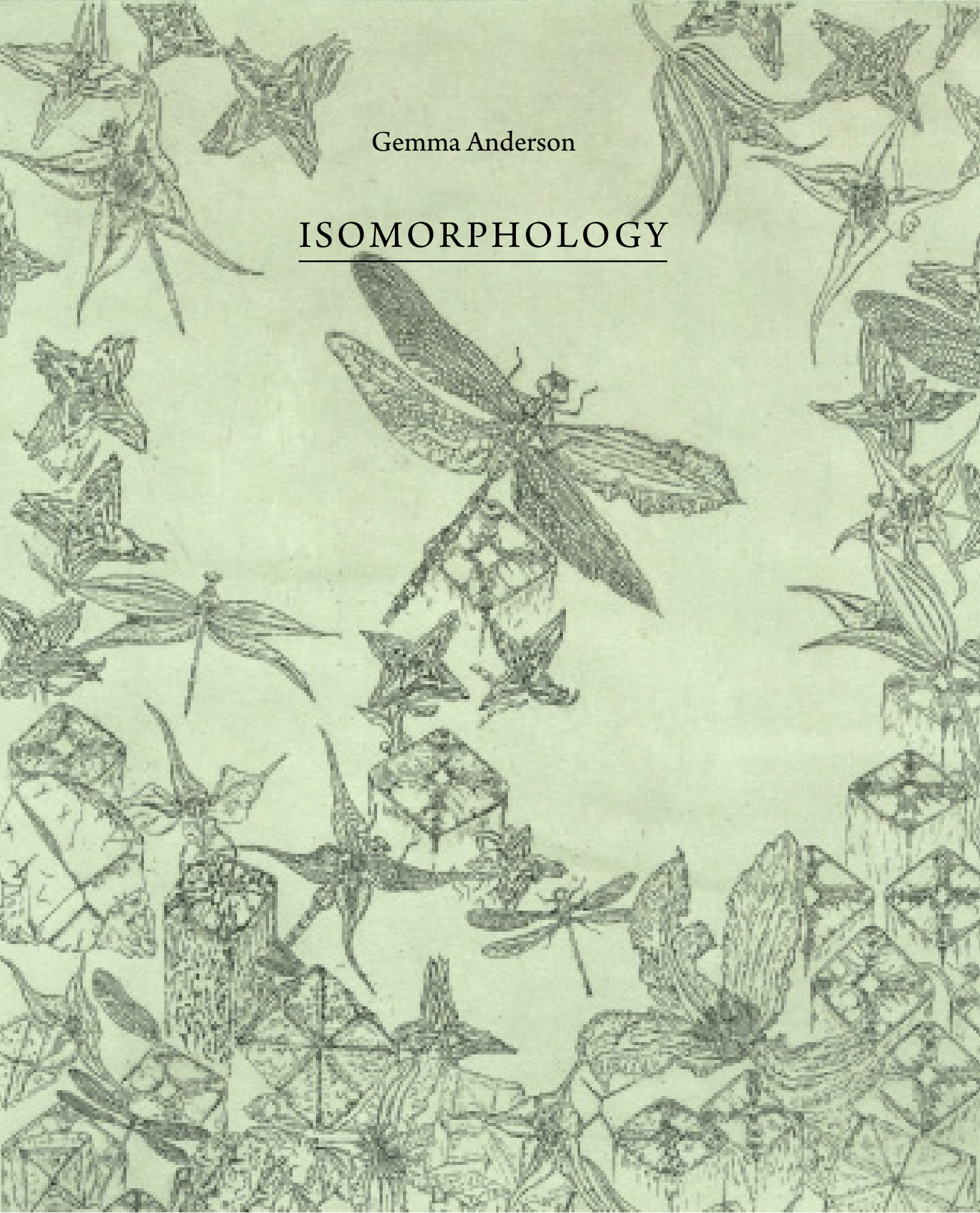

Gemma Anderson

ISOMORPHOLOGY

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ISOMORPHOLOGY

7 February - 6 April 2013

Contents

'ISOMORPHOLOGY: HEXAGONAL FORM' COPPER ETCHING, 2013. DRAWN FROM NATURAL HISTORY MUSEUM COLLECTIONS.

An introduction

CHIARA AMBROSIO

Gemma Anderson's work is quietly controversial. At its core lie silent practices – observing, drawing, etching, building models, experimenting with photography. It is the tacit dimension of these practices that informs her visual inquiries into the nature of form. A genuine blending of artistic and scientific experimentation, Gemma's work cuts across morphologies – animal, vegetable, mineral – and brings out new modes of seeing, categorising and classifying the world.

Isomorphology is the convergence of the grammar of seeing and the grammar of drawing. Conceived as a way of stretching the boundaries of traditional classificatory practices, isomorphology is an inquiry that runs parallel to scientific classification, and borrows some of its methods for the purpose of interrogating it. The starting point of Gemma's work across art and science is observation – the most ubiquitous and yet less discussed practice in scientific experimentation. Observation in science is a way of training the eye, of calibrating what we see against what we know, of giving stability to the objects of our inquiries. This characterization of observation implies that there is much more to the process of observing than just the passive registering of data from the world outside us. Construed as a process which is deeply intertwined with scientific inquiry, observation is inseparable from understanding and ordering the world. Isomorphology is built on this dynamic conception of observation, in which the eye of the artist and the eye of the scientist, each 'observant' in their own ways, are placed side by side to learn from each other and challenge each other's visual priorities. Observation in this context is not simply restricted to vision. It is, instead, a whole epistemic ethos built on a myriad of simple gestures and tacit practices such as focusing microscopes, learning to handle specimens, experimenting with new configurations and materials that will bring out common morphologies.

Drawing is one of the ways of giving voice to the unspoken grammar of observation. Gemma rescues the 'endangered' practice of observational drawing in science and places it right at the core of her artistic experimentation. Her approach is based on the simple principle that artistic practice does not merely 'illustrate' scientific concepts: in isomorphology drawing is a way of producing knowledge. Perceived resemblances, as in the case of Gemma's work on the Rashleigh Mineral Collection, play a key role in her visual arguments about the epistemological value of drawing. Here the science of mineral morphology blends with popular and vernacular ways of making sense of nature to generate new modes of classification. Drawing is a way of bringing out practices that pre-date the systematic classification of mineral specimens, at the same time showing the limits of our current classificatory practices. Resemblance in this case is not inherent in the structure of the world: it is a relation, or rather a plurality of relations, that are discovered through the very processes of observing and drawing. Far from simply mirroring phenomena, drawing discloses new resemblances and fills undisclosed portions of the world with new significance.

Gemma's practice displays the features of a process of experimental inquiry in other respects. Her exploration of the many languages of form extends from drawing to a broader range of representative practices, all modelled on scientific experimentation and yet all reflecting concerns and questions that are framed and directed by her artistic sensibility. Etchings, photography, ceramics and mathematical models realised in various materials are complementary practices that speak of the many ways in which form emerges as the end result of a process of deep immersion in the physical and conceptual spaces of science. This is well exemplified by Gemma's work in collaboration with mathematicians at Imperial College. Here drawing gives way to a manifold of other practices – paper sculptures, ceramics, 3D rapid prototypes – which 'liberate' mathematical forms by giving them a presence and a tangible materiality outside the virtual world of computer software.

Gemma's approach to artistic experimentation has important consequences. If artistic practice is construed as a way of producing knowledge, then it should be placed in open dialogue with scientific knowledge, from which it absorbs methods and modes of inquiry. Here Gemma's work serves as a lesson on the ways in which artistic practice can function as a constructive critique of the assumptions and modes of working that scientific practitioners take for granted. Isomorphology stretches the boundaries of classification and experimentation, and in doing so it suggests that there are many ways in which we can pick out, explore and organise portions of the world. Science is one of them, but its very methods and aims should be projected toward a creative expansion of the categories we use to make sense of the world, rather than imposing a single method of producing knowledge. More importantly, isomorphology suggests that artistic practice, when truly engaged with science in the pursuit of common goals, should embrace its obligation and responsibility to feed back into scientific practice itself, and contribute to the growth of scientific knowledge. This critical mission, which I like to define provocatively 'artistic visualisation as critique' should be taken very seriously by artists and scientists alike, especially in a time of interdisciplinary collaborations and artist-in-residence programmes. Far from being considered as dispensable accessories in the toolkit of scientific visualization and communication, artists have now the opportunity to take an active role in scientific inquiry, by re-opening questions that scientists themselves have stopped asking. In this respect, artistic practice seems to share many of the features that characterize the role of philosophy science: that of questioning, disturbing and challenging assumptions that scientific practitioners take for granted.

It is in this sense that Gemma's work is quietly controversial. The silent space of observation, the simple and tacit gestures that accompany it, offer a frame and a context for reassessing aspects of our knowledge that are taken as self-evident, established and in no need of further elaboration. If science intends to continue to take pride in its fallible attitude and pose it as a model and a value for other forms of knowledge, then it should cherish the challenges and opportunities that isomorphology discloses. In interrogating foundational aspects of science – observation, classification, representation, experimentation – isomorphology interrogates the limits of our knowledge and directs our scientific gaze toward new questions, new practices and new challenges.

Chiara Ambrosio
University College London
January 2013

'ISOMORPHOLOGY: FOUR FOLD SYMMETRY' COPPER ETCHING, 2013. DRAWN FROM NATURAL HISTORY MUSEUM COLLECTIONS.

What is Isomorphology?

Isomorphology is a comparative, drawing based method of enquiry into the shared forms of animal, mineral and vegetable morphologies. As a holistic and visual approach to classification, Isomorphology runs parallel to scientific practice while belonging to the domain of artistic creation. It is complementary to science: addressing relationships that are left out of the scientific classification of animal, vegetable and mineral morphologies.

Drawing is a method, which can reveal the shared forms of conventionally unrelated species and the drawing process is intrinsic to the epistemological value of Isomorphology.

1. Observation

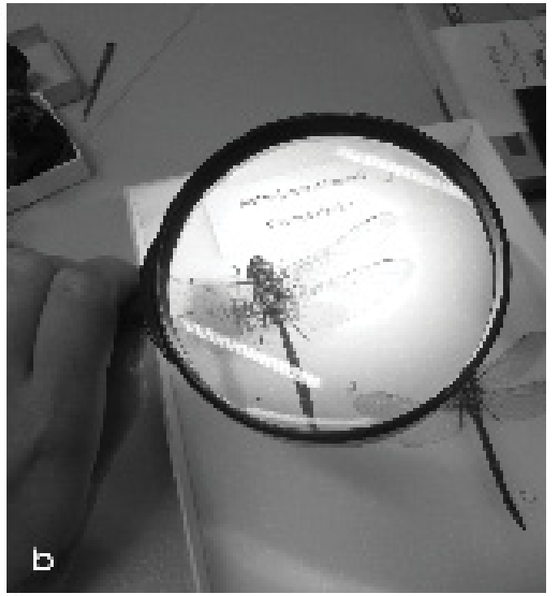
Permission to draw and handle each specimen enables close observation, revealing unexpected comparisons of form. Observational drawing involves hand-eye coordination, analysis, delineation, abstraction, improvisation, collage and deep concentration. Perception of the object is a process of transition from experience to judgement, insight to application.

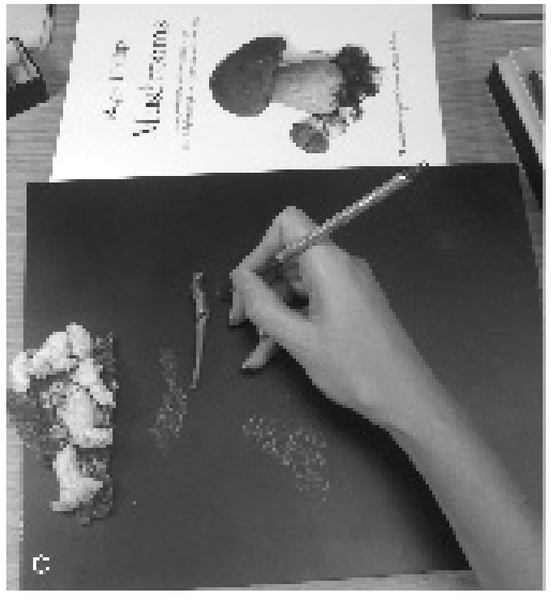
2. Trained Judgement

Concentrated observation within the act of drawing creates new perceptual knowledge. The morphology is observed in detail – activating the process of comparison. Each form observed joins a bank of knowledge in the observer's mind and each new drawing experience triggers a different formal memory stored in this bank. Each drawing adds value to each drawing previously made, and vice versa.

