This chapter focuses on drawing as a way of knowing that requires engagement with scientific collections and specimens. As an artist, I have been working with museum specimens since 2006, mainly studying the resemblance between animal, mineral and vegetable species through the collections of The Natural History Museum, Kew Gardens and University College London. This work has been based on the hypothesis that a group of underlying morphological characteristics (forms and symmetries) are shared by animal, mineral and vegetable species.

Although this work is nested in the emerging field of 'drawing research', it is distinctive in its proposal of observational and conceptual drawing practice as a way of knowing form and formative process, as inspired by Goethe's morphology. Thus, the recursive nature of this research relates to what Daniel Zeller identifies as a goal of artistic research 'to discover a new vocabulary and new rules that can be incorporated back into the process, like a feedback loop, allowing the cycle to expand and evolve' (Zeller 2011).

Artistic research generally, and drawing in particular, is now recognized as a form of interrogation (Holert 2011). In this work, I employ drawing as a method to interrogate the forms, symmetries and formations of animal, mineral and vegetable structures and to offer 'artistic visualization as critique' (Ambrosio 2014: 134–37). Building on this initial framework, more specific details of how these methods have been developed and then shared with others are outlined in each of the subsequent chapters of this book.

A short note on objectivity

At this point, let me elaborate on the concept of objectivity, which will assist the understanding of the nature of this artistic practice within a scientific context. The purpose here is not to critique science or to diminish its aspirations, but to encourage a thoughtful understanding of its nature and to make the links between scientific practice and artistic practice clearer: artistic practice cannot be purely subjective just as scientific practice cannot be purely objective; rather, both have elements of subjectivity and objectivity at the same time.

If we look back a few centuries, the Enlightenment programme depended on the disenchantment of nature (Ravetz 1989: 105), but it did not depend on objectivity, at

least not as we conceive the term today. Daston and Galison propose that objectivity was introduced around 1830 as a conceptual framework for looking, seeing and representing that lasted until the middle of the twentieth century (2010: 371). They also establish that rather than objectivity being an enduring foundational framework within which scientists have always operated, it actually only lasted for around one hundred years before being replaced in the mid-twentieth century by the idea of the 'trained judgment' of skilled experts who have undergone an educational and practical training programme appropriate to their chosen field (Daston and Galison 2010: 309–63). In *Art, Science and Cultural Understanding*, Brett Wilson refers to Daston and Galison (2010: 260–61) when he describes the sustained attachment to the concept of objectivity, saying that

> [...] the frequently-repeated sentiments of contemporary scientists that their theories and experimental work are all based on some form of 'objective reality' that can be independently accessed by carefully structured experiments and the removal of personal bias is a position that effectively conflates two separate philosophical stances: that of structural objectivity, as outlined above, coupled to scientific realism, which claims that scientific theories are not just useful, but true in some sort of absolute sense.
>
> (Wilson et al. 2014: 15)

Science now seems to be abandoning the idea of an absolute and unchanging truth as implied by disembodied scientific realism, and relies instead on a more flexible narrative based on internal consistency, testability and falsifiability.

Drawing as a way of knowing

In what follows, I open a discussion of drawing, touching upon various subjects: drawing and decision-making, observational drawing, drawing and memory, drawing and the tacit, drawing and the haptic. This discussion aims to build a rationale for drawing as a way of knowing. As a practice that can generate and communicate knowledge across disciplines, drawing is employed throughout this work to investigate, synthesize and communicate the shared forms and symmetries of animal, mineral and vegetable species. The process of drawing can 'make visible' (Klee 1973: 21) relations between things that otherwise remain invisible. As an embodied, volitional activity, drawing involves more than can be expressed in language. The later section 'Drawing and the tacit' aims to capture the explicit aspects of this connection and to account for aspects of the practice that resist systematic description.

This matrix provides an overview of the range of methods involved in this study, which are discussed in detail in the following sections.

