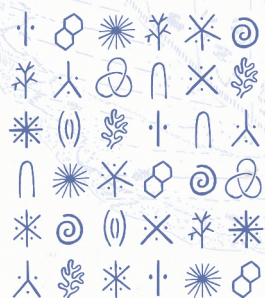


*Drawing as a Way
of Knowing
in Art and Science*



Gemma Anderson

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This book is dedicated to my grandmother Eileen (Eleanor) Teresa Donohue (1913-2006) and to the memory of Christopher Hannah (1981-1999).

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Introduction

This book focuses on the twin themes of drawing and morphology through an exploration of intuitive and experimental drawing methods. The aim is to develop and share new ways in which drawing practice can enhance morphological insight, specifically within the contexts of art, mathematics and the natural sciences. Central to this is Goethe's concept of morphology, which he defined in 1792 as 'the study of form and formative process' (Goethe and Naydler 1996) combined with a narrative of the development of 'drawing as a way of knowing' in my own artistic practice. A series of interdisciplinary collaborations with natural scientists and mathematicians have informed the development of the drawing methods discussed throughout, which are designed to explore morphological questions emerging from both artistic and scientific study.

Chapter by chapter, this book aims to extend Goethe's concept of morphology to unite contemporary art practice with natural science and mathematics in the study of form by encompassing diverse methods and approaches. To this extent, I propose the artist Paul Klee as a morphologist within the framework of Goethe's morphology, a proposition that is supported by accounts of his interactions with the science of his time, his drawings and his teachings at the Bauhaus. Images are central to the argument that Klee's work reveals morphological insight into the dynamic nature of form and are important to my interpretation of his work as a visual counterpart to aspects of Goethe's morphology. Positioning Klee as an artist and morphologist supports my argument for drawing as a way of knowing in both artistic and scientific practice.

As elaborated throughout this book, morphology as the study of form provides a meeting point for art and science, but lacks a clear paradigm for an artistic approach to its study. Over time, the following morphological questions have emerged out of my own artistic practice: What shared morphological characteristics (form and symmetry) of animal, mineral and vegetable species can be identified, known and represented through the process and object of drawing? And how can artistic practice develop an extra-scientific model of classification which is complementary to the scientific approach? These questions seek morphological similarities, not differences, and build on the foundation of my own study of resemblance. They are unpacked and discussed further in the chapter 'On drawing as a way of knowing', which follows this introduction.

Throughout this book, drawing is used to address these questions and, through the process of this practice-based enquiry, drawing methods emerge that allow artistic and scientific work to converge and then to diverge. Much of this practice has taken place at the Natural History Museum, London (NHM) where working relationships with scientists

and curators have been developed to support an approach that draws directly from the museum's collections.

A broad characterization of this work brings it in line with three major emerging fields in practice-based research: drawing research, Art/Science and the Educational Turn.

Drawing research

Drawing adds to the repertoire of possible forms of knowing.

(Daston and Lunbeck 2011)

Drawing research has emerged in recent years, through a number of exhibitions, conferences, symposia and publications, as an active strand of artistic and ontological interest. In *Writing on Drawing: Essays on Drawing Practice and Research*, Steve Garner argues for the value of drawing research to communities beyond the art world, namely the scientific and cultural: 'drawing research presents a powerful opportunity to demonstrate the ability to generate new knowledge about the visual and to communicate this through the visual' (2012: 15). Garner's view, like John Berger's in *Ways of Seeing* (2009), challenges the assumption of the supremacy of the written word in visual research. *Drawing as a Way of Knowing in Art and Science* therefore contributes to the understanding of drawing as a way of knowing and 'as a way of bringing art and science together' (Hernly, 2015), specifically as a collaborative tool in relation to practices of the established scientific disciplines of natural sciences and mathematics.