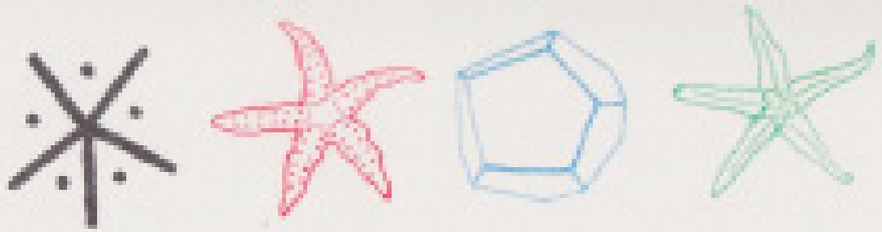
3. Abstraction

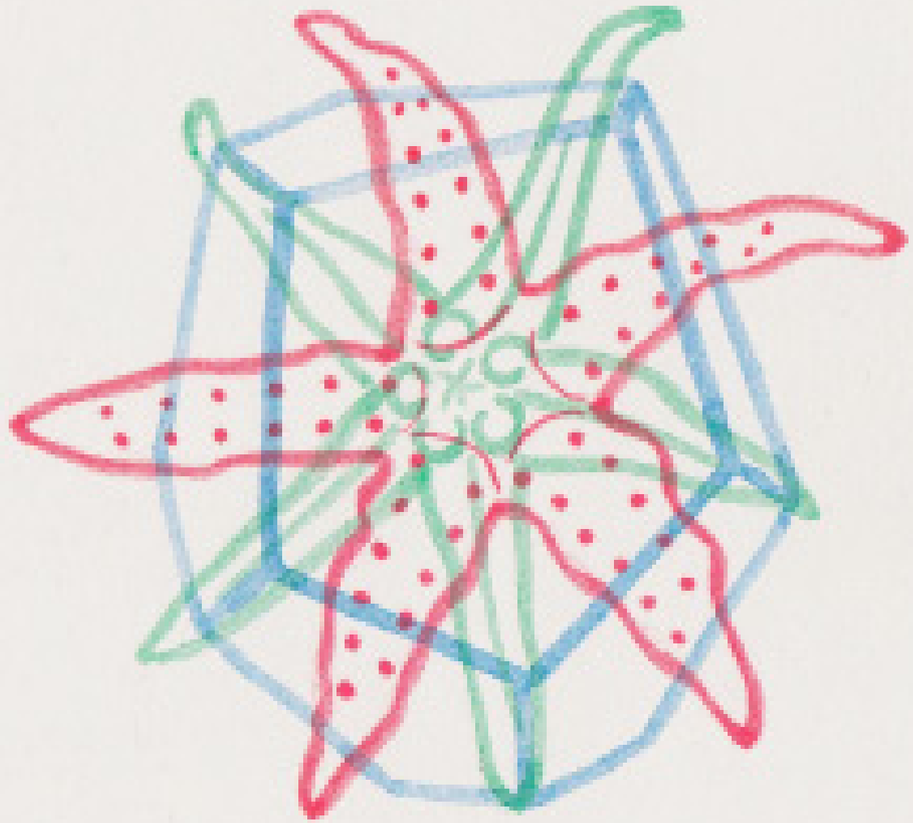
A necessary process of abstraction occurs during the observational drawing process. All knowledge of the object and its conventional context and name are forgotten; what is left is an involvement in the form of the specimen. The concentration shifts from drawing the whole to drawing a series of parts. This process, which concentrates on form, trains the artist to abstract: to draw and to play with the form, eventually without observing the object and thus entering a new realm of understanding.





[A] DRAWING NEMATODES WITH THE AID OF A LEICA MICROSCOPE, DARWIN CENTRE, NATURAL HISTORY MUSEUM
[B] ANISOPTERA AND MAGNIFYING GLASS, ANGELA MARMOT CENTRE, NATURAL HISTORY MUSEUM
[C] DRAWING FUNGI SPECIMEN DIRECTLY ON TO COPPER PLATE, MYCOLOGY DEPARTMENT, KEWGARDENS
[D] DRAWING DENDRITIC COPPER FROM THE PRIVATE MINERAL COLLECTION OF COURTENAY SMALE, CORNWALL.



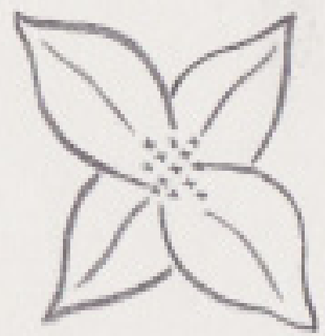


'RISOGRAPH PRINT FROM ISOMORPHOLOGY: AN INTRODUCTION, 2013. SUPER/COLLIDER, LONDON.'

Four fold symmetry

Animal: Anisoptera

Mineral: Andaluite



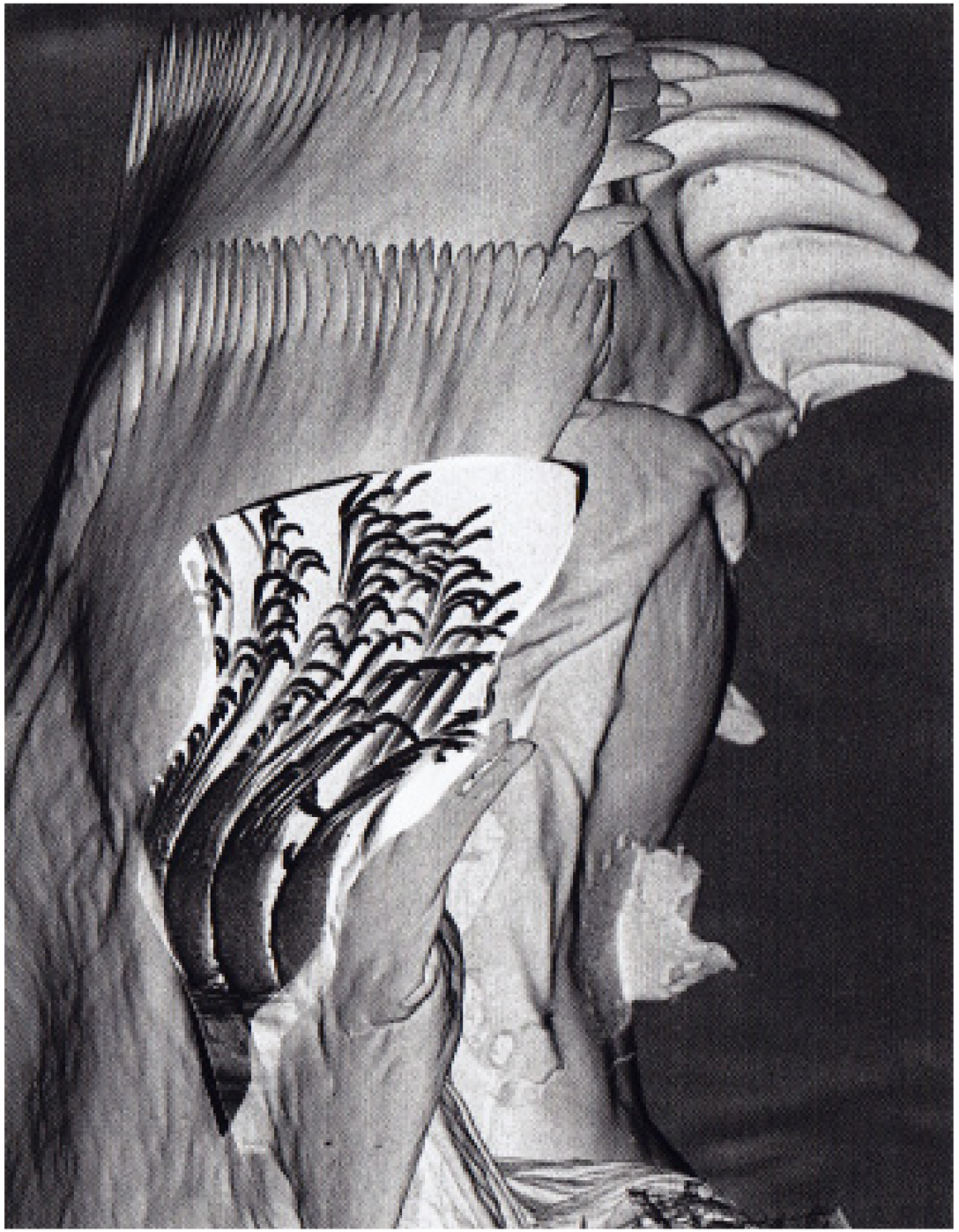
Vegetable: Cornaceae

'SIDERITE' COPPER ETCHING, HAND PAINTED WITH JAPANESE INKS, 2012, DRAWN FROM THE RASHLEIGH MINERAL COLLECTION, ROYAL CORNWALL MUSEUM.

'AEONIUM' COPPER ETCHING, ON LITHOGRAPH, 2012. DRAWN FROM TRESCO ABBEY GARDENS.

To introduce the following research I refer to the themes of Observation, Classification and Form. These themes are evident in the following research documents and run throughout my PhD research, currently titled 'Isomorphology: Classifying natural forms through drawing practice: animal, vegetable, mineral.'

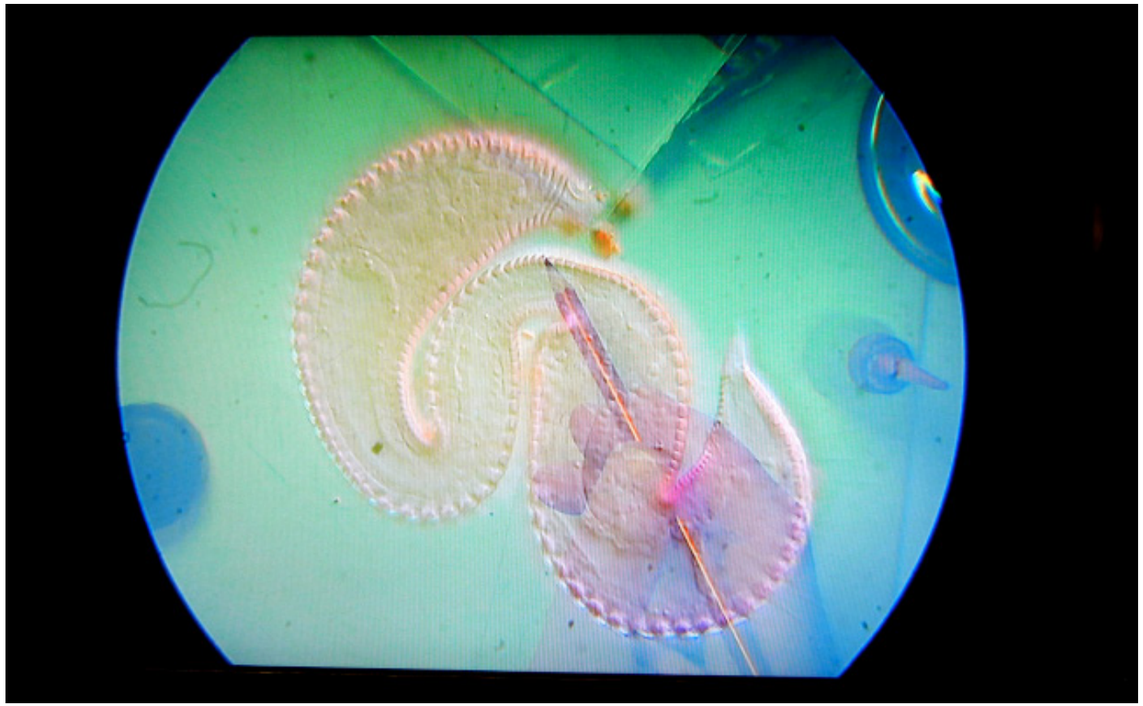
SCANNING ELECTRON MICROSCOPE COLLAGE PHOTOGRAM (SILVER GELATIN PRINT), 2012.



SCANNING ELECTRON MICROSCOPE COLLAGE PHOTOGRAM (SILVER GELATIN PRINT), 2012.

Excerpt from ENDANGERED:
A study of the declining practice of morphological drawing in Zoological Taxonomy

GEMMA ANDERSON



CAMERA LUCIDA VIEW OF MICROSCOPIC NEMATODE SPECIMEN. PHOTOGRAPHED IN DR TIM FERRERO'S LABORATORY, DARWIN CENTRE, NHM, 2012.

DRAWING IS NOT TIMETABLE-ABLE

Morphological drawing makes use of a camera lucida, a microscope mounted device, which performs an optical superimposition of the object being viewed onto the drawing surface. Both object and drawing surface can be viewed simultaneously, as in a photographic double exposure, enabling the draughtsman to trace the outlines of the microscopic object.

