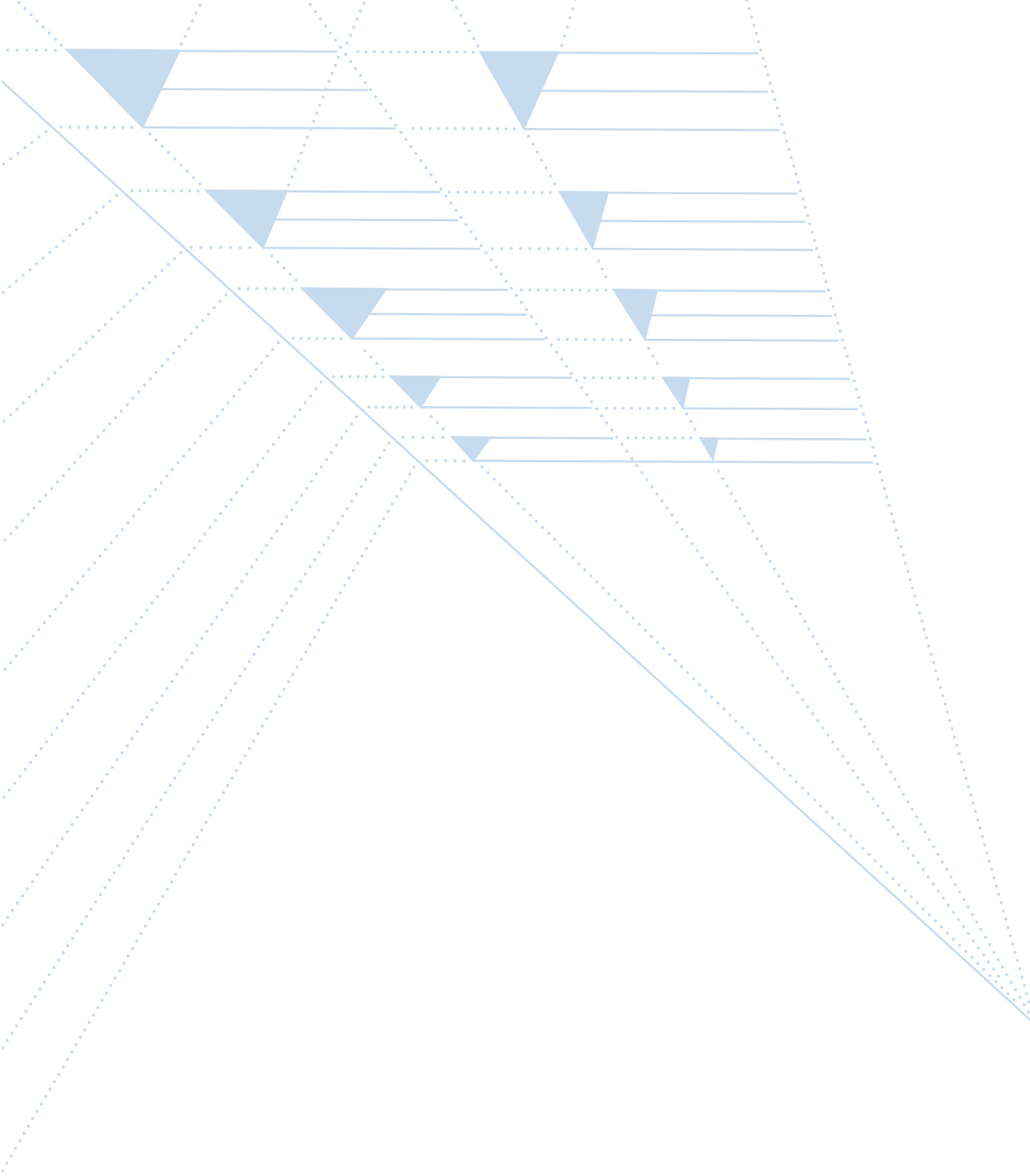Ruskin's Perspectives:
The Art of Abstraction

Explore Lancaster University's Ruskin
Whitehouse Collection exhibited in
London and the Lake District.