The Jerwood Drawing Prize has been exhibiting the diversity of contemporary drawing in London since 1994 and provided inspiration for the dynamic workshop and exhibition programme 'Drawing making: Making drawing' (Southern 2014), which included some of the UK's leading artists working with drawing practice, such as Cornelia Parker, Tim Knowles, Claude Heath and Dryden Goodwin, and to which I also contributed. 'Drawing making: Making drawing' was held at The Drawing Room, London, the UK's largest drawing-centred exhibitor and publisher specifically focused on drawing. The Drawing Room provides a regular curated exhibitions programme, while the Drawing Center in New York is distinctive as a museum and the only US non-profit space solely for drawing exhibitions. Perhaps one of the most ambitious attempts to assess what drawing can mean today is the exhibition *Drawing Now: 2015* (Lahner 2015) at the Albertina Museum in Vienna, 40 years after *Drawing Now: 1955–1975*, the seminal exhibition created by the Museum of Modern Art in New York (Rose 1976). The initiation of Drawing Biennales in the United Kingdom, Italy, France and the United States has contributed to a growing international interest in drawing while smaller organizations like the Drawing Hub, Berlin, the Centre for Recent Drawing, London (Hewish 2004) and projects such as the Cornwall Morphology and Drawing Centre (CMADC) (Anderson 2015c) co-exist as part of a wider network of drawing activity. Alongside these focused projects, The Big Draw – a charity founded in 2000 – has wider reach, aiming to promote drawing activity and, more recently, drawing

research (Anderson 2016b), and is key to widening public knowledge of and participation in drawing culture.

A series of recent publications have contributed to the making and sharing of the culture of drawing: *Lines of Thought* (Seligman 2016), *Writing on Drawing: Essays on Drawing Practice and Research* (Garner 2012), Cornelia Butler and Catherine de Zegher's (2010) *On Line: Drawing in the Twentieth Century*, Katharine Stout's *Contemporary Drawing: From the 1960s to Now* (2014), Mick Maslen and Jack Southern's *The Drawing Projects: An Exploration of the Language of Drawing* (2011), Phil Sawdon and Russell Marshall's *Hyperdrawing: Beyond the Lines of Contemporary Art* (2012), Laura Hoptman's (2002) *Drawing Now: Eight Propositions* and Jean-Luc Nancy's *The Pleasure in Drawing* (2013). Alongside these major book publications, other artists' publications include Auerbach's 'Grapheus was here' (2011), featured in Nikolaus Gansterer's publication project *Drawing A Hypothesis: Figures of Thought* (2011: 65–76), which explores the ontological basis of forms of visualization and the development of the diagrammatic perspective and its use in contemporary art, science and theory. Based on an exploration of figures found within Gansterer's hand-made maps and models, Gansterer collaborated with artists and scientists to reveal drawing as a medium of research, which enables the emergence of new narratives and ideas. This work has evolved to explore the relationship between drawing, choreography and writing through the current collaborative research project 'Choreo-graphic figures: Deviations from the line' (Gansterer et al. 2017).

Journals investigating drawing have also emerged over recent years, most recently *Drawing: Research, Theory, Practice (DRTP)* (Intellect Ltd) that published its first volume in 2015. Key topics explored by *DRTP* include drawing as an experimental practice, as research, as representation, as process and drawing as an interdisciplinary practice.

As a form of 'drawing research', *Drawing as a Way of Knowing in Art and Science* is connected to a number of academic studies and research groups. Conferences and symposia held at various UK institutions like RCA, Wimbledon School of Arts, London (*Thinking through Drawing 2012: Drawing in STEAM* symposium) and the *Drawing Out* conferences (University of the Arts London, 2010 and 2012) have shed light on the epistemological value of drawing. Research groups such as 'Knowledge in the Making: Drawing and Writing as Research Techniques' (Hoffmann, Rheinberger and Wittmann 2010) and the emerging 'Thinking through Drawing: International Drawing & Cognition Research and Education' network have focused on drawing as a transdisciplinary practice. Along these lines, interdisciplinary projects and publications like 'Picturing to learn' (MIT) (Frankel 2007) and 'Drawing to learn in science' (Ainsworth et al. 2011) argue that drawing helps to reveal misconceptions of both science and art students. Ongoing campaigns such as 'STEM' to 'STEAM' (i.e. adding 'Arts' to STEM education) and 'SEAD' (Network for Science, Engineering, Art and Design) contribute to the current debate on the essential role of the Arts within formal education alongside, and within, Science, Technology, Engineering and Maths. The STEAM campaign, highlights the value of 'visual literacy' (the 'ability to construct meaning from visual images') (Giorgis, Johnson, Bonomo, Colbert, et al. 1999: 146) at a critical moment when the unique epistemological value of drawing has become