Observational drawing using a camera lucida involves intense concentration in a meditative space, without interruption, and it demands practiced hand-eye coordination, analysis, delineation, abstraction and improvisation. One of the values of drawing over photographic or molecular technologies is that the time spent observing the specimen evidences the perceptual learning process. As the object is delineated, it becomes comparable and consistent with the history of the visualization of the scientific object through drawing. The observer's perception of the object itself is in a process of transition from experience to judgment, insight to application.

DR NATALIE BARNES, DR TIM FERRERO AND THE NEMATODES

Natalie Barnes and Tim Ferrero study new species of nematodes. Four out of five living organisms are nematodes and they inhabit a significant part of the Meio fauna, a micro ecosystem. Scientists have studied and drawn nematodes since 1880, a history which allows characters in contemporary morphological drawings to be compared with historical drawings, in order to verify the diagnosis of the organism in question. As scientific knowledge accumulates, the function of drawing increases; as there becomes more scope for comparison, new drawings breathe life into old ones.

It takes about ten years of developing observation and microscopy techniques to know which characters are important and to become an expert capable of defining a species. Tim describes this process as 'a dynamic balance between similarity and dissimilarity.' He told me about a particular species: 'if you look at the image of Cheironchus, you see two enormous mandibles shaped like something between a grappling hook and a knight's mace [N.B. the colours differentiate characters in different focal planes]. This is a predatory animal and DNA analysis would put it in the correct family/genus of predatory animals, but the morphology of those mandibles really give an insight into the hunting behaviour of the animal – basically it is an ambush predator that uses its large mandibles to grab on to prey and hold on tight. Similarly, it's only when you see the shape of the epsilonematidae nematode that the true nature of its inchworm ambulatory behaviour can be clearly understood'. This is evidence of the epistemological value of Tim's morphological observations.

THE ARTIST AND THE CAMERA LUCIDA MICROSCOPE

Morphological drawing compiles a visual encyclopedia of the forms of life. To discover a new species is to discover new anatomical features, which add to the zoological vocabulary of form, which the artist can articulate through line. Unfortunately the drawings of morphologists are kept in museums, laboratories and libraries, and can be difficult to access.
Important to this study is the artists' experience and interpretation of the morphologists' drawing process. The following is an account of my experience of drawing at the NHM.

'On the 9th December, Greg set me up at his camera lucida microscope at the NHM. A new genus and species of scolopendrid centipede from the Australian desert was the specimen offered for observation. At first, my ocular gaze could not 'find' the camera lucida, it took a couple of minutes to locate the correct portal in which to view.
I was reminded of Hackings musing: "We do not see through a microscope, we see with one. But what do we see?"(Hacking) Once found, the specimen, the hand and the drawing tool are visible - it is quite magical. I had to resist my instinct to draw as I normally would, relying on my own estimations and decisions, rather, I found myself tracing the shadow of the ghost-like specimen, which the superimposed view of my own hand could pass through.
There are several reasons why I chose to draw straight onto copper; 1. my own drawing practice which uses line as a language to explore formal relationships has evolved from rotring pen to copper plate because I prefer the quality of line that can be achieved with copper etching. 2. I wanted to reposition the subject within the significant history of etching and engraving in the natural sciences.
The next experiment; switching the camera lucida off, I drew, unaided, activating the natural rhythm of my line. Interestingly I started drawing pores, which Greg said he would not draw, as they are not taxonomically important, but Rony would draw, as he considers every feature of taxonomical importance. Like Rony, I was interested in drawing all observable morphologies. As the observation endured, a labyrinth of forms curiously emerged. I began to perceive

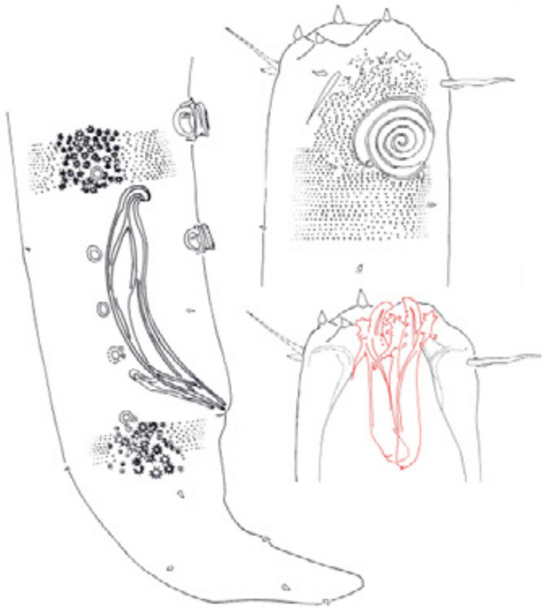
morphologies that would not emerge in a photograph. I share Barbara Wittmanns' belief that "drawing makes something visible that no other technology can make visible" (Wittmann). As I drew, my admiration for the interpretive work of the morphologist grew. In the observational drawing process, I found myself perceiving and visualizing new ways to compare forms, each observation opening a possible new route of comparison. Although my unaided drawing is not 100% morphologically correct, it conveys my perception and understanding more than the camera lucida drawing'.

'I returned to the NHM on the 26th of January, with an appointment to draw nematodes with Dr. Natalie Barnes and Dr. Tim Ferrera. Nematodes are very three dimensional. When drawing through the lens of the microscope, I constantly focus in and out as features exist at different ranges of vision. I quickly noticed I had adopted the following method: focus on one range and draw features that appear significant, then focus on next layer, draw, and so on. When drawing it becomes clear that there are so many structures on so many layers that it would be impossible to show the morphology with a photograph, also because the specimen is preserved in alcohol, it has lost its colour. Nematodes have radial, bilateral and tri-radial symmetry with pocket like structures and a lot of triangular biology. Drawing a nematode felt comparable to attempting to observe a mountain range from above, drawing each level of altitude, its geological features, and the whole mountain in focus.

It is essential to my own process of drawing to focus on the morphology of each part and to abstract this into a linear shape. Play must enter the work, and a process of free association, for example; comparing the main body of one of the nematodes to an accordion tube as it was concertina-like, the theatrical snake-like head-dresses, insect-like ornamental setae, and how the nematode bodies curl up in knots, reminding me of Scanning Electron Microscope images of the topology of DNA. In the act of observation, I develop hypotheses about new comparisons for the forms for example, through drawing I could also compare nematodes to Japanese knotweed and placental growth. I test my hypotheses by interchanging morphologies (i.e. by drawing the nematode in the form of a DNA knot). In this drawing process, where I am operating with my imagination, I am both telling the truth and lying at the same time. The value of direct observation for my own work as an artist lies in the formal discoveries which create a new group of imaginative associations that can be further developed through drawing.'

<u>DR GREG EDGECOMBE AND SEM TECHNOLOGY</u>

Greg started to use the Scanning Electron Microscope (SEM), and morphological drawing combined in diagnostic papers of type specimens about ten years ago, but, he has never published a drawing of a specimen that he has also imaged in SEM. One reason for this is that Greg draws specimens wet (preserved in alcohol), so internal anatomy is preserved and so the specimens can be checked as wet specimens by future generations of investigators. Although it is possible to use SEM with uncoated specimens (the Natural History Museum has an environmental SEM) Greg prefers the sharpness of images of specimens that have been coated. He has SEMed uncoated specimens at the NHM and describes the results as 'okay, just not as good, or sharp, or bold… It is a perfectly fine option if you really don't want to dry or coat a specimen (a historically-important type specimen, for example) but to my eye the coated specimens look better on the SEM'. Conversely when Greg images a specimen through SEM technology he dries it and prepares the specimen with a gold-/palladium-coat. Greg will not draw coated specimens because they lose some of the information, most notably- pigmentation. ' I treat the specimens separately. I have the "same" information in drawings and SEMs all the time, often even in the same standard orientation, but the image is always created from different specimens. My intent is to double up the amount of information by showing two different specimens in available page space instead of the more nearly redundant information that would apply were I to show the same specimen by two different illustration techniques.' SEM brings further understanding to the analysis, but it does not replace drawing. Greg compares the two images 'The drawing depicts the overall morphology most clearly, but the SEMs bring extra detail, such as what the surfaces look like.' Photography has its advantages, but drawing remains the sole technology that can detail and clearly show diagnostic features simultaneously in focus.



UNPUBLISHED FIGURES OF MARINE NEMATODES. T.J FERRERO & N. BARNES, NATURAL HISTORY MUSEUM, LONDON, UK, 2011

NEMATODE, COPPER ETCHING, JAPANESE INKS, DRAWN IN TIM FERRERO'S LABORATORY, DARWIN CENTRE, NATURAL HISTORY MUSEUM, 2012.

DETAIL OF DNA KNOT TOPOLOGY, COPPER ETCHING, JAPANESE INKS, 2012

The current general acknowledgment is that a species diagnosis that includes anatomical information (as can be conveyed via drawing) is more useful than photograph or DNA only papers. However, for many in the latest generation of taxonomists, who have not developed a morphological drawing practice, diagnostic methods are restricted to SEM and DNA analysis. It is a great idea to combine DNA analysis and morphological drawing, but the question is, will this younger generation 'know' how to continue the practice of drawing in taxonomy?

'The practice of drawing shapes the mind and it is often within the time and space of an observation of a specimen that a realization or even revelation may occur. Drawing is an intimate, devotional act of wonder at the many forms and puzzles species present. To draw is to know a specimen in a unique way. To study a drawing by another is to understand their view, their priorities, and their work'.

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Barbara Wittmann, "Knowledge in the Making: Drawing and writing as research techniques" Max Planck Institute.
Available at: http://knowledge-in-the-making.mpiwg-berlin.mpg.de/knowledgeInTheMaking/de/index html [Accessed 17/11/2011]

CERAMIC KNOT (BASED ON DNA TOPOLOGY), 2012.

ARAGONITE SPAWNING UNDER FULL MOON, DRAWN FROM THE NATURAL HISTORY MUSEUM, PALAEONTOLOGY DEPARTMENT CORAL COLLECTION, 2011

Resemblance Perception as Epistemic Drawing Process.

GEMMA ANDERSON

DETAIL OF 'MOLLUSC ORE' FROM 'PHILIP RASHLEIGH'S MINERAL NICKNAMES, COPPER ETCHING, A LA POUPEE. DRAWN FROM THE ROYAL CORNWALL MUSEUM, THE NATURAL HISTORY MUSEUM, KEW GARDENS, THE COLLECTION OF COURTENAY SMAYLE AND CAMBOURNE SCHOOL OF MINES, 2012'

In the catalogues of the Rashleigh Mineral Collection at the Royal Cornwall Museum, Truro, I discovered a blend between poetic fiction and scientific fact: a number of mineral specimens, which have been given playful nicknames by Cornish miners. There is a history of the scientific recording of specimens which bear resemblance to another scientific object, and Rashleigh's nicknamed minerals are one of the last examples of this episteme.

THE RASHLEIGH MINERAL NICKNAMES

Philip Rashleigh (1725–1811) collected Cornish minerals throughout his life. His collection, housed at the Royal Cornwall Museum is known for the quality of the specimens and for the quality of Rashleigh's system of cataloguing.

The catalogues where compiled between 1800 and 1810, a time when there where no systematic scientific names for these minerals, therefore a useful nmemonic device was the association of the mineral forms to familiar objects. Although it may seem unscientific to refer to minerals using nicknames, the use of resemblance to name, remember, and describe scientific objects of the animal, mineral, and vegetables kingdoms has a rich history. Until the 16th century resemblance played a constructive role in knowledge formation in Western culture (Foucault). Many of the minerals hidden in the depths of mines like Wheal Gunner and Wheal Towan (wheal being the Cornish name for mine) were mysterious objects, which had not been observed before. The miners projected meaning and identity on to these unknowns by association of colour, lustre or shape based on the miners local knowledge of Cornish Nature.

In October 2011, I visited the Courtney library at the Royal Cornwall Museum to consult Rashleigh's catalogue. When reading, it was interesting to discover how frequently the descriptions involved the term 'resemblance', for example the cassiterite specimen the miners nicknamed 'wood tin' is described as; "Plate one, wood like tin ore (tinners' term), with fibrous or radiated texture, forming concentric circles like wood, resembling the colour and appearance of wood cut from a knotted tree" (Rashleigh 1797). Although, when observing the minerals in the collection, I discovered that iron ore was much more wood-like than cassiterite and ascribed my own nickname of 'wood knot ore' to the specimen. Rashleigh described a number of specimens using the term 'resemblance' and he noted the nicknames invented and used by the miners as he found them interesting: others include 'beetle ore' and 'blister copper'.