Topic / Method	Drawing as a way of knowing (Epistemological value of drawing) (chapters: 2, 3, 4, 6, 7, 8)	Morphological understanding and classification (chapters: 3, 7)	Historical and contemporary context (chapters: Introduction, 4, 5, 7)	Artists' contribution to morphological understanding (chapters: 2, 3, 4, 5, 7, 8)
Into drawing practice	Collaboration with scientists Conversations with scientists	Artist-in-residence within scientific institution practice Shadowing scientific fieldwork Conversations with scientists	Visiting exhibitions	Workshop design, administration and delivery Exhibition making Reflection on drawing practice Collection of feedback from workshop participants Contributing to conferences in Art/Science fields Publication of research in academic and non-academic contexts
Through drawing practice	Observational drawing practice Observation of scientific practice Collaboration with scientists	Microscopy Haptic engagement with museum collections	Drawing from historical and contemporary artworks	Drawing, etching and watercolour
For drawing practice	Collaborative drawing Skype and e-mail exchanges with artists and scientists Reflection on drawing practice	Compiling unique list/database of specimens with shared morphological features Visiting museum collections Negotiating access to collections Handling museum collections Organizing and managing a series of meetings with scientists and curators at a number of institutions	Researching in archives library research Literature and image review in art and science contexts	Attending workshops of other artists Weaving Ceramics Rapid prototyping Laser cutting Investment casting Slice-form production

Drawing and decision-making

When reflecting on the personal and experience-led drawing process, in which the subject and the object are constantly being negotiated, I am reminded of Nietzsche's statement: 'There are no facts, only interpretations' (Nietzsche 2011: 89). Scientific work often aims to neutralize any subjective mediation involved in interpretation, whereas in this work the subjectivity of drawing enables the selection of what is interpreted whilst remaining connected to the observation of 'objective' morphological characteristics. Drawing creates a communicable common ground where these morphological characteristics can be negotiated and re-positioned, and this is a useful exercise for art as well as science. In this way, drawing offers a particular form of objectivity: one that allows for the priorities of the individual. The lived character of drawing experience requires a first-person perspective on the object of study. Also the interplay between subjective and objective work is central to this practice, which will sometimes be described from a first-person perspective.

In *Objectivity*, Daston and Galison identify concrete practices of abstract reason by Enlightenment naturalists as 'selecting, comparing, judging, generalizing' (2010: 70). Drawing involves continuous selective decision-making over time, and feedback between the drawer and the drawn. As the driver of the drawing, the human is both the technology and the mediator. Drawing – as mediation – is different to a photograph or digital image because there is no (non-biological) mechanism or external process between the drawer and the drawn. Drawing requires the drawer to select salient information (Anderson 2014a), which varies depending on individual experience. The drawing process also involves feedback: as dynamic sensory transference from the optic to the kinaesthetic to the haptic that requires concentration and interactive decision-making.

Observational drawing

Goethe describes how 'every act of looking leads to observation, observation to reflection, reflection to combination, in every attentive look on nature we already theorize' (Goethe in Seamon 1998: 57). Concentrated observation within the act of drawing creates new perceptual knowledge. Morphological information can be observed in detail, thus activating the process of comparison; each form observed stimulates a new understanding and joins a 'bank' of formal knowledge in the observer's mind. Each new drawing experience then triggers a different formal memory 'stored' in this 'bank'.

Analogies emerge through the act of drawing, allowing resemblance to be discovered rather than invented. Observational drawing therefore allows for the comparison of what is already known and what is observed, and for extending this comparison until what is known, what is drawn and what is observed are relatively consistent, a process that can take years of practice to establish.

The practice of observational drawing, its immediacy, simplicity, open-endedness and spontaneity, enables a heightened awareness of the morphological characteristics in nature.

This awareness leads to an ability to quickly recognize morphological characteristics shared across species, which is crucial to the process of working with vast museum collections and busy museum curators to find specimens. Drawing morphological characteristics (of forms and symmetry) approximates to the notation of an isomorphic alphabet: a writing of form, but without the syntax of language. Nelson Goodman's research on notational systems and different sign-systems could provide further context for this kind of visual notational scheme (1976).

Observation consists of the zooming in and zooming out of details. Although it is possible to draw a complete specimen over time (consisting of many morphological parts composited together), the eye cannot perceive all morphological details simultaneously. This is why a drawing, as a medium that can select and represent salient features of morphological characteristics and the whole simultaneously, holds a unique epistemological value. Therefore, any single drawing represents multiple and continuous observational acts of focusing in and out through the connected movement of the hand and the eye, which form a drawn image over time. The drawing then offers a view of an object that is otherwise impossible without the time endured in the patient act of drawing, and allows us to observe and compare details simultaneously.