increasingly underappreciated in scientific practice and education (Anderson 2014a; Anderson et al. 2015; Tversky 2010; Wittmann 2013; Kozma et al. 2000).

Art/Science and interdisciplinarity

In recent years there has been a growing culture of 'Art/Science' or 'SciArt' in the United Kingdom, largely related to the SciArt programme, which emerged in the mid-1990s and was funded by the Wellcome Trust (Glinkowski and Bamford 2009). The programme coincided with an emergent trend towards the breaking down of disciplinary boundaries, both within and across the arts and the sciences, and a move towards interdisciplinary collaboration, which encouraged flexibility and open-endedness. The programme's very nature describes the assumptions on which the two cultures of art and science work as profoundly alien to each other; scientists are perceived as more likely to work according to a set of axioms for/against some hypothesis and are nominally bound by the scientific method, whereas artists are generally perceived to have more freedom to explore unconventional questions and critique the media that they are using.

As the programme came to an end in 2005, the broader Art/Science movement was defended by the periodical *Leonardo: Journal of the International Society for the Arts, Sciences, and Technology*, founded in 1968 by engineer-artist Frank Malina. *Leonardo* has long been an important locus for discussions of art and science, including explorations of creativity in the two fields. In an editorial in the April 2004 issue of *Leonardo*, 'ArtScience: The essential connection', biologist and historian of science Robert Root-Bernstein emphasized creativity as a basic link between science and art, a theme he has expanded on in books such as *Sparks of Genius* (Root-Bernstein 2004; Root-Bernstein and Root-Bernstein 1999).

It is important to note that in advance of C. P. Snow's *The Two Cultures* (Snow 2012), originally delivered as a lecture in 1959, others had started this discussion. For example, the mathematician and critic Archibald Henderson outlined the 'contemporary battle of the cultures' in *American Scientist* article 'Science and art: An approach to a new synthesis' (1946) and Martin Johnson's book *Art and Scientific Thought: Historical Studies Toward a Modern Revision of Their Antagonism* (1944) emphasized the role of imagination in science and art. The articulation of the importance of 'Form, Pattern, Structure, in material or mental images' in both science and art (Johnson 1949: 42, 137) reinforced that artists and scientists share a common interest in the formative process and patterns of nature as abstractly conceived. The theme of 'Form, Pattern, Structure' became central to the 1951 symposium *Aspects of Form: A Symposium on Form in Nature and Art*, organized by Lancelot Law Whyte (Whyte 1951a, 1951b) to coincide with the exhibition *On Growth and Form at the Institute of Contemporary Art* (ICA) (Hamilton 1951). This exhibition, convened by artist Richard Hamilton, had been inspired by D'Arcy Wentworth Thompson's 1917 classic study of morphogenesis, *On Growth and Form* (Thompson 1942). Following this thread, emphasis

on creativity in art and science continued through articles like ‘The creative process’ in a 1958 issue of *Scientific American* (Bronowski 1958) and the exhibition *Creativity in Art and Science, 1860–1960* held at the Cleveland Museum of Art in 1987.