This list acts as a classification of all specimens with in the Rashleigh collection which have been given nicknames;

1. Wood tin- cassiterite
2. Beetle ore- clinoclase
3. Brick (tile) ore- cuprite
4. Cog–wheel ore- bournonite
5. Cube ore- pharmacosiderite
6. Goose-dung ore-
7. Horn silver- chlorargyrite
8. Horseflesh ore- bornite
9. Horsetooth ore- siderite
10. Jack straw crystals- cerussite
11. Peacock copper- bornite
12. Ruby copper- cuprite
13. Sparable tin- cassiterite
14. Wood copper- olivenite
15. Toads eye tin- cassiterite

With the introduction of scientific names by the Mineralogical Association in the second half of the 19th century, mineral nicknames fell out of use and their documentation discontinued. Aside from the nicknames given by the miners other minerals in the Rashleigh Collection inspired both myself and mineralogist Courtenay Smayle to create our own mineral nicknames. For example Courtenay nicknamed this chalcedony specimen from the Williams Mineral Collection at Caerhay's Castle 'Griffin ore'.

RESEMBLANCE PERCEPTION AS EPISTEMIC DRAWING PROCESS

It is resemblance that organizes the play between the mineral specimens in the Rashleigh Collection and the objects they correspond to. Resemblance makes possible knowledge of the

CHALCEDONY AND DETAIL OF 'GRIFFIN ORE' FROM 'PHILIP RASHLEIGH'S MINERAL NICKNAMES
COPPER ETCHING, A LA POUPEE. DRAWN FROM THE ROYAL CORNWALL MUSEUM, THE NATURAL HISTORY MUSEUM, KEW GARDENS, THE COLLECTION OF COURTENAY SMAYLE AND CAMBOURNE SCHOOL OF MINES, 2012'

visible specimen and the invisible resemblance it shares with another specimen; drawing makes this invisible in-between space visible, establishing forms according to what they resemble. 'It is the dividing line that produces equivalences, in their unlike likenesses, and that lets one perceive things unrelated as the parts and portents, sections and signs, of one harmony' (Heller-Roazen).

I have used drawing to evidence the signatures and resemblances perceived in the Rashleigh Collection of minerals. In the etching, specimens are drawn and composed on the basis of their resemblances, each specimen poses as the object it resembles; the resembling forms are reassembled, and the mineral material of the specimen may not be perceived by the viewer.
Together the minerals form a landscape of resemblance.

This work demands the observation of each specimen, involving permission and appointments to draw at the Royal Cornwall Museum, The Natural History Museum, Camborne School of Mines, Kew Gardens and Courtenay Smayle's private collection.
'In Drawing this specimen, which resembled a griffin, I could articulate the forms in order to bring out the 'griffinness' of the specimen. In the perception of one form resembling another, the foundational relationships of symmetry and curvature can begin to be understood and visualized.'

THE ARTIST CREATES ORDER

I have developed unique methods of classifying the specimens I draw, employing a holistic approach to taxonomy, a comparative method that seeks to find similarities, not differences. I translate the forms of nature into a chain of resemblances, slowly merging object bodies into one another, creating a newly classified order:
each drawing, an experiment with individual modifications.

John Dupre echoes Foucault's The Order of Things (2001) with his book The Disorder of Things where he states "classifications, must, in some sense, be discovered rather than merely invented" (Dupre 1993: 17) and advises "there are countless legitimate, objectively grounded ways of classifying objects in the world. And these may cross classify one another in indefinitely complex ways."

My own principles of classification; applied through the process of drawing to 'Rashleigh's mineral nicknames'

1. The specimen resembles another object
2. The specimen drawn has the quality of illusion
3. The specimen displays isomorphic qualities
4. The specimen's form suggests playfulness
5. The specimen can be understood as a paradox of classification
6. The system of order is both discovered and invented
7. The organizing principle is one of analogy, drawing upon resemblances of morphologies in diverse organisms
8. The classification depends on objective properties of the specimen

Aims of these principles
1. To playfully displace the object from conventional models of classification and to disrupt established perceptions of the object.
2. To allow wonder to flow from nature's anticipation of art.

Dupre introduces the term 'promiscuous realism' and discusses how the seeker of any categorical order must ascend to some higher level of abstraction "to some category of which species, genera and so on are merely instances" (1993: 20). This raises the question of essences the signifier and the signified. Resemblance perception occurs both in the conscious observation of the specimen as a whole, for example, the specimen wood tin apparently resembled wood, but resemblance perception also occurs on a more subconscious level when the artist/observer is concentrating abstractly on the form and pattern perceived within the specimen. It is often in this more subconscious space that surprising resemblance perceptions occur. When drawing 'wood tin', a mineral specimen nicknamed after wood, because of its physical resemblance to wood, I perceived the forms within the specimen as wood like. A few weeks later when I visited Kew Gardens Bark collection to find a specimen of wood that the mineral had signified, I perceived that the individual nature of wood specimen also signified forms of objects such as minerals and biological forms. This led me to question the essence of what both mineral and the wood where signs of, and if they were both manifestations of one essential form.

"Resemblance imposes adjacencies that in their turn guarantee further resemblances one thing signals another and can continue infinitum, each specimen drawn begins a link that resembles another specimen and so continues in the chain of resemblances" (Foucault 2001: 20)

The markings and forms within nature's materials can be delineated through drawing.
Practiced observation develops a literacy of these marks, which become increasingly 'readable' and a continued drawing practice can articulate these marks into meaningful works. Of underlying importance to this is the trained judgment and pattern recognition in the observational skills of the artist working within a scientific context. By scientific context, I mean drawing from specimens within scientific collections, where it is not the scientist's, but the artist's job to recognize the poetic patterns.

In the language of drawing, a mineral can be compared to a plant, or an animal because the artist can find the common forms and use these forms as the alphabet for the drawing.

DETAIL FROM PHILIP RASHLEIGH'S MINERAL NICKNAMES, COPPER ETCHING, A LA POUPEE. DRAWN FROM THE ROYAL CORNWALL MUSEUM, THE NATURAL HISTORY MUSEUM, KEW GARDENS, THE COLLECTION OF COURTENAY SMAYLE AND CAMBOURNE SCHOOL OF MINES, 2012

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PHILIP RASHLEIGH'S MINERAL NICKNAMES, COPPER ETCHING, A LA POUPEE. DRAWN FROM THE ROYAL CORNWALL MUSEUM, THE NATURAL HISTORY MUSEUM, KEW GARDENS, THE COLLECTION OF COURTENAY SMAYLE AND CAMBOURNE SCHOOL OF MINES, 2012

Excerpt from ‘On Drawing and Mathematics’

GEMMA ANDERSON
DR TOM COATES
PROF. ALESSIO CORTI
DR DOROTHY BUCK
(Imperial College London)

“Thinking is really the same as seeing.”
William Thurston, mathematician, 1946–2012

Drawing as mathematical proof

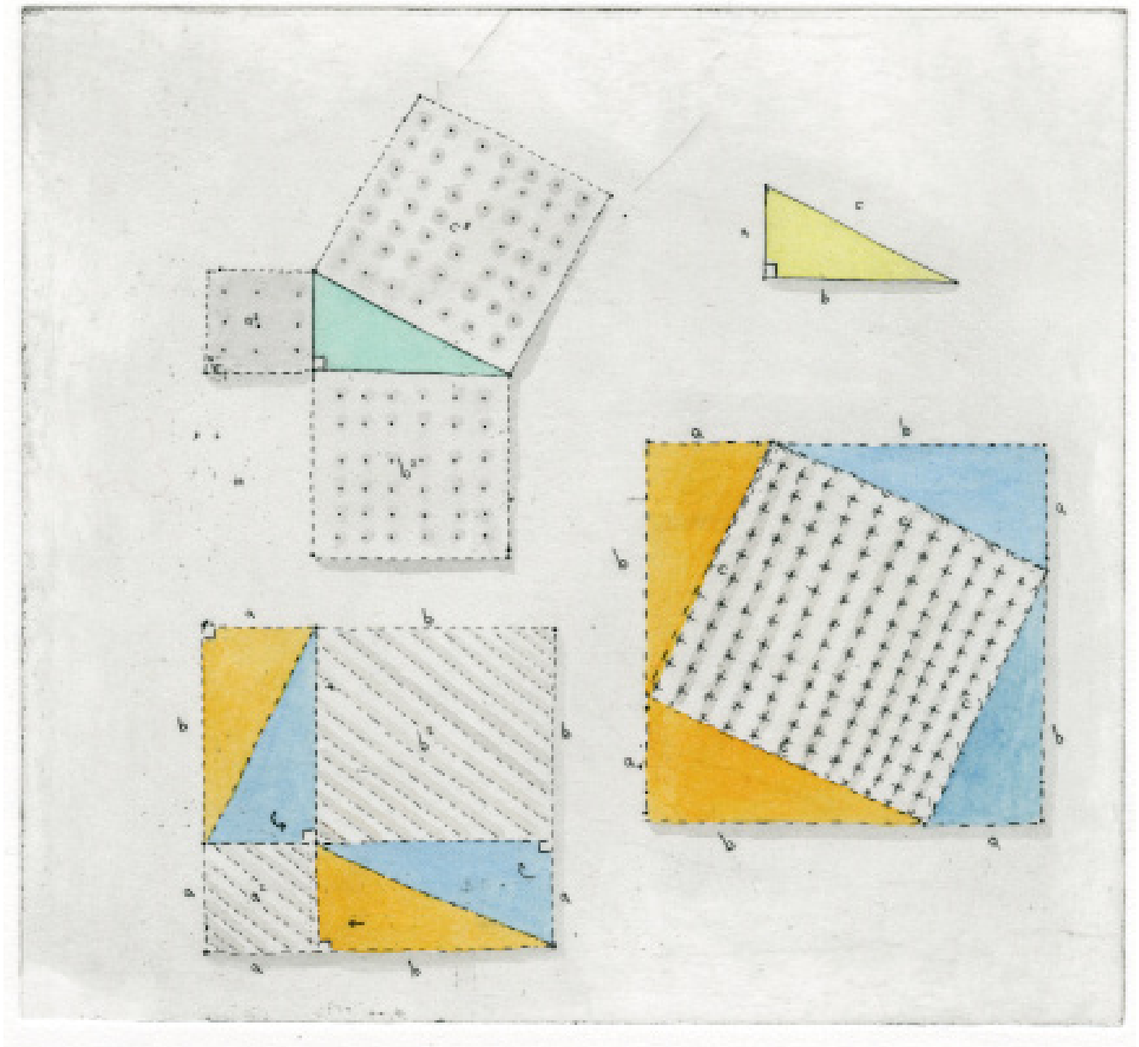
One way that drawing arises in mathematics is through drawing-based mathematical proofs. A proof is a logical demonstration that some statement is true. Starting from something that is known to be true we make a sequence of deductions, each following unassailably from the step before, that end with the desired statement. We illustrate this with the famous Theorem of Pythagoras:

“In right-angled triangles the square on the side opposite the right angle equals the sum of the squares on the sides containing the right angle.”
[T. L. Heath, Euclid: The Thirteen Books of The Elements, Dover, 1956]

In other words, if the sides of a right-angled triangle are of lengths a,b and c , as shown in the etching: the $a^2 + b^2 = c^2$. Let us prove this. Consider a square with side-length a + b , partitioned as shown on the left:

One shaded square (the smaller one as shown) has side-length a, hence area a^2. The other shaded square has side-length b, hence area b^2. The total shaded area is therefore equal to $a^2 + b^2$. Each of the four triangles is right-angled, and the sides adjacent to the right-angle have lengths a and b; thus in each case the hypotenuse (the side opposite to the right-angle) has length c. Thus, each of the four triangles is a copy of that shown in Figure 1. Now consider the same square, partitioned in a different way:

Once again, each of the four triangles is right-angled with sides a, b, c, and thus is a copy of the triangle in Figure 1. In particular, therefore, the length of each side of the shaded square is c, and so the area of the shaded square is c^2. Yet the total shaded area shown in Figure 2 must be equal to the total shaded area shown in Figure 3, for they are each equal to the area of the large square (a square of side-length a + b) minus the area of four copies of the triangle from Figure 1. It follows that $a^2 + b^2 = c^2$. QED



PYTHAGORAS THEOREM: DRAWING AS PROOF, COPPER ETCHING, WATERCOLOUR, 2012

Not every mathematical drawing is a proof. For example, a drawing of a circle is not a proof; it is just a picture of a mathematical object. For a drawing or drawings to form a proof requires that the drawings convey or cause reasoning. In this paper we consider various different mental processes: mathematical proof is our paradigmatic example of what we will call *linear logical thinking*, and so a drawing-based proof must cause or convey linear logical thinking.