John
Ruskin
in the
Age of
Science

II

Cover: John Ruskin, Fig. 54, *Elements of Perspective* (London: Smith, Elder & Co., 1859)

Ruskin's Perspectives:
The Art of Abstraction

22
July
—
25
Sept
2022

Ruskin's Perspectives:
The Art of Abstraction

Drawing on the collections of The Ruskin, Lancaster University, the Royal Society, and the Brantwood Trust, 'Ruskin's Perspectives: The Art of Abstraction' is exhibited at Ruskin's former home, Brantwood.

'Ruskin's Perspectives: The Art of Abstraction' draws on a cultural history of mathematics to explore nineteenth century scientific ideas about the relationship of things and their properties to each other.
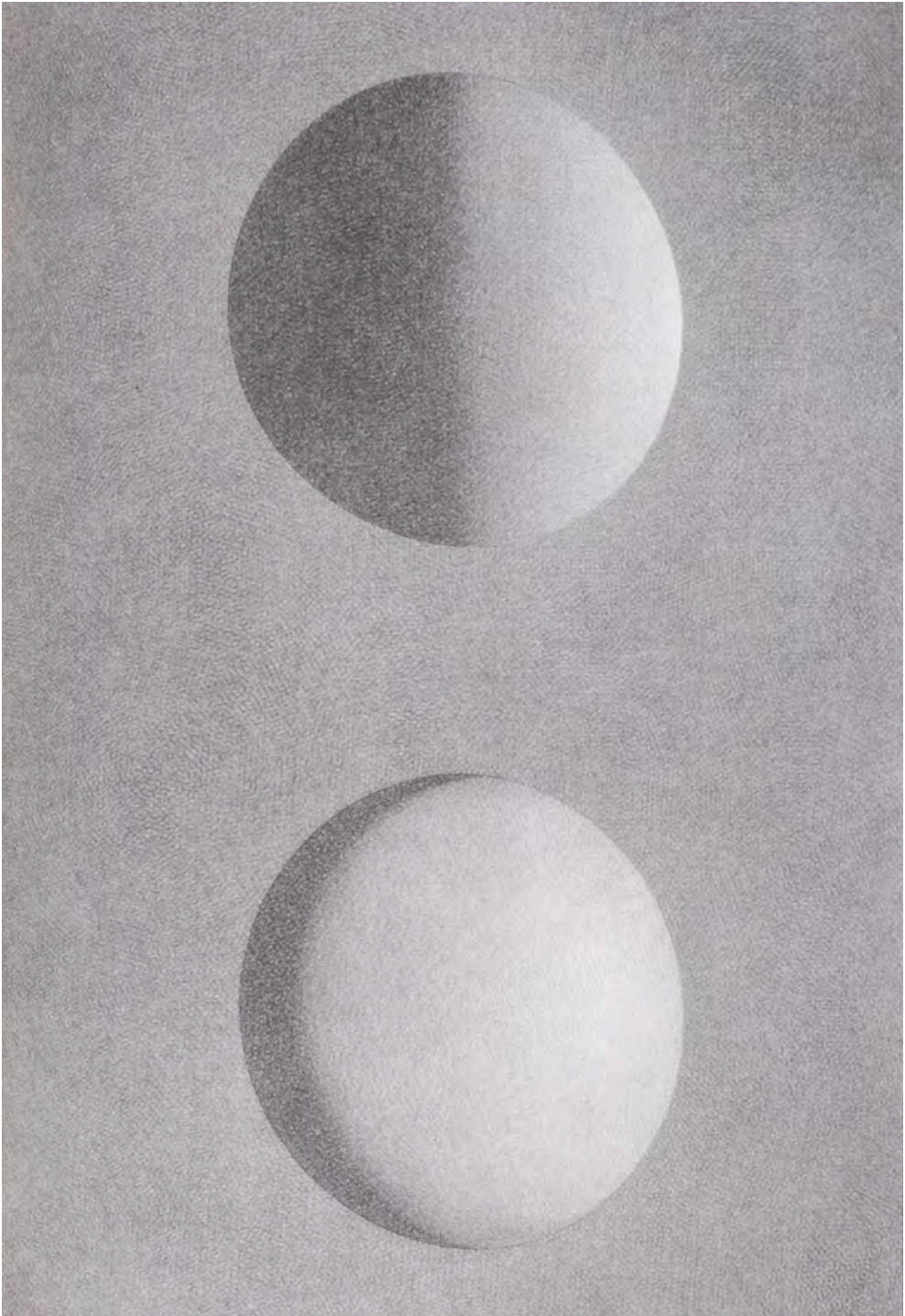
From trade and travel, to the economy and decision making based on statistics and probability, the impact of mathematics on nineteenth century culture and society was immense. As scientists worked by deduction, as well as empiricism based on observation and imitation, these methods became part of the artist's process.