Books such as *Creation: Modern Art and Nature* (1984) including the chapter ‘Form and creation: The impact of the biological sciences on modern art’ by Jennifer Mundy (Mundy in Weaver 1984), *The Educated Eye* (Anderson and Dietrich 2012), *Picturing Science, Producing Art* (Galison and Jones 1998) and *Objectivity* (Daston and Galison 2010) have since provided an important historical grounding for Art/Science practice, with particular emphasis on the epistemological value of the image. The recent book *Art, Science and Cultural Understanding* demonstrates that a real dialogue is now possible between art and science, partly because scientists themselves have become more aware of issues and problems, such as the limitations of truth systems or objectivity (Wilson et al. 2014). On the back of these developments, Art/Science has emerged as a popular theme in contemporary art. GV Art gallery (London) has become a hub for collaborations between artists and scientists, as seen in the 2011 exhibition *Art & Science: Merging Art and Science to Make a Revolutionary New Art Movement*, exhibiting artists such as Oron Catts and Annie Catrell accompanied by a panel discussion moderated by Arthur Miller.

Although Art/Science is now widely accepted as a contemporary movement in art and education, it is important to recognize that it has a long history. This study draws particularly from the work of Paul Klee, an artist and teacher at the Bauhaus School, and Johann Wolfgang von Goethe, a writer, morphologist and statesman, both of whom pioneered an interdisciplinary approach through their own study of natural form. With this in mind, the contemporary notion of ‘Art/Science’ can be regarded as a rediscovery of an approach that is not in itself new but rather one that many, like Goethe and Klee, have practised before.

The drawing practice presented in this book has observed, adapted and critiqued the non-art disciplines of the life sciences (especially morphology) and mathematics in both practice and theory for the purpose of furthering an artistic practice and study of form that offers new methods and analogies back to science. In recent decades, new fields of science have arisen in the form of molecular biology and chemistry, systems biology, nanotechnology, genetics and epigenetics, collectively expanding the horizon of ‘visible’ things. Alongside these developments, the emerging field of ‘molecular aesthetics’ (Fruk and Weibel 2013) contributes to a culture of ‘making visible’ morphology at the molecular level. As microscopes and other imaging technologies have developed, we are now able to penetrate deeper beneath the surface of things – to transcend the limits of natural observation and to see what was previously invisible. The drawing practices described in the later chapters of this book offer new methods for visualizing the invisible, therefore building on the history of drawing as an epistemological tool; from Crick’s pencil drawing of the DNA double helix in 1953 to Jane Richardson’s drawings of protein structures in the 1980s.

My artistic practice at the Natural History Museum (NHM) described throughout this book can be understood as a form of residency. The approach supports as well as challenges scientific convention, aiming to open a dialogue and exchange rather than an opposing or

strictly challenging position. This project at the NHM was unusual; although there are many artists working from the NHM's collections (on an appointment basis or working from the museum displays), I was given a research pass, access to collections and a desk space in the Sackler Imaging Lab in the Darwin Centre. My artistic research became embedded in a lab where I was visible both to the public (through the Darwin Centre Cocoon) and to scientists in the lab.

As such, my work performed an intervention with the museum collections and research culture, and therefore became an active, even radical agency within the NHM. My artistic practice operated as modest and non-disruptive, while being driven by a motivation to challenge and critique scientific paradigms, especially those of classification. To engender this, I had countless meetings and conversations with curators and scientists and spent a significant amount of time drawing, viewing and handling specimens, which provided an opportunity to ask questions and offer different viewpoints for discussion. Martha Fleming recognizes the difficulty in creating this kind of interjection into such an institution, pointing out:

Examples of artists actually working directly with existent collections inside the logic of individual museums, and making this the very subject of their inquiry from within are very rare. This sort of investigation is the kind of project that always points out of its apparently hermetic specificity to become epistemological in nature. It is an activity for which one must have stamina, sustained vision, and highly developed diplomatic as well as intellectual tools. It does not so much differ from curatorial practice as extend it by bending its laws to breaking point; in fact, bending them round so that they face each other and form a question mark as much about themselves as about the entire practice of collection and display.