Drawing-based mathematical proofs are rare, and indeed only occur in certain sub-fields of mathematics. But there is a different, and much more widespread, use of drawing in mathematical research: as a channel for intuition and creativity. This occurs in many different parts of mathematics, even in those sub-fields which frown on drawing-based proofs.

The liberation of form

Drawing has been a major part of our collaboration, as a language for discussing the scientific ideas involved and as artistic output. But the drawings involved are far more than direct communication or

translation. Our collaboration began in 2011, when Anderson found herself reading the Imperial College Newsletter article 'A Periodic Table of Shapes'. This article introduced Fano Varieties, studied by Coates and Corti, as atomic pieces of mathematical shapes.

Anderson was immediately attracted to the alien, beautiful forms of the Fano Varieties. Furthermore, Coates and Corti's research project aims to classify Fano Varieties and Anderson, who has a longstanding interest in drawing and classification in the natural sciences, was struck by the fact that these geometric forms have no satisfactory system of classification. She took the article back to her studio and began to make drawings, exploring the forms. Later this developed into a fully-fledged collaboration, first between Anderson and Coates and then between all of us.

Through drawing and modelling, we played with instinctive ideas of how to order and express the forms; for example Anderson made an etching of all the rank-1 Fano Varieties, classified by shape and resemblance to one another. To give body and weight to the forms, which previously had no physical existence outside digital computer software, we experimented with 3d printing and casting, and with making interlocking paper sculptures called sliceforms. The paper making up the sliceform of a Fano Variety is etched with images related to that Fano Variety, such as Cayley graphs of the associated modular symmetry groups. In building the Fano models we make contact with a long tradition of mathematical model building in the 19th century[1], now largely lost; but we revisit this with the full power of 21st century mathematical science[2] and with a blend of traditional and modern techniques (etching, hand-tinting, casting; Rapid Prototyping, laser cutting, computer algebra, computer-aided manufacture).

'In every century, the way that artistic forms are structured reflects the way in which science or contemporary culture views reality'. (Umberto Eco, Opera Aperta (Milan: Bompiano, 1962).

COPPER INVESTMENT CAST OF FANO VARIETY, 2012

To build the models we had to develop new software and algorithms for building sliceforms from algebraic equations, and also for turning these equations into the thickened polygonal meshes required for Rapid Prototyping[3].

The drawing occurring in our artistic collaboration is quite different to the modes of drawing that we have discussed so far. In mathematics drawing is typically an informal process, which is later translated into algebra or text. In Anderson's process there is no further translation: the drawing is the work. Through drawing and modelling, the forms are liberated and can exist and function on different levels. They are no longer constrained by their mathematical meaning but become accessible to different forms of understanding and appreciation: by artists and the wider public.

'A work of art, therefore, is a complete and closed form in its' uniqueness as a balanced organic whole, while at the same time constituting an open product on account of its susceptibility to countless different interpretations which do not impinge on its unadulterable specificity.' (Umberto Eco, Opera Aperta (Milan: Bompiano, 1962)

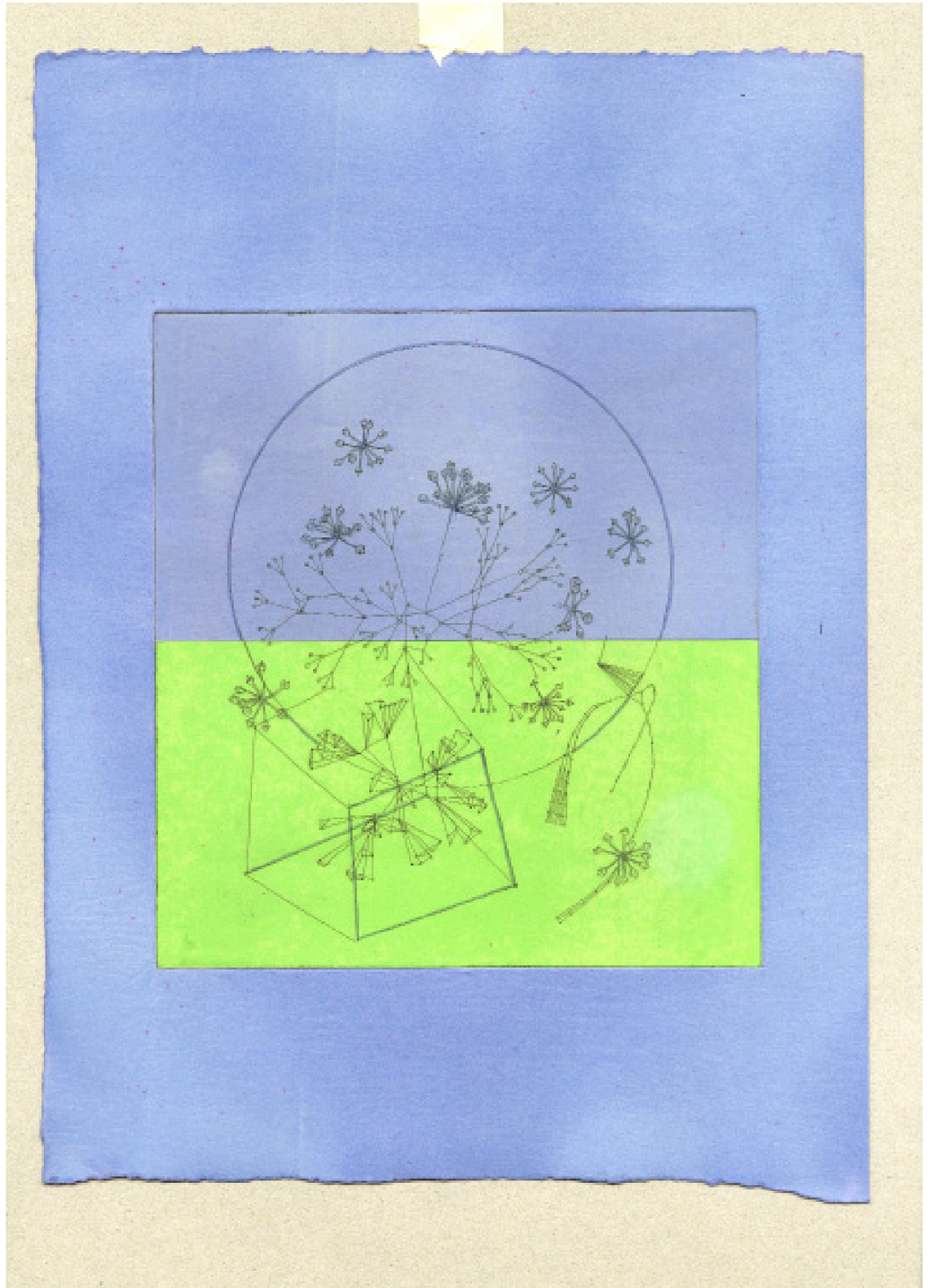
For the mathematicians in the collaboration, a point of great value is that they did not have to compromise or infantilize their ideas. Equally, the artist did not have to compromise her vision or instinctive approach. This collaboration is not an exercise in traditional, didactic scientific popularization; it brings mathematical research to a wider audience in a new way, respectful of both traditions involved and open to different forms of engagement.

We believe that drawing can unlock geometries and forms hidden within research mathematics, bringing them to a new and wider audience. For Anderson, these shapes are new and exciting, to the point that they demand to be drawn. Our collaboration has changed her practice, bringing a new focus on models and three-dimensionality. For Buck, Coates, and Corti, our collaboration brings new perspectives on the objects that they study, and the opportunity to create and respond to a truly unconventional set of questions. The work created reflects this: an experimental combination of mathematical and artistic logics: contradictory and complimentary- open to many perspectives and interpretations.

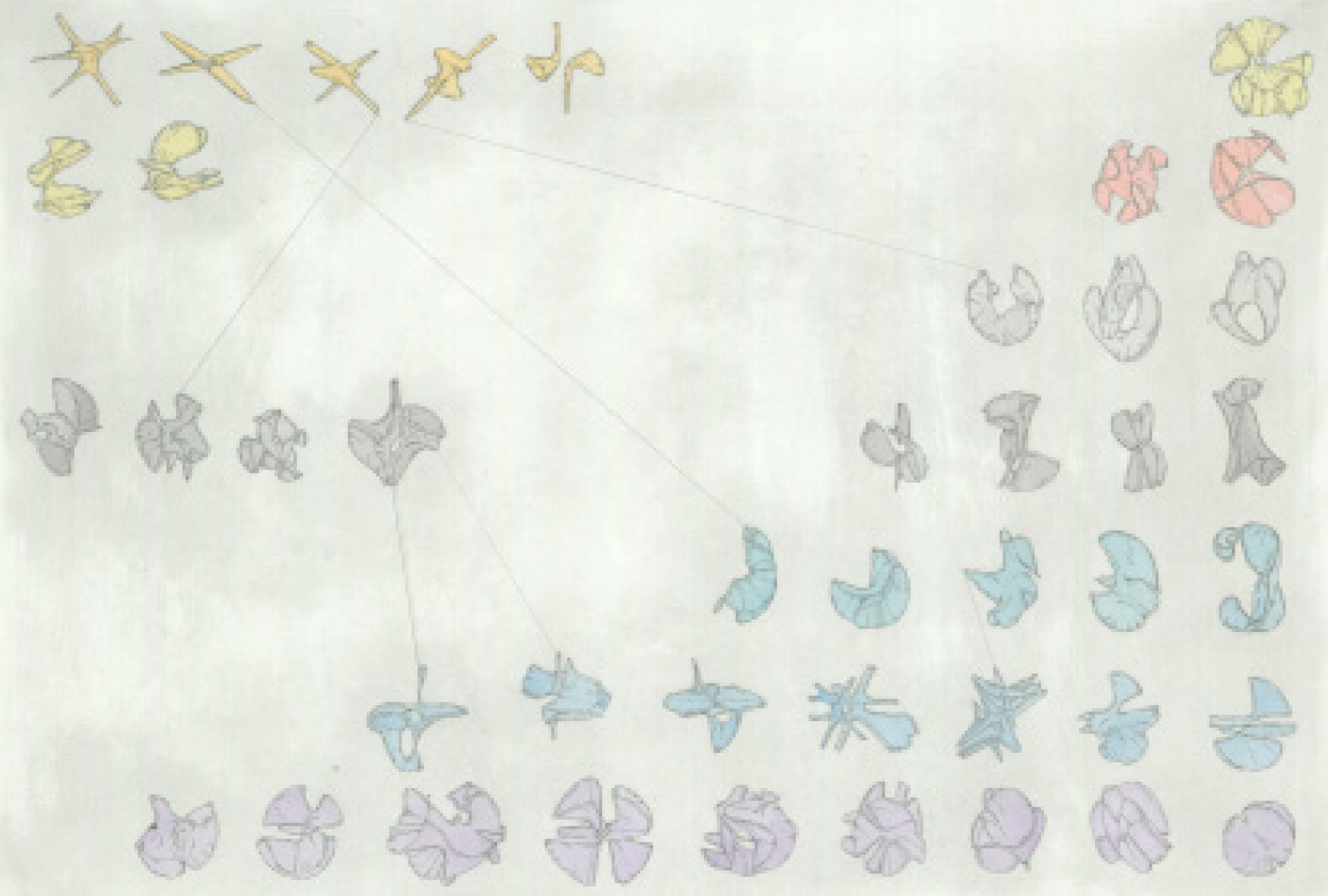
[1]Anderson was inspired by mathematical models in the Science Museum, especially the cardboard sliceform models of ellipsoids made at the Munich Workshops taught by Felix Klein and Alexander Von Brill in the 1870s. Also of inspiration: a model of the cubic surface made by Olaus Henrici in 1875; and paper models from Joseph Alber's Bauhaus preliminary courses (1925-1928).

[2]The classification questions that Coates and Corti study have been open since the work of Gino Fano in the 1930s, yet the techniques that they apply (a blend of ideas from geometry, string theory, and high-performance computing) would have been unthinkable even a decade ago.

