room for interpretation on the topic. Further scholarship on the FPG includes Jackson (2008), McGill (2007), Schoeser (2001), and Forgan (1998).

3. Burstow acknowledges however that its precise imprint is difficult to pinpoint in their sculpture, especially as the artists studied mathematical models also, the geometric forms of which are clearly evident in their work and resemble the geometric forms of crystals (Burstow 2014: 60).
4. Hartland Thomas was an active member of the MARS group (Modern Architectural Research), the British arm of the modernist architecture body, Congrès internationaux d'architecture moderne (CIAM).
5. A possible source of Thomas's knowledge of crystalline form was the book *On Growth and Form*, which had also circulated among architects in postwar Britain. Thompson's investigation of recurring morphologies and the mathematical determinants of form in nature extended to crystal growth: "the snow-crystal is a regular hexagonal plate or thin prism [. . .] Nature superadds to the primary hexagon endless combinations of similar plates or prisms, all with identical angles but varying lengths of side; and she repeats, with an exquisite symmetry, about all three axes of the hexagon, whatsoever she may have done for the adornment and elaboration of one" (Thompson 1961: 153). Crystal structure, especially the way Thompson depicts it here, mirrors Hartland Thomas's modulus ideal, and the elements of classical geometry the architect championed.
6. As Jo Littler has observed, however, a subtler version of Imperial Britain was on display, for instance, in the imagery of Britannia that was integral to the Festival's logo (Littler 2006).
7. This is evidence in recent research interest in relationships between histories of science and art (which accounts for a larger body of scholarship than histories on science and design). In 2002, historian Ludmilla Jordanova identified the research attempting to bridge histories of art and science being published at the time as part of a broader cultural engagement with "art and science" (Jordanova, 2002: 341). Examples include work by art historians Arthur I. Miller (2014) and Martin Kemp (2006). It is embodied also by the work of institutions, such as the Wellcome Collection, a museum and gallery that opened in London in 2007, concerned with the "connections between science, medicine, life, and art" (The Wellcome Collection 2018). And in 2008, the Museum of Modern Art in New York staged an exhibition, "Design and the Elastic Mind," which included several design projects sitting on the border with science (Antonelli and Aldersey-Williams, 2008).

References

Antonelli, P. and H. Aldersey-Williams (2008), *Design and the Elastic Mind*. New York: Museum of Modern Art.

Barlow, A.J. (1996), "Barbara Hepworth and Science," in D. Thistlewood (ed.), *Barbara Hepworth Reconsidered*, 95–107, Liverpool: Liverpool University Press.

Bernal, J.D. (1945), "Transformation in Science," in M. Brumwell (ed.), *This Changing World*, 15–26, London: George Routledge & Sons.

Brumwell, M. (1945), "Forward," in M. Brumwell (ed.), *This Changing World*, 1–2, London: George Routledge & Sons.

Brumwell, M. (1946), Letter to Helen Megaw, March 1, Archives of Art and Design, Victoria and Albert Museum, London, UK, 1977/3/13.

Burstow, R. (2014), "Geometries of Hope and Fear: The Iconography of Atomic Science and Nuclear Anxiety in the Sculpture of World War and Cold War Britain," in C. Jolivette (ed.), *British Art in the Nuclear Age*, 51–80, Surrey: Ashgate.

Cotton, M. (2011), *Design Research Unit 1942–72*, Cologne: Buchhandlung Walther König.

Crowther, J. G. (1974), *The Cavendish Laboratory, 1874–1974*. New York: Science History Publications.

Forgan, S. (1998), "Festivals of Science and the Two Cultures: Science, Design, and Display in the Festival of Britain, 1951," *The British Journal for the History of Science* 31 (2): 217–40.

Gabo, N., B. Nicholson and J.L. Martin, eds (1937), *Circle: International Survey of Constructive Art*. London: Faber and Faber.

Gardiner, M. (1982), *Barbara Hepworth: A Memoir*. Edinburgh: Salamander Press.

Glazer, M. (2002), "Helen Megaw" (obituary), *Independent*, March 28, www.independent.co.uk/news/obituaries/helen-megaw-9178295.html, accessed March 30, 2018.

Glazer, M. (2009), "Megaw, Helen Dick (1907-2002)," in L. Goldman (ed.), *Oxford Dictionary of National Biography*, 712–14, Oxford: Oxford University Press.