(Fleming 2004)

This way of working can be understood in relation to what are now well-established artistic strategies; for example, Scottish artist Katie Paterson collaborates with specialists in different scientific disciplines to engage in experimental research and practice. Similarly, UK-based artist Christine Borland has developed a number of collaborations with scientists. In Borland's artistic research, collaboration provides a platform for questions about 'scientific fact' and an opportunity to merge the materials of her art with the media of new technologies. In this way, Borland's work links with the contemporary American artist Mark Dion, whose practice reflects different ways of understanding the world. He says:

Scientists and artists often seem to occupy the same job, which is to describe and understand the world around us, however they have a remarkably different set of tools with which to accomplish this task. Science can be very good at discerning what the world is, however art can help us figure how we feel, think and cope with that.

(Dion 2014)

Mark Dion's work came to the fore in the 1990s to establish a trans-disciplinary art practice, specifically through his engagement with the fields of science and the museum, which offered an alternative approach to traditional taxonomy:

I think it is a marvelously challenging model today in our time of extraordinary specialisation, in which it can be impossible for people to have conversations across disciplines. Fields of knowledge have become extraordinarily specific and focused. I am a big fan of those who act as ambassadors from complex fields to a broader public: the Oliver Sacks, Steven Jay Goulds and Sylvia Earles of the world.

(Dion 2014)

This statement emphasizes the value of the (precarious) freedom of the artist, which allows a reflection and overview of many other disciplines (which themselves are too narrow and well defined to allow for this). The work of both Dion and Borland reflects the ongoing culture of institutional critique that since the late 1960s and early 1970s has consisted of artistic interrogation and cross-disciplinary practices, on which this project builds.

The educational turn and contemporary art practice

The 'educational turn', a term coined by Paul O'Neill and Mike Wilson (2010) is outlined through examples of artists and curators who consider artwork as an educational medium. In the book *Curating and the Educational Turn* (2010), they propose that curating and artistic production have undergone an 'educational turn'. To enquire into these new developments in practice, O'Neill and Wilson organized a series of seminars and public discussions including 'You talkin' to me? Why is art turning to education' at the ICA (14 July 2008, London). Liam Gillick, who was involved in this symposium, later published an article based on this talk called 'The fourth way' in *Art Monthly* (Gillick 2008) where he states: 'in exhibitions and biennales in recent years there has been a move towards including quasi-educational projects – not as add-ons but as an integral part of artistic production'.

This work shares many characteristics of practice situated within the 'educational turn', combining strong educational motivations and an interest in sharing artistic process rather than product. It contributes through presenting and discussing methods that develop a way of seeing and understanding the morphology of animal, vegetable and mineral in the context of collaborative interdisciplinary workshops that are led through an open dialogue between workshop participants, myself and the collaborating scientist. The dissemination of the drawing methods developed through the Cornwall Morphology and Drawing Centre – a drawing research space that presents the process and product of this work through collaborative workshops and aims to share the epistemological value of

drawing in relation to the natural sciences and mathematics – is discussed in detail in the last chapter of this book.

Identifying the limitations of this book

As described above, this artistic research largely took place at the Natural History Museum (NHM) and encountered a number of limitations. As an independent artist and researcher, I did not have access to the NHM specimen database ‘Data Portal’ (<http://data.nhm.ac.uk>) or to contemporary imaging technologies at the NHM Imaging Analysis Centre due to the entailed expense of training and bench fees to work with such equipment.

Aside from these procedural limitations, I encountered further limitations due to the varying availability of individual scientists, and their level of interest in my project. Disciplinary differences emerged in debates around the nature and status of what different scientists considered as ‘the scientific method’ – a notion I discovered to be ingrained in some (though not all) of my collaborators. Earning credibility with scientists who had not previously given time to engage with an artistic research project was, at times, challenging.