Drawing museum specimens from life is always an experiment because the individual nature of the specimen can be very unpredictable. The individual variations of specimens bring challenges and surprises to the work, and also to any process of classification (true of both scientific taxonomy and this artistic research). What occurs is an improvised response motivated by ideas and observations, which are reified through engaging with the real. One morphological character can be compared to another and through drawing body parts can merge, transplant and exchange as form takes precedence over scale. In this improvisation, morphology suggests art, and the lengthy and patient observations are rewarded through a joyful and creative experiment in drawing, each with its own individual modifications. Goethe insisted that this combination of insight and synthetic judgement required the observer to detect 'the idea in the observation' (Goethe in Daston and Galison 2010: 233), which approximates to what I have just described. Building on this idea of 'the idea in the observation', Daston and Galison consider that the qualifications necessary to see like a naturalist include synthesis, adding that 'to see like a naturalist required more than just sharp senses: a capacious memory, the ability to analyse and synthesize impressions, as well as the patience and talent to extract the typical from the storehouse of natural particulars' (2010: 58). In the space of the page, the physical distance between museum specimens, normally housed in different parts of the museum, is confounded and allows for 'extra-scientific' comparisons revealing general patterns and processes at different scales and in different orders of being.

Observation, mediation and memory

Drawings can become powerful 'aide memoires' as the result of drawn experience that accumulates as a kind of memory bank of perceptual experiences, which can then be

recalled by further drawing experience. In this way, drawing can function as a mnemonic device, which is created and sustained by practice. An important aspect of human memory is the visual sense – viewing a drawing post-production can transport the drawer back to the centre of the experience. Drawing is therefore a way of transforming invisible experience into visible, material and embodied knowledge, which in turn transforms further experience. Drawing exercises the mind through a process that does not cling to any object, but rather transforms through objects of study with emphasis on a creative engagement in the process. As John Berger motioned 'a drawing is an autobiographical record of one's discovery of an event – either seen, remembered or imagined [...] A line, an area of tone, is not really important because it records what you have seen, but because of what it will lead you on to see' (Berger 2013). This transformation propels thought towards the next stage of investigative experience. The drawing process challenges the impulse to attach, name and possess and to fade the present into the past prematurely. Drawing therefore extends the ability to experience a subject in and through real time in order to achieve a qualitative object that is the result of its own unique process of making, which cannot be obtained through a quantified exchange.

In the case of the photograph, the camera mediates – and how much agency directs the image from behind the camera is a debate that cannot be fully addressed here. Aspects of the photographic experience are externalized through mediation and therefore impact the observer's work in a different way to drawing experience. Sontag offers an interesting reflection on these differences, 'people remember through photographs but that they remember only the photographs, [...] the photographic image eclipses other forms of understanding [...] To remember is, more and more, not to recall a story but to be able to call up a picture' (2001: 94). It is the length of time spent through drawing experience that increases this ability to 'call up a picture' from the depths of our memory. There are two thoughts here: first the camera mediates through mechanism whereas the drawing mediates through organism, and second that drawing generally takes more time. Drawing tells a story and helps us, as Sontag emphasizes 'to call up a picture'. Viewing a drawing is a way of recalling 'a story' that activates the connection between memory and embodied experience as opposed to recalling an instantaneous picture.

As a process requiring sustained engagement and feedback, drawing is less mechanistic than engagement through a device like a camera or a computer program, in which aspects of the process happen without human interaction. With mechanization some of the mediating process is beyond the reach of human creativity. Photography can freeze an instance, creating a time slice of the dynamic world, whereas drawing can open and unfold an experience through an engagement with a series of connected moments.

Through the act of drawing, time and space are contained and mediated by the drawn line. Drawing allows for an expansion of the subject through a time-based practice. The following is an excerpt from my journal, reflecting on practice:

> In the duration of drawing, the past presses against the present enabling a new form to emerge. The process of observational drawing slows the tempo of my visual and embodied

> experience and provides a contrast to the contemporary 'digital' speed, enabling a strong, time-based connection between the drawer and the drawn. These different speeds, a kind of multi-temporality, are intrinsic to the result of producing different kinds of knowledge. Drawing provides space for thought to form, for decompression and release which is essential for the creation of new ideas.
>
> (Anderson, journal entry, 2014)

One way of looking at drawing is to see it as a honing of the human being as an instrument suitable for scientific or artistic work, an idea that is important to the process of Goethean observation: 'For Goethe, the human being is the most powerful and exact instrument if we take the trouble to sufficiently refine our sensibilities' (Goethe and Naydler 1996: 23). In the dynamic process of drawing, then, the drawer is the mediating instrument as the eye constantly moves over areas of contrast in the dynamic process of seeing. The eye navigates the object searching for lines, structures and patterns, for dark, light and colour. Drawings not only represent the subject they describe but also the embodied human experience of the seeing process itself.