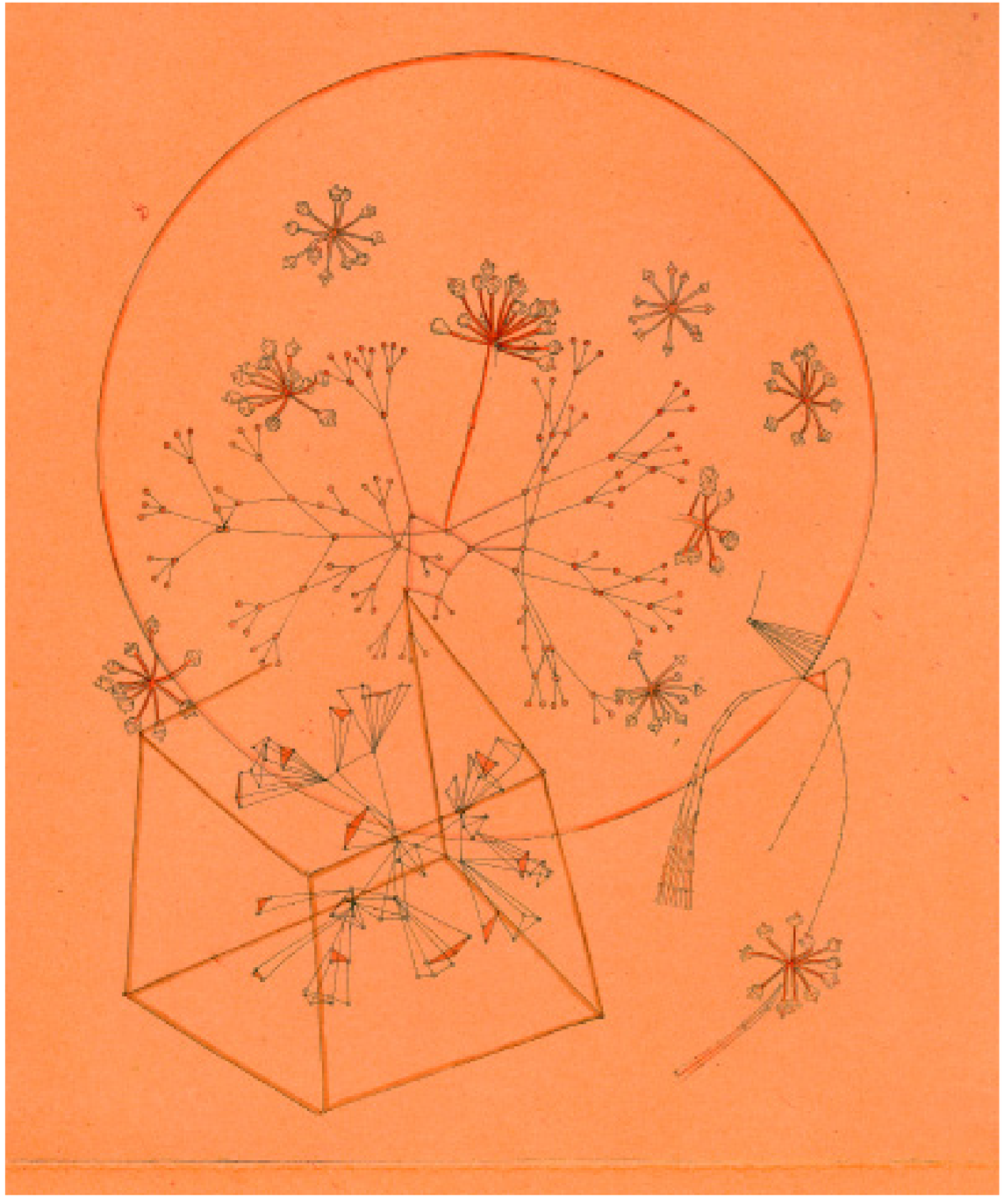
[3]The algebraic equations on which the etchings and models are based were developed in Coates and Corti's research program. The equations were visualised, and certain parameters adjusted, using the open source program surfex. The sliceforms were generated using new code written in Mathematica; the equations were turned into .stl and .obj files suitable for 3d printing using Mathematica, the open source program meshlab, and new code written in the open source mathematical software language Sage.



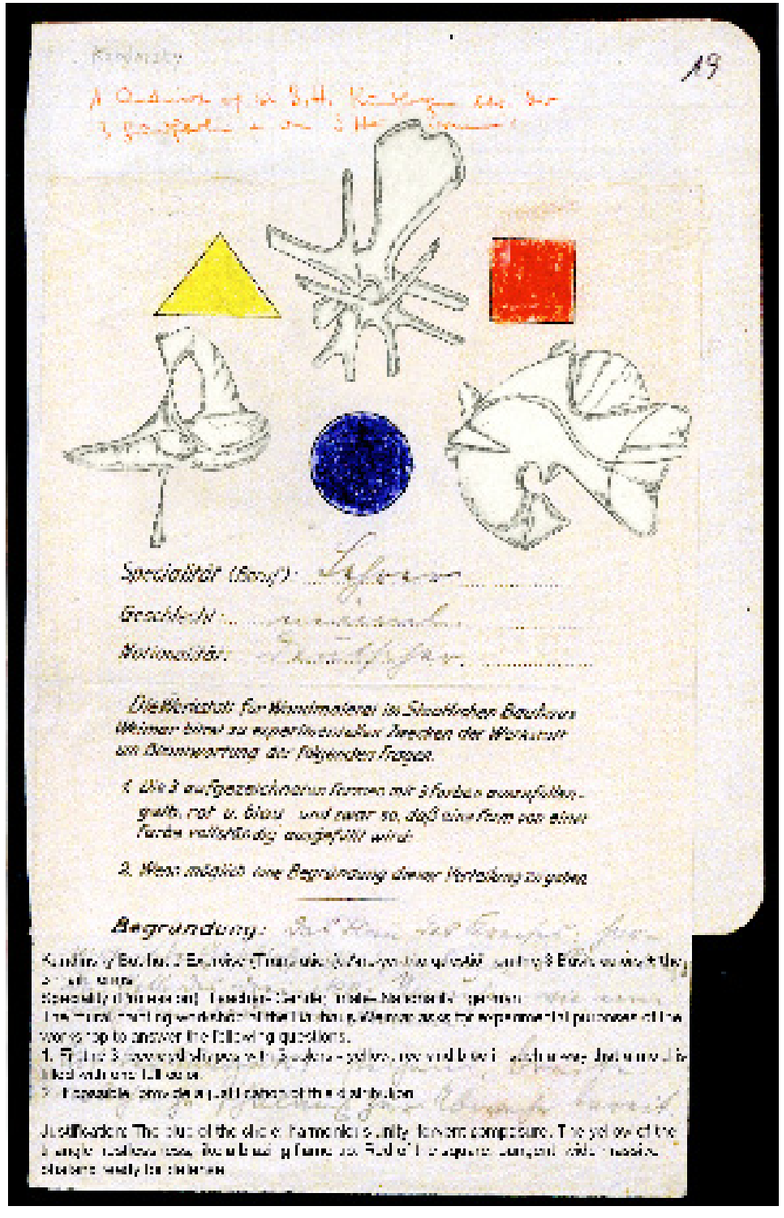
CALEY GRAPH AND FORM, COPPER ETCHING, HAND DYED AND PAINTED WITH JAPANESE INKS, 2012



PERIODIC TABLE OF CALABI-YAU MANIFOLDS, COPPER ETCHING, WATERCOLOUR, 2012

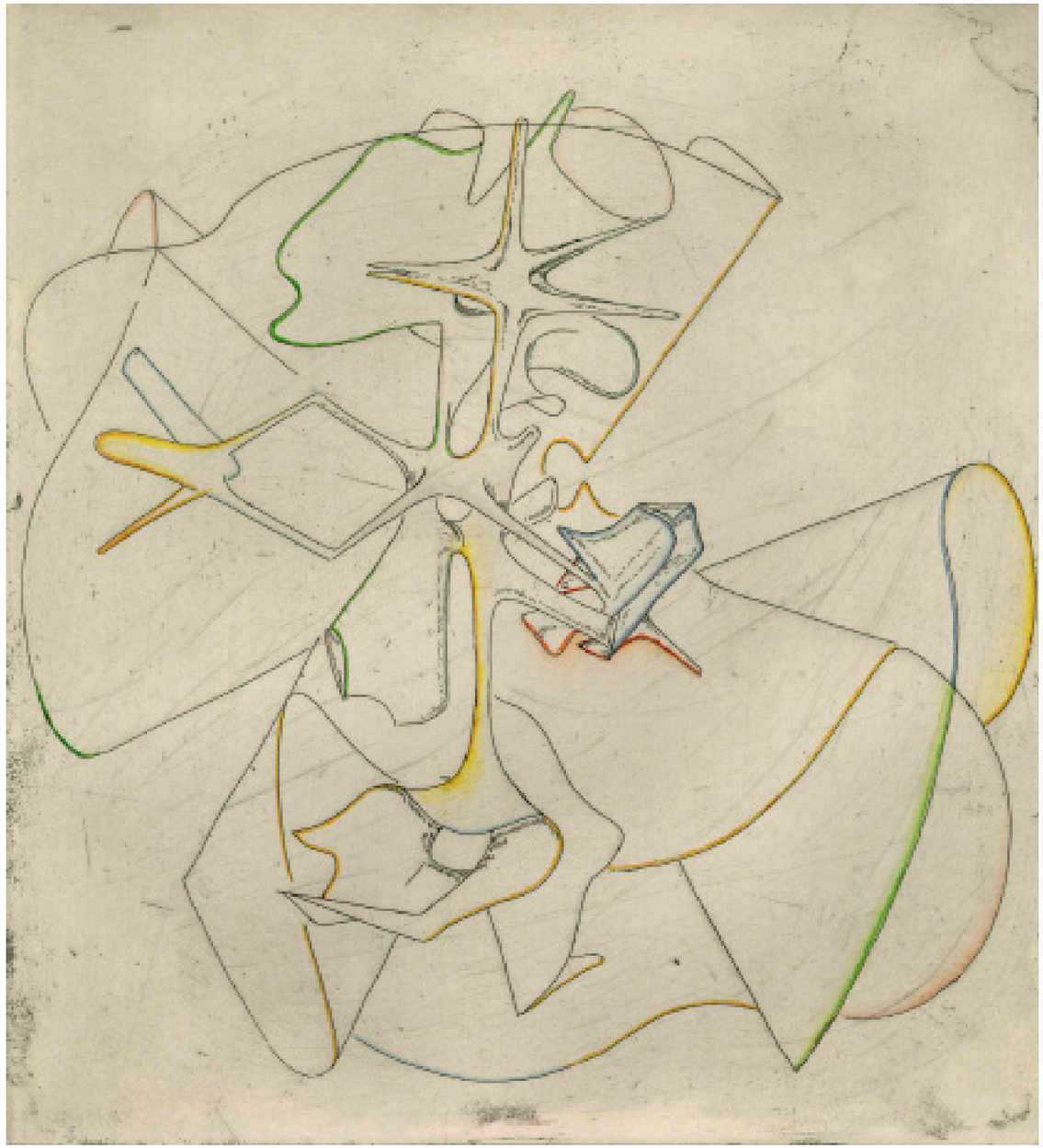


CALEY GRAPH AND FORM, COPPER ETCHING, HAND DYED AND PAINTED WITH JAPANESE INKS, 2012



KANDINSKY PRELIMINARY BAUHAUS EXERCISE, APPROPRIATED WITH FANO VARITIES, DIGITAL PRINT, 2012

The mathematical forms that we work with, called 'Fano Varieties', have no natural colour. They are visualized using mathematical software which assigns them colours arbitrarily, with no reason for the colour selection. I am interested in Kandinsky's Bauhaus exercise which asks students to respond to form with a colour association. I have adapted this exercise, inserting three Fano Varieties to encourage a more relational and thoughtful process of colour choice for each form.



CALABI-YAU COMPOSITE, COPPER ETCHING, PAINTED WITH JAPANESE INKS 2012

Conversation between Johanna Zinecker and Gemma Anderson

GEMMA ANDERSON, DRAWING IN THE DARWIN CENTRE, NATURAL HISTORY MUSEUM, 2012

JZ: When we first met in 2010, we talked a lot about your interest in science, which surfaces in all of your work - can you say something about your fascination with science?

GA: I think my real fascination is with the study of natural form, which naturally led to a deeper engagement with the natural sciences, mathematics and systems of classification.

JZ: Did this interest in form and science also lead you to undertake a PhD, which in spite of the growing number of programs, is still rather an unusual step for a visual artist?

GA: Yes, I have been working with museums and scientists since 2005 - developing my enquiry into the shared forms of animal, vegetable and mineral species and I wanted to shape this research into a PhD.

JZ: How does your artistic practice benefit from this engagement?

GA: The academic convention of doing a PhD has helped my work with scientists and museums as the PhD form is recognized and accepted in the science community. I have found that my work has been taken more seriously in scientific contexts when it has been introduced as PhD research.

JZ: I understand Isomorphology and the avenues it takes - especially with its educational element - as a project that is shaped into the subject of your PhD thesis but has also already been a result of your academic engagement. Can you say something on the reciprocal influences of your academic practice and your artistic practice?