In addition to the limitations of this work, it is important to acknowledge the difficulties when undertaking research with a broad constituency of participants (from scientists to artists and workshop attendees). A difficulty due to disciplinary boundaries appeared during the workshop practice. Approaching scientists with an experimental (and rigorous) drawing method was challenging. Certain scientists held different and often heterogeneous views of the scientific method that prevented an openness to some of the proposed workshop activities. At the other end of the spectrum, structuring workshops with a rigorous and systematic (quasi-scientific) programme proved challenging for non-scientists. These constraints were predictable and did not, in my view, undercut the validity of the work. In fact, they reinforced the very aim of this project as a pluralist epistemology for morphology intended to bridge the gaps between the differing views and approaches of art and science, showing their relative merits especially when placed in dialogue with each other.

In this book, certain data, for example the workshop feedback, are used as corroborating evidence rather than as a subject of analysis. As a consequence, data from the workshops have the status of what I hope is informed reflection rather than thorough-ongoing interpretative analysis. The workshops had a double function: to be successful as a workshop for participants and to be successful as an integrated component of the enquiry. As a consequence of this double function, I encountered the difficulty of acquiring sufficiently detailed and consistent feedback (largely due to the voluntary nature of the feedback request – although almost everyone contributed largely positive responses) to assess the specific learning outcomes of participants. I did not take the feedback as quantitative evidence, but as a qualitative component of the evaluation which I could collate into more general corroborations of how I met the project objectives.

How to read this book

This book represents a philosophical and practical investigation into drawing as a way of knowing in art and science. Gradually, a set of practices form in between art and science. To nourish these practices with idiosyncratic elements and key ideas from the theory and practice, many disciplines are integrated along the way.

An important aspect of the artistic practice is a strong motivation to share what is created, through transferable methods. The resulting artworks, exhibitions and workshops accompany this book as a digital online archive (www.cmadc.uk; www.gemma-anderson.co.uk; www.isomorphology.com).

The chapters of this book provide a theoretical and contextual framework for the set of practices, containing details of the literature and artwork consulted in the course of the research. The chapters are best understood as a series of sequential episodes faithful to the path of this enquiry: each reflects a distinctive aspect of the process at a particular time, and leads forward to the next iteration of practice and investigation.

The initial chapters provide examples of drawing as a way of knowing morphology, outlining work done in collaboration with contemporary natural scientists and mathematicians. Together, Chapters 1 and 2 begin a narrative of the development of drawing as a way of knowing. The significance of 'resemblance' to my practice is revealed in Chapter 3 through the study of the morphological resemblances between animal, mineral and vegetable species in museum collections. This study led to the emergence of the concept and practice of Isomorphology, an alternative approach to classification through drawing. Building on Isomorphology, Chapter 4 explores Goethe's original concept of morphology and adapts Goethe's morphological approach to create another drawing method. This development redirects Isomorphology from the study of form and symmetry in whole organisms towards a focus on the parts of organisms and, at the same time, initiates a move from observation to abstraction. Following this, relationships between Goethe's morphology and selected works by Paul Klee are explored in Chapter 5, through which I propose that the artist can be considered a morphologist. Klee's work reveals the dynamic nature of form, arriving at similar morphological insights to Goethe. This chapter provides a basis for my own exploration of form as a dynamic and time-based process.

The short 'Chapter 6: Mathematics and art: Notes from an artistic collaboration', based on work with a mathematician on drawing in four dimensions, uses analogy and metaphor to enable a shift from an observational to a conceptual understanding of form. The seventh chapter explores the development of 'Isomorphogenesis', a drawing-based algorithm informed by biological principles and the coinciding influence of Paul Klee, D'Arcy Wentworth Thompson, William Latham and the conceptual science of theoretical morphology. The eighth chapter is on the Cornwall Morphology and Drawing Centre (CMADC) – a culmination of the practices and collaborations described throughout this book, and documents how the practices developed are shared through a series of participatory workshops with artists, natural scientists, students and the general public.