Drawing and the tacit

Michael Polanyi summarizes the idea of tacit knowledge in his work *The Tacit Dimension* with the assertion that 'we can know more than we can tell' (1967: 4). By this he implies that there is knowledge that cannot be adequately articulated by verbal means, and suggests that all knowledge is rooted in some kind of tacit knowledge. Polanyi tells us that tacit knowledge can be acquired without language and this is part of the reason why it can be difficult to share and to describe. Observation and drawing combine to form tacit and language-less knowledge of the specimen. Therefore drawing, like observation, is its own teacher. Polanyi also tells us that the key to acquiring tacit knowledge is experience and that without some form of shared experience it is difficult for this knowledge to be disseminated. The drawing practices generated through my research can only be shared within a relevant and situated context. As a method for creating an appropriate context, workshops have proven an integral part of the work. The realization of the full potential of drawing as a way of knowing requires the engagement of the drawer, or what Polanyi refers to as 'the knowing subject' (1967).

An example of tacit knowledge that relates to this work, which aims to recognize and to know morphological features through drawing, is that of facial recognition given by Lam (2000: 489), 'We know a person's face, and can recognize it among a thousand, indeed a million. Yet we usually cannot tell how we recognize a face we know, so most of this cannot be put into words'. When observing a face, or in this case a museum specimen, knowledge of the individual features is not always conscious, but it is still possible to recognize the museum specimen through recall, association or direct handling, which all contribute to a tacit way of knowing (Lam 2000).

Another way that I have understood the tacit nature of drawing as a way of knowing has been through comparing drawing with walking. Rather than understanding walking as an

artistic medium, I see walking as a practice that helps to direct the complexity of thought – often as a linear movement, a function comparable to drawing. Walking has enabled me to think about drawing as a parallel activity one dimension up: walking is drawing with an added dimension. The linear movement, forming through space, is sometimes punctuated by observations and restful reflections that weave in and out of focus. Walking is a dynamic way of experiencing the movement, rhythm and tempo of the body as it creates invisible lines within a landscape. As such, the trace of a walk can be compared to the trace of a drawing; a body scaling the landscape as the hand and drawing tool scale the page, or, as Klee famously put it 'taking a line for a walk' (1973).

In walking I am most frequently following a line – a path that has been defined for me and walked by countless others – whereas in drawing I create the line freely within the space of the page. My eye is following the lines of the morphology I am observing, and I visualize this process as analogous to how the body follows the physical lines carved in the landscape. Like drawing, walking provides a space to reflect without interruption, offering unique intellectual value in the reorganizing of concepts and revitalizing of ideas. Drawing expands thought in space and time and enables elements to move around and to recombine, to move forwards or backwards, or just to move around. Walking through a landscape becomes a way to get to know the shape of the landscape over hours and days and to feel the three-dimensional form of the landscapethrough the senses. Both drawing and walking are processes that enable an individual – as an agent – to know and transcribe the world as a three, even four-dimensional space.

Drawing brings a deep sense of embodiment and connection to our experience of the world, providing a space to hold and to unfold complexity. There are continuous changes: pausing to observe, choosing direction, changing tempo, transitioning between focused and wider attention, inside and outside the line, of selecting what to take forward and what to let go.

> As I draw and walk, I wonder what is the difference of being within and without the line? To be within is to be moving, with direction [...] contained [...] pausing, reflecting, with a sense of direction, purpose and growth. To be without loses direction, focus, and linearity. The drawn and walked lines that I make are not straight, they meander in and out of near and far, of particular and whole, pausing and changing direction as the path unfolds, always in a state of becoming... experienced as the moving present. Through the line we pass from where we have been to where we are going. The drawn experience is always a dynamic one.
>
> (Anderson, journal entry, 2014)

The haptic: Working in the museum

The drawing process aligns internal duration with external representation. The act of handling museum specimens reduces the physical distance between the observer and the

observed. In this handling process, the duration of viewing might differ greatly, all the way from a glance to a profound meditation. The drawing process, as a lived, physical experience, provides embodied connection with morphological structures.