GA: The concept of Isomorphology has developed out of years of observational and intellectual enquiry, and I can see elements of Isomorphology in all of my previous works. Such a large proportion of my practice happens within scientific collections such as those at the Natural History Museum, University College London and Kew Gardens, that I now feel more comfortable working within a scientific context, for instance, a museum or laboratory space than I do working in a studio. The influence of academic engagement is evident in my work and research, for example, my research paper, "Endangered: A study of the declining practice of morphological drawing in zoological taxonomy" (published by Leonardo Journal, MIT press) includes equal references to the philosophy of science, contemporary scientific papers and artistic practice.

I think working with the Natural History Museum, which operates with academic rigour and formality, has made my art practice incredibly well organized. I prepare for meetings with scientists, I research before consulting specimens from the collections, and I make appointments to work in the specialist libraries. I have adapted my practice to work within scientific and academic contexts, as my work relies on the collections and academic knowledge of these places.

JZ: How does this exchange between art and science contexts affect your exhibition practice ?

GA: Well, my work has been heavily influenced by museum display practices and by contemporary and historical art practices. I am directly inspired by the visual languages (often historical) I have found at the Natural History Museum and the Science Museum, including drawings, etchings, and paper models. I feel these languages power a linkage between art and science. In terms of exhibition practice, I try to explore the space between the gallery and the museum and to expand these languages in both contexts.

JZ: To think of your work to occupy an in-between or even a 'bridging' position calls up the idea of dialogue: I understand your work to have an underlying dialogical and relational dimension. Is this something that also manifests in responding to (exhibition) space?

GA: Yes, I have an internal dialogue between art and science and my methods lie between art and science. Then there is the dialogue I have, as an artist with the scientists that I collaborate with, the dialogue between the visual languages of art and science that I work with and the dialogue between the educational display of the museum and the enigmatic display of the gallery. I want these dialogues to

be represented in my work and exhibitions. For example, at the Wellcome Trust, I exhibited research dialogues, and at the Freud Museum I exhibited specimens from museum collections, research notes and drawings, while the space itself provided a research context for the artwork.

JZ: Is doing research and mediating it in your shows also to do with an explicit engagement with the public and the viewer? And - considering the educational model that Isomorphology provides - is there an aspect of learning in your work?

GA: Isomorphology has developed out of the unusual education I have experienced as an artist. I want the work to reveal what I have seen and what my insight has been: to some extent to share my 'vision'. I also want to show the research, to impart some form of knowledge but for the artwork to also stand alone. I am interested in opening up possible ways of engaging with a subject. When the viewers look at my drawings, they are looking at my observation too, and the

INTERIOR OF THE NATURAL HISTORY MUSEUM, 2012

epistemological value of drawing becomes evident here. Even though the viewers are not looking at the actual specimen, (a mineral, for example) they are looking at the mineral with a multi-layered interest: it is a mineral and it is a drawing. It has more entry points than looking at the specimen alone because you are looking at an interpretation of the specimen both subjective and imaginative. With Isomorphology, I have thought further about the educational pote(a mineral, for example) they are looking at it with a multi-layered interest: it is a mineral and it is a drawing. It has more entry points than looking at the specimen alone because you are looking at an interpretation of the specimen both subjective and imaginative. With Isomorphology, I have thought further about the educational potential of my practice. I have been piloting workshops, introducing people to the forms of Isomorphology, using examples from the natural world, and exploring how to represent these forms through drawing. I have also produced a publication with Super/Collider (London), *Isomorphology: An Introduction*, which I see as a playful educational document.

JZ: Drawing as a practice then becomes a specific site of knowledge production itself?

GA: Yes, drawing has been my way to get to know the world, to know objects and to know people. I believe drawing is a knowledge producing process, as it is within the space of drawing that an understanding and exploration of the subject occurs. I am revealing something that no other technology can reveal; drawing shows me what I understand, and it shows this understanding to others. It is a great privilege to access many of the specimens I draw, as they are often stored in museum collections, far from public view. I see drawing as a way to share the objects that I work with, it is a mode of display, and I like this aspect of drawing.

Another form of learning happens through conversations, for example, in Portraits: Patients and Psychiatrists[1] the imagery was largely generated through the conversations with individual sitters. Different, but equally informative conversations occur in my collaborative work with scientists.
One curator I worked with at the Natural History Museum described drawings as 'aide memoires' and I think this is another side to the epistemological value of drawing.

JZ: A Memory bank for experiences in response to objects – that is an enticing image. Experiences though are largely ephemeral by nature - is your 'archiving' also a move towards tangibility and control?

GA: I remember visually, and a drawing brings me right back into the centre of the experience: it is a very powerful memory tool. In a way, I am collecting my experiences in drawings, like letters to myself, which reflect my deepest interests. And yes, it is a way of collecting and possessing - I want to hold on to the experience, even though the moment of making the work is ephemeral and can never be reproduced.

JZ: Through your work with natural science collections you not only spend a lot of time physically working through archives but your work can be seen as a reworking or re-examining and appropriation of a given collection in the sense of what Foster has termed the "archival impulse"[2] as it is also following its own playful and "quasi- archival" logic.

GA: Yes - I am re-ordering and re-curating the collections based on an alternative logic, a playful logic. You could call it 'quasi-archival' as it mixes my general knowledge of the morphologies from different kingdoms and orders specimens based on their morphological

[1]Wellcome Trust Arts Award, 2010.
[2]See Foster, Hal. *An Archival Impluse* in October (Fall 2004), 3-22

resemblances.

JZ: So you are also working – in parts - with the scientific method?

GA: Within the museum context - I find my process parallels the process of scientific taxonomy. The work begins as an abstract idea of form, like the idea of a 'type', which leads to the reality of certain specimens, which have been classified as this type. The individual specimen's variation on the 'type' or 'form' is what the taxonomist has to deal with, and what I have to deal with through the observational drawing process. This is a difficult process, which prompts reflection on 'ideas' and 'ideals' and the reality of achieving these through practice. Somehow, working through the difficulties of the observable reality allows for an expanding and evolving conception of what the work is, and this is how the conceptual process often evolves - inside the practice.

JZ: I see your practice as performing a critique of normative classification. Does this connect to your interest in epistemologies that are based on form and resemblance? I am thinking of historical forms of 'scientific' knowledge such as for example "The Doctrine of Signatures",[3] which features in your earlier work?

GA: Yes, I like Chiara Ambrosio's[4] argument for artistic visualisation as critique and see my work as a critique of the current scientific model of classification as it consciously re-orders and rejects scientific convention - classifying specimens based on similarities rather than differences. And I am drawn to pre-linnaen systems of classification, which are based on shape and form - as this feels like an instinctive approach. "The Doctrine of Signatures" is an example of this, indicating the medicinal virtues of plants based on their resemblance to specific human organs they are believed to be able to cure, thus creating an order for them. For example the doctrine teaches that aconite will cure eye disease and that ground walnuts mixed with spirits of wine will ease a headache. The origin of these remedies lies within the perception of a resemblance between the forms or 'signatures' of species. In Baptista Della Porta's Phytognomica there are a series of drawings of species showing these resemblances. I am interested in how drawing can represent resemblances and contribute to alternative models of classification.

JZ: This interest in older, seemingly already historicised knowledge and your appropriation of them for the contemporary world evokes the idea of time travelling. Are you a time traveller?

GA: Well, I often imagine being on the voyage of the Beagle, or working as a polymath in the 19th century. When I am working with plants, I imagine I am Goethe! I believe very strongly in the value of observation, especially in contemporary culture. I enjoy travelling through the history of observation - recovering ideas and re-imagining these ideas through drawing.

[3]Porta, Giabattista della. *Phytognomonica*. (Another edn). Rothomagai, 1650.
[4]Dr Chiara Ambrosio, Lecturer in History and Philosophy of Science at University College London.
[5]THOMPSON, D'Arcy Wentworth. *On Growth and Form*. (an abridged edn), 1971. Cambridge University Press

SPECIMENS WITH HEXAGONAL MORPHOLOGY, THE DARWIN CENTRE, NATURAL HISTORY MUSEUM, 2012

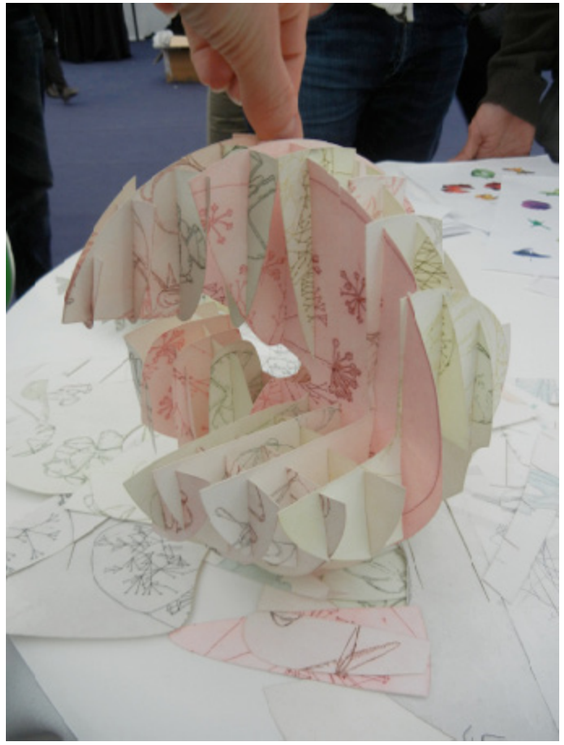
JZ: You mentioned Goethe – any other thinkers and artists that accompany you in your work?

GA: Yes, Goethe is very important to me. I feel an affinity to the 'delicate empiricism' employed in Goethe's mix of scientific and creative endeavour. Another important character is D'Arcy W. Thompson, who was a great polymath and wrote the book On Growth and Form[5], which analyses biological forms from a mathematical and physical perspective. He proposes groups based on shared forms, for example "tetractinellid", "hexactinellid", and he makes unconventional relations between species drawing analogies between radiolaria[6] and snowflakes. His work has been an important inspiration to me.

JZ: Time travelling myself - I am inspired to think of an almost romantic notion within your work, also in relation to the 'universal' or 'progressive' artist - transgressing boundaries of disciplinary knowledge and merging of contexts. How do you define your role as an artist within society?

GA: Most of the historical figures I am interested in are 'polymaths' and I feel a great connection to the approach of the polymath. I like to work in a holistic manner, studying forms that are shared across the natural world is an interdisciplinary job! This fits the notion of the artist as a universal progressive conception. But working in this way today has a very different meaning to working as a polymath in the nineteenth century. Interestingly, there is a shift towards interdisciplinarity in contemporary culture. I believe there will always be a need for new connections to be found between existing subjects, in order to create new areas of study - and to bring new perspectives. I

[6]Radiolaria are amoeboid protozoa (diameter 0.1-0.2 mm) that produce intricate ske mineral skeletons which are found as are found as zooplankton throughout the ocean.



PAPER SLICEFORM, GEMMA ANDERSON AND TOM COATES, 2012.

see this as one of the roles for artists within today's society.

JZ: Speaking of 'relations' - lets talk some more about the aspects of 'conversation' and 'collaboration' - both key terms of the so called 'Relational practices'.[7] This is a contextual frame that your work might not readily be placed in but which I see as helpful for speaking about the dialogical and interactive approach and the collaborative nature of your projects.