This exhibition is curated by Sandra Kemp (The Ruskin), with Howard Hull (Brantwood) and Keith Moore (the Royal Society). It is the second in a series of exhibitions in London and the Lake District, 'John Ruskin in the Age of Science', which examine Ruskin alongside his scientific contemporaries, exploring his influence on science and society, in his time and our own.

Contents

A glossary is provided for mathematical terms marked with the dagger symbol ($\dagger$).

'I do not mean by beauty of form
such beauty as that
of animals or pictures …

but straight lines and circles, and the plane and solid figures that are formed out of them by turning-lathes and rulers and measures of angles; for these I affirm to be not only relatively beautiful like other things, but they are eternally and absolutely beautiful.'

8

Drawn by John Ruskin, Engraved by George Allen. 'Schools of St George. Elementary Drawing.
Plate X. Appellavitque Lucem Diem. Et Tenebras Noctem', ***The Laws of Fésole***
(London: George Allen, 1879)

9

John Ruskin, Frederick Crawley, ***Rouen: Cathedral of Notre Dame, north transept door,*** 1854. Daguerreotype. 163 x 123 x 4 mm. 1996D0125 © The Ruskin, Lancaster University

Ruskin's Perspectives: The Art of Abstraction

Mathematics was at the centre of John Ruskin's (1819–1900) art. Fascinated by form, pattern, proportion and symmetry in the world around us, Ruskin believed that mathematical knowledge underpinned both the technical proficiency and the 'analytic power' needed to compose a work of art. In their most rudimentary forms – the rules of **arithmetic**[†] and the foundations of plane **geometry**[†] – mathematical concepts were more dispersed through all classes of nineteenth century society than any other kind of knowledge. **Euclidian geometry**[†] was taught in schools, universities and working men's colleges. Mathematics was regarded as a vehicle for teaching students how to think.[1]

Ruskin wrote that art begins with 'command of line' (*LE* 20 1905, 128-9). He believed that artists should acquire a working knowledge of geometry in order to understand the rules of classic linear perspective: parallel lines, the line of the horizon and the vanishing point. He argued that drawing 'a line of absolute correctness' (*LE* 20 1905, 132) using the theory and practice of **perspective**[†] should underpin composition, 'so as to leave no blots – no uncertain lines – no careless shadows'.[2] To this end, Ruskin produced three drawing manuals: *The Elements of Drawing* (1857), *The Elements of Perspective* (1859) – which was to be read alongside the first three books of Euclid's (325 BC–265 BC) *Elements* (300 BC) – and *The Laws of Fésole* (1877–8).