In order to test my intuitions of the shared morphological characteristics of animal, mineral and vegetable species, I chose to observe directly from specimens in the museum and in the field. Drawing museum specimens from life is the preferred method for the exploration of the Natural History Museum's collections, and vital to this exploration is the handling of each specimen, which activates a to-ing and fro-ing between the optic and the haptic. Handling and sensing the specimen can evoke ideas about representing form and texture through line and mark-making, for example: sharp edges can be represented through angular lines or the hand can be used as the measure of scale, noticing that spindles on a shell are a finger's distance apart.

The handling of museum specimens allows for an intimate gaze and connection to the object. The ability to rotate and to choose a perspective from which to draw is crucial in order to find the angle that reveals the morphology clearly and makes it comparable to the morphology of others. The drawer must select the salient information from the subject. The decisions I make when drawing from the museum specimen are different from the decisions scientists make, although the approach has many shared characteristics (as explored further in Chapters 3, 7 and 8).

Drawing, etching and watercolour

One of the main characteristics of morphological drawing in both science and art is of describing form with a simple, economic line that reduces the aesthetic 'noise' of the morphology as observed in real life. This approach to drawing is not concerned with shading or gesture, but is concerned with rhythm, mark making and delineation. At an early age, I was inspired by morphological drawings in scientific textbooks and by the drawings of Leonardo da Vinci (da Vinci 1980). I have consciously maintained an approach that is consistent and comparable with this history of scientific and artistic drawings that hold epistemological value. In order to communicate to both art and science practitioners and audiences, it is important that the drawings created through this research are comparable to (but not the same as) other morphological drawings. The etched line is also consistent with the fine lines of scientific drawings.

The line can be interpreted as a navigator and container for the complexity of the mass that it travels through. If we take the line as an analogy for a 'pathway' – a term often used in science more generally (think of blood cells travelling in lines, and arterial and metabolic pathways) – the line delineates and creates definition for mass. All lines are linear but this does not mean they are all straight. A drawing can be a composite of many linear lines without being itself linear or 'a' line as a whole. The line can create a pathway where there was none, follow an existing path or evolve a new pathway of thought, guiding and giving form to our experience.

After years of practice, etching has shown itself to be a medium suitable to represent the morphological characteristics of animal, mineral and vegetable species due to the fine, anatomical quality of the etched line, which can both reveal and compare form. The use of watercolours (see Chapter 7) emphasizes the gradual nature of form change and takes direct inspiration from Paul Klee's colour gradation method, which can best be understood as a numerical ratio of changes and as a continuous contrasting to and fro movement of tone and/or colour (1973: 340). Klee compares the intensity of colour gradation to sound, describing the movement/gradation of colour along a 'tonal scale' (mixing each colour for each gradation) and suggesting colour gradation as a signifier of gradual change over time by adding a sense of motion and transformation.

Microscopy for and through drawing

Inspired by pioneering drawings from the microscope such as 'The Art of God' by Robert Hooke (1665), this book offers contemporary reflections on the act of drawing the microscopic. Often when drawing through a microscope, it is difficult to immediately recognize even the general nature of what we are looking at; whereas when observing a specimen at macro-scale (the correct scientific name may not be known), it is still possible to recognize that the specimen is a mineral. This is not always the case under a microscope: it is often impossible to tell from observation if the object is animal, mineral or vegetable. It is not possible to rely on previous knowledge or assumptions as in the case of drawing a figure or a landscape. Drawing in the unknown microscopic territory helps to maintain openness to the drawing process and disables the tendency to assume a name or identification prematurely. This unfamiliarity forces the creation of new questions and, in return, new knowledge. Once the microscopic subject has been removed from its natural context, its abstracted state as a scientific specimen is then more conducive to further methods of abstraction through the drawing process.

A difficulty often encountered when drawing from the microscope is the 'interruption' in the drawing process, i.e. having to look through the lens and then look away towards the page and then to find the previous viewpoint. A microscope slide is a two-dimensional cross-section, literally a 'slice' that does not have depth. This makes the experience of drawing from a slide and a photograph very different. Even though a photograph is two-dimensional and therefore lacks physical depth, the image often presents an illusion of depth. There is no illusion of depth in the microscopic slide, which leads to the feeling of a more surface-based engagement with pattern. With a microscopic view, it is possible to get lost in the specimen as the familiar 'anchors' such as the head of a figure or the hill in a landscape are no longer available. The microscopic slide is a cross-section existing within a two-dimensional plane, an alien environment that can be entered through drawing. The identification of pattern helps when drawing with the microscope, as the pattern provides structure for drawing from which we can refer back to the specimen for the particular details. Recognizing a morphological pattern, for example, the repetition

of a branching or spherical form, is helpful but can also limit understanding, as there can be an inclination to cling to the pattern – to rely or rest on it – which can make the observation less active. To counter this, it is preferable to draw as continually informed by the particulars of the specimens, considering each as a variation on the 'type' of pattern that is recognized.