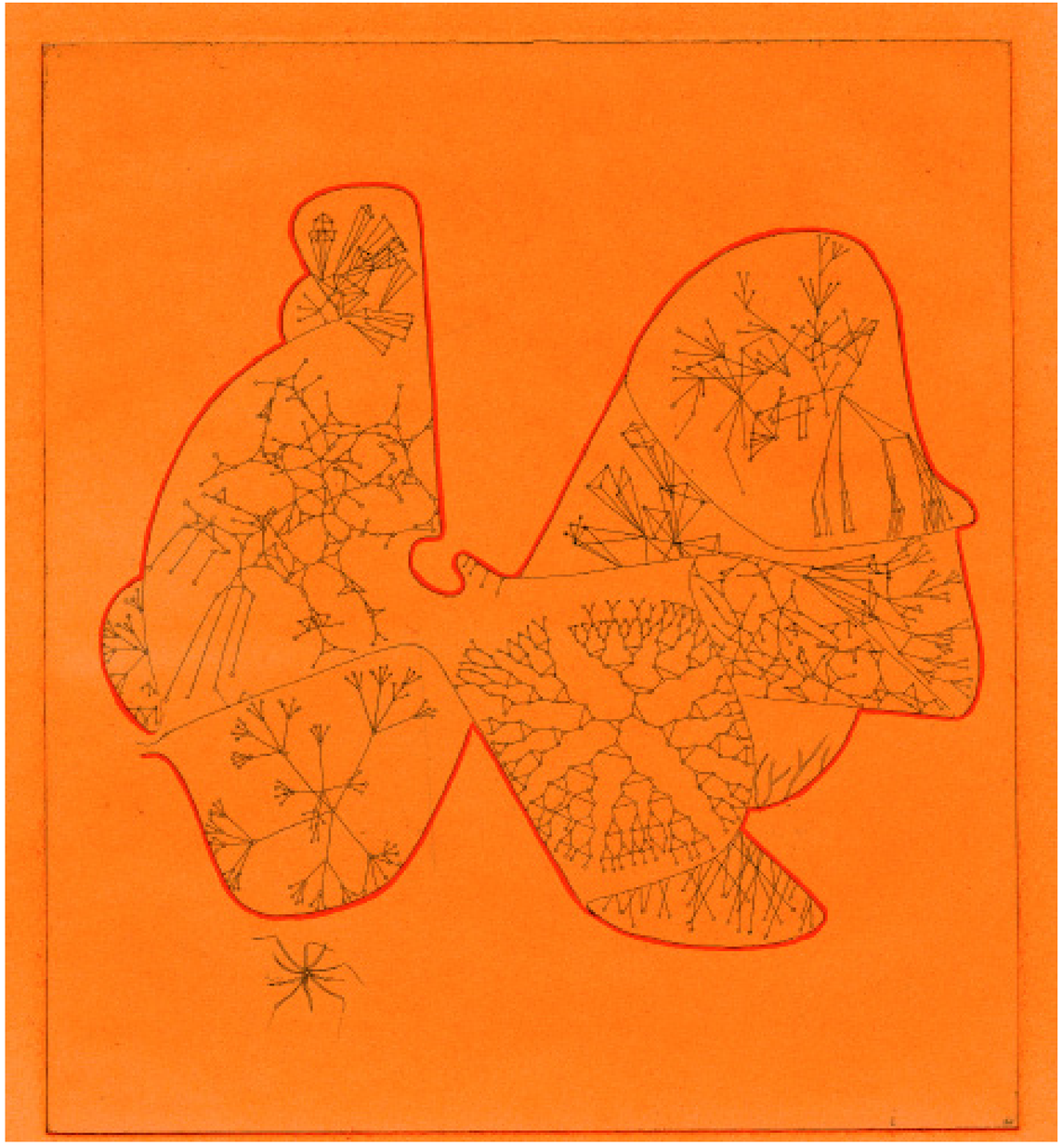
GA: Yes, conversations and collaborations are an integral part of my process. I have long been in conversation with scientists and museums, mostly after an enquiry to draw a particular specimen. These initial enquiries evolve into a conversation 'around' the specimen and the subject: it's history, its individual story and they occasionally lead to a collaboration. The conversational process relies on intial research for questions beforehand, and then it is improvised (this is often where the most interesting aspects come up). The conversations often enter into territory that I am not familiar with, and I have to learn very fast in order to generate ideas to feed back into the dialogue. This conversational aspect is an active, generative process that moves the work beyond conventional discourse.
The inter-subjective experience in my work is an example of the kinds of knowledge that aesthetic work is capable of producing. It is a relational practice in the sense that it is based around communication and exchange, but its status as a more traditional aesthetic form is secured by its materiality: the etching, the drawing and the model.

JZ: To look at your work as 'relational' in an abstracted way places value and meaning on the social aspects of your work and the aesthetic experiences generated through them - an aspect, which is not so immediately accessible in the materiality of your work, but seems to be at the core of your practice.

GA: Well, especially in the case of the mathematicians, the artwork must express what is genuinely drawn from the exchange. The conversations become a lively critique within the creative process; they give me ideas and sometimes I stop mid-conversation to make notes or draw an image that has appeared in my mind. While this process deviates in many ways from the traditional process of making an art object, it is essential to the final work. I am free to break away from the pre-existing role of the artist in the studio and to react and interact with science in unforeseeable ways, I can never predict how the conversations will impact the drawings, but they almost always do: reflecting the experiential specificity of the world around them.

GEMMA ANDERSON AND ALESSIO CORTI, IMPERIAL COLLEGE MATHEMATICS DEPARTMENT, 2012

[7]Relational Practices' is derived from 'Realtional Aesthetics' as postulated by Nicolas Bourriaud in *Relational Aesthetics*. It functions as an umbrella term for a field of practices which goes by a variety of names such as "socially engaged art"; "dialogical art"; "research-based art" or "collaborative art" etc. See Bishop, Claire. *The Social Turn: Collaboration and it's discontent* in Artforum (February 2006), 179-185



FANO VARIETY AND CALEY GRAPH' COPPER ETCHING, HAND DYED AND PAINTED WITH JAPANESE INKS, 2012

PHOTOGRAPH OF ARAGONITE SPECIMENS, PALAEONTOLOGY DEPARTMENT, NATURAL HISTORY MUSEUM, 2012

JZ: In your writing you elaborate on what skills an artist must possess in order to succeed in observational drawing, a rigorous approach which evokes ideas of mastery and also handicraft. Is this an outcome of an academic engagement with methods? And can (artistic) freedom be found in restriction?

GA: Yes, I believe in the practice of observation and drawing as disciplines. Observation, trained judgement and abstraction are the skills, which I use in the drawing process all the time. I think observation is the foundation, and trained judgement and abstraction grow from practiced observation. For Thierry de Duve, any artwork is nothing other than a "sum of judgements"[8] - both historical and aesthetic - stated by the artist in the act of its production and my judgements are the result of this rigorous method. The practice generates the skill and the confidence, which in turn gives more freedom. And yes, in a way, I believe freedom can be found in restriction, for example, when I am restricted to the etching plate, and the etching tool, within that space I feel total freedom.

JZ: So this training in observation generated Isomorphology and its alphabet?

GA: Yes, after years of drawing specimens from scientific collections such as those at the Natural History Museum and at Kew Gardens, I have gradually identified a number of forms and symmetries that can be found in animal, mineral and vegetable species. These are conceptual forms[9] which have become a major part of my day to day outlook. I actively seek out the forms in the world around me, abstracting from observation and playing with observation wherever I am.

This conversation was conducted December - January 2012/13 through Skype and email.

[8] De Duve, Thierry, Essais Dates. Editions de la difference, 1987

[9] Conceptual is here understood as the act of conceptualizing, the act of abstracting from nature

RAPID PROTOTYPE MODEL OF FANO VARIETY, GEMMA ANDERSON AND TOM COATES, 2012.

Johanna Zinecker is a cultural producer, editor and curator based in Berlin. She studied English and American Cultures and Literatures as well as German Studies at Humboldt-University Berlin and the University of Manchester and wrote an academic thesis (M.A.) which analysed Gemma Anderson's *Portraits: Patients and Psychiatrist* in the context of contemporary art at the interface with psychiatry. Since 2008 she has been working as a project coordinator and curatorial assistant at the department of Visual Arts at Haus der Kulturen der Welt, Berlin.

GEMMA ANDERSON

Awards and Prizes

2012 Leverhulme Artist in Residence Award.
2011 Engineering and Physical Sciences Research Council, Pathways to Impact grant.
2011 University College Falmouth, PhD Studentship Award
2011 Royal Society, Special Project Award
2010 Arts Council of Northern Ireland Individual Artist Award
2009 Wellcome Trust Arts Award
2009 Royal Hibernian Academy Thomas Dammann Junior Memorial Trust Award
2008 Sapporo Artist-in-Residence (S-AIR) Award
2008 Arts Council of Northern Ireland Individual Artist Award
2008 Arts Council of Northern Ireland Travel Award
2007 Corbett Projects and Mayor of Kensington and Chelsea Award for Drawing
2007 Man Group Drawing Prize Winner, Royal College of Art

Residencies

2012 Leverhulme Artist in Residence, Imperial College, London
2010 Jerwood Visual Arts, London
2010 (to 2015) Acme Fire Station, London
2010 Arts Council of Northern Ireland, New York
2009 Centre Culturel Irlandais, Paris
2009 (and 2011) Cill Rialaig, Ballinskelligs, Ireland
2008 Intercross Creative Centre, Sapporo, Japan
2008 St Michael's Printshop, St John's, Newfoundland
2008 Curfew Tower, Cushendall, Northern Ireland
2007 Burren College of Art, Ballyvaughan, Ireland
2006 Poustinia Land Art Park, Belize
2004 Accademia di Belle Arti, Venice

Public Collections

Victoria and Albert Museum, London
Wellcome Trust Collection, London
The Natural History Museum, London
Arts Council of Northern Ireland, Belfast
Braid Museum and Art Centre, Ballymena, Northern Ireland
Falmouth College of Art, Cornwall

Selected Exhibitions

2013 EB &Flow Gallery, London, Isomorphology, Solo
2013 D'Arcy Thompson Museum, Dundee, Drawn from structures
2012 Imperial College research festival
2012 '100 Years of Laue Mineral X-Rays' (Mineralogy) Natural History Museum, London
2011 Jerwood Project Space, London, Solo
2011 The Naughton Gallery, Queens University, Solo
2010 The Freud Museum, London, Solo
2010 Daiwa Anglo-Japanese Foundation, London, Solo
2010 Acme Project Space, London, Solo
2010 Globe Theatre, London, Solo

2010 Wellcome Collection, London, Skin
2010 Courtauld Institute of Art, London
2010 The Rooms Provincial Museum, St John's, Newfoundland
2010 Hay Festival of Literature and the Arts, Hay-on-Wye, Wales
2009 Golden Thread Gallery, Belfast, Isolated
2009 Centre Culturel Irlandais, Paris
2008 Jerwood Space, London, An Experiment in Collaboration
2008 A1C Gallery, St John's, Newfoundland
2008 St Luke's, Old Street, London, Catlin Art Prize 2008
2007 Royal College of Art, London
2007 Royal Academy of Arts, London

Talks and Events

2013 Nature Live, Natural History Museum, London
2013 Isomorphology Workshop, Grant Museum, University College London
2012 Keynote: 'Drawing in Mathematics: Geometry, Reasoning, Language and Form' with Tom Coates (Geometer, Imperial College), Dorothy Buck (Topologist, Imperial College) and Alessio Corti (Geometer, Imperial College) at 'Drawing in STEAM' Conference, Wimbledon College of Art
2012 'Endangered: A study of the declining practice of morphological drawing in Zoological Taxonomy', 'Drawing Out' conference, University of the Arts, London
2012 'Resemblance perception as epistemic drawing process: Rashleigh's Mineral Nicknames', Drawing Research Network conference, Loughborough University
2010 National Portrait Gallery, 'Contemporary Portrait Practices' Seminar, Guest Speaker
2010 Jerwood Visual Arts, Artist-in-Residence Talk
2010 The Freud Museum- Artist Talk
2010 Kings College London, Humanties Seminar, Main Speaker.
2010 Daiwa Anglo-Japanese Foundation, London, Artists Talk
2010 "How the Light Gets In" Philosophy Festival, Hay on Wye Festival, Artists Talk
2010 Bethlem Royal Hospital, Gallery and Museum, Artists Talk and Publication Launch
2009 Institute of Forensic Psychiatry, Annual Conference, Dublin, Guest Speaker
2009 Psychiatry Trainee Conference, London, Interview with Riflemaker Gallery
2008 Jerwood Visual Arts- An Experiment In Collaboration- Panel Discussion

Publications

2013 An Introduction to Isomorphology, Super/Collider, London.
2013 Isomorphology, EB & Flow Gallery, London.
2012 'Endangered: A study of the declining practice of morphological drawing in Zoological Taxonomy' Leonardo Journal of Arts, Science and Technology, MIT Press.
2011 Drawing Projects "An Exploration of the Language of Drawing" Black Dog, London.
2011 Jerwood Artist-in-Residence Publication
2010 Portraits:Patients and Psychiatrists Gemma Anderson, London.
2009 Isolated, The Golden Thread Gallery, Belfast

Professional Training and Teaching

2012 – Present, Visiting Lecturer, BA Drawing, Falmouth University
2011-2014 University College Falmouth, PhD Studentship
2005–2007 Royal College of Art, MA in Printmaking
2006 University College London, Anatomy for Artists Certificate
2002–2005 Falmouth College of Arts, BA in Fine Art, (First Class Honours)

SCANNING ELECTRON MICROSCOPE COLLAGE PHOTOGRAM (SILVER GELATIN PRINT), 2012.

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Edited by Gemma Anderson

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