Hartland Thomas, M. (1947a), "Aesthetics the Vanguard Now," *Architectural Design*, February: 36–7.

Hartland Thomas, M. (1947b), *Building Is Your Business*. London: Allan Wingate.

Hartland Thomas, M. (1950), Letter to Brian Peake, June 2, Design Council Archives, Brighton, UK, 5384.

Hartland Thomas, M. (1951), *The Souvenir Book of Crystal Designs*. London: Council of Industrial Design.

Hammer, M. and C. Lodder (1996), "Hepworth and Gabo: A Constructivist Dialogue," in D. Thistlewood (ed.), *Barbara Hepworth Reconsidered*, 109–133, Liverpool: Liverpool University Press.

Hepworth, B. (1946), Copy of letter to Marcus Brumwell, enclosed in letter from Brumwell to Helen Megaw, March 15, Archives of Art and Design, Victoria and Albert Museum, London, UK, 1977/3/15.

Jackson, L. (2008), *From Atoms to Patterns: Crystal Structure Designs from the 1951 Festival of Britain*. Somerset: Richard Dennis.

Jordanova, L. (2002), "And?," *British Journal for the History of Science* 35 (126): 341–5.

Julian, M. M. (1990), "Women in Crystallography," in G. Kass-Simon and P. Farnes (eds.), *Women of Science: Righting the Record*, 335–83, Bloomington: Indiana University Press.

Kemp, M. (2006), *Seen/Unseen: Art, Science, and Intuition from Leonardo to the Hubble Telescope*. Oxford: Oxford University Press.

Law, J. (1992), "Notes on the Theory of the Actor-Network: Ordering, Strategy and Heterogeneity," *Systems Practice* 5: 379–93.

Littler, J. (2006), "'Festering Britain': The 1951 Festival of Britain, Decolonisation and the Representation of the Commonwealth," in S. Faulkner and A. Ramamurthy (eds.), *Visual Culture and Decolonisation in Britain*, 22–42, Hampshire: Ashgate.

Long, P.O. (2011), *Artisan Practitioners and the Rise of the New Sciences, 1400–1600*. Corvallis: Oregon State University.

McGill, T. (2007), “Design Under the Microscope: The Festival Pattern Group 1951: The Council of Industrial Design and the Mechanics of Industrial Liaison,” *The Decorative Arts Society Journal* 31: 92–115.

Megaw, H. (1946a), Letter to Marcus Brumwell, February 20, Archives of Art and Design, Victoria and Albert Museum, London, UK, 1977/3/12.

Megaw, H. (1946b), “Pattern in Crystallography,” November 1946, Design Council Archives, Brighton, UK, 1466.

Miller, A.I. (2014), *Colliding Worlds: How Cutting-Edge Science is Redefining Contemporary Art*. New York: W. W. Norton & Company.

Neumann, E. (1996), “Architectural Proportion in Britain 1945–1957,” *Architectural History* 39: 197–221.

O’Connor, R. (2009), “Reflections on Popular Science in Britain: Genres, Categories, and Historians,” *Isis* 100: 333–45.

Pandora, K. (2009), “Popular Science in National and Transnational Perspective: Suggestions from the American Context,” *Isis* 100: 346–58.

Read, H. (1935), *The Green* Child. New York: New Directions.

Read, H. (1956 [1934]), *Art and Industry*. London: Faber and Faber.

Read, H. (1945), “Threshold of a New Age,” in M. Brumwell (ed.), *This Changing World*, 7–14, London: George Routledge & Sons.

Reilly, P. (1976), “The Role of the Design Council,” in M. Banham and B. Hillier (eds.), *A Tonic to the Nation: The Festival of Britain 1951*, 58–61, London: Thames and Hudson.

Russell, G. (1950), Letter to Dr. R.S. Edwards, June 26, Design Council Archives, Brighton, UK, 5384.

Schoeser, M. (2001), “The Appliance of Science,” in E. Harwood and A. Powers (eds.), *Twentieth Century Architecture 5: Festival of Britain*, 118–26, London: Twentieth Century Society.

Teasley, S., G. Riello, and G. Adamson (2011), “Introduction: Towards Global Design History,” *Global Design History*, New York: Routledge.

Thompson, D. W. (1961 [1917]), *On Growth and Form*. Cambridge: Cambridge University Press.

“About Wellcome Collection,” *The Wellcome Collection*, https://wellcomecollection.org/about-us, accessed April 6, 2018.