Drawing workshops

Workshops are central to the evaluation of drawing as a way of knowing. I have considered the drawing practices developed to be valuable if they prove transferable between my own practice and an art, science or general audience. Each workshop is developed through and for testing this transferability, which incrementally builds insights from participants that lead to new questions and new possibilities for the practice. Workshops are not only about the morphological topic (botanical, mineral, zoological) but also about drawing as a way of knowing.

Drawing from exhibitions and archives

In order to understand how my own drawings can offer understanding of the natural world, it is important to assess the kind of knowledge gained from the drawings of others. Visiting exhibitions and archives to observe and draw artworks is essential to understand the epistemological value of the drawings of others. This close observation of drawings as artefacts involves exploring how both the process and the object of drawing can create knowledge and meaning for others. Moreover, the handling of other artists' drawings in the archive allows for an intimate gaze and encounter with the physical drawing.

Working with the Natural History Museum (NHM)

The collaborative element of this work is multi-faceted in nature: both formal and informal, involving meetings, working with scientific collections, formal and informal conversations and drawing. Collaboration is essential to access specimens and to enter into dialogue with museum curators and scientists who know about the morphology of their collections. Direct engagement with scientists provides a first-hand account of scientific practice, which allows the opportunity to observe and to compare scientific and artistic approaches, while working within the museum provides a space to test drawing as a mode of knowing in a scientific context.

Despite my lack of formal scientific training, I have embedded my artistic practice within the conventions of scientific institutions and collections. This practice has generated

unconventional questions and has resulted in an unconventional body of knowledge. During this process, it has been important to observe the practice of scientists at the museum in order to realize what is shared between these scientific practices and my own method, for example; observation, trained judgement and abstraction.

As a morphological study, this practice has grown from and required the existence of an evolving interdisciplinary network: a (fragmented) collection of natural scientists, mathematicians, philosophers and artists in London, Exeter and Cornwall. This is necessary because the natural sciences, mathematics and art overlap in their study of form, and there are many aspects that are complementary to one another.

Collaborating with natural scientists and mathematicians has affected the focus of my attention on specific scientific objects, which can be observed or reached through conceptual means to address my questions. For example, natural scientists at the NHM directed my attention towards specimens that I had not previously considered or known about, and mathematicians could answer my questions about the nature of certain forms through collaborative drawing. At first, a lack of scientific understanding seemed to be a limitation but, in time and through experience, I have grown to appreciate the 'extra-scientific' value of the questions I brought to these collaborations. These questions of drawing are different but related and often complementary to those of science.

On the role of conversation in collaboration

Conversations range from informal exchanges to more focused conversations where specific questions are prepared in advance to aid the investigation and to take advantage of the evidence that often emerged from chance conversations, not only with collaborating scientists but also with fellow artists. Conversations have been a way to triangulate evidence, ideas and clues I had been gathering, for the construction of the arguments that are presented in this book.

Conversations have proved to be a lively form of critique within the creative collaborative process, generating ideas and demanding pauses in mid-conversation to make notes or draw an image that has arisen. While this process deviates in many ways from the traditional process of making an art object, it is essential to this practice, which breaks away from the role of the artist in the studio in order to react to and interact with science.

Conclusion

Like all methods, drawing has its limitations: the interplay between subjectivity and objectivity in drawing, the limitation of working with a few collaborating scientists and the

relative slowness of drawing. This discussion provides key features that constitute drawing as a way of knowing in the context of art and of science where the knowledge created depends on the tools that have been used. Knowledge becomes embedded in drawing, not simply by looking for information in a different place or time, but of learning to see in a different way by creating new conceptual models, which like all models are always provisional and should never be treated as final.

Anderson, Gemma,
2012-2014,
'Four Fold Symmetry',
Isomorphology series,
copper etching
'a la poupeé'
on Lithograph