10

[†] **Arithmetic** the branch of mathematics dealing with the properties and manipulation of numbers.
Geometry the branch of mathematics concerned with the properties and relations of points, lines, surfaces, solids and their higher-dimensional analogues.
Euclidian geometry the geometry that follows Euclid, as opposed to the 'non-Euclidean geometries' discovered in the nineteenth century.
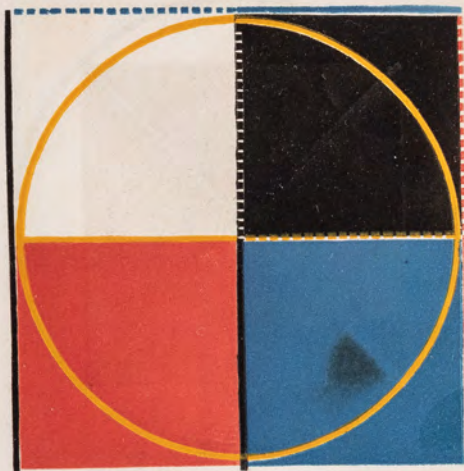**Perspective** the art of representing three dimensional objects on a two-dimensional surface.

'Symmetry, as wide or narrow as you may define its meaning, is one idea by which man through the ages has tried to comprehend and create order, beauty and perfection.'

Hermann Weyl, *Symmetry*, 1938

T O *inscribe a circle in a given square.*

Make ▬▬▬ = ·········· ,

and ▬▬▬ = ·········· ,

draw ····▬▬ ‖ ▬▬···· ,

and ▬▬▬ ‖ ▬▬▬ ,

(B. 1. pr. 31.)

∴ ■ is a parallelogram ;

and since ▬▬···· = ····▬▬ (hyp.)

▬▬ = ····▬

∴ ■ is equilateral (B. 1. pr. 34.)

In like manner, it can be shown that

■ = ■ are equilateral parallelograms ;

∴ ·········· = ·········· = ▬▬▬ = ▬▬▬ ,

and therefore if a circle be described from the concourse of these lines with any one of them as radius, it will be inscribed in the given square. (B. 3. pr. 16.)

Q. E. D.

Fig. 11

John Ruskin, Fig. 11, *Elements of Perspective* (London: Smith, Elder & Co., 1859)

Linear perspective plays an important part in the conceptualisation of ideas by architects, engineers and designers, providing the means to envisage the end result. It is thought to have been devised in around 1415 by Italian Renaissance architect Filippo Brunelleschi (1377–1446), and documented by architect and writer Leon Battista Alberti (1404–1472) in 1435. In 1525, the German artist Albrecht Dürer (1471–1528) published the first introductory manual of geometric theory in Europe, including the first scientific treatment of perspective.

From the Renaissance onwards, the science of mathematics had led to a new form of making art based on geometry. Until the late nineteenth century, Euclidian geometry was considered both fundamental to understanding the properties of spatial reality, and the preeminent source of knowledge about the human and the divine. Ruskin makes frequent reference to Dürer in his works. In his *Catalogue of The Educational Series* for teaching art at Oxford University (1878), Ruskin comments that Dürer's line is 'always decisive and always right' (*LE* 21 1906, 146); and in *Fors Clavigera*, Letter 60 (1875), he notes that his illustrations for *Love's Meinie* have involved 'a care in plume drawing which I learned in many a day's work from Albert Dürer' (*LE* 28 1907, 460).

Elsewhere Ruskin turned his attention to the basic tenets of arithmetic, railing against the 'ruinous' practice of 'forbidding accuracy of measurement' (*LE* 15 1904, 342) in nineteenth century drawing systems. His own sketchbooks are full of measurements of both natural and built environments. From the outset of his career, the architecture of Italy was central to Ruskin's work. In 1857, Ruskin hailed Verona as 'the spot of the world's surface which contained at this moment the most singular concentration of art-teaching and art treasure' (*LE* 16 1905, 66), with examples of architectural styles from Lombardic to Gothic. Like Brunelleschi, Alberti and Dürer, Ruskin combined the practical mathematics of the mason with knowledge of geometry. Many of his sketches are stylistically similar to those in Dürer's treatise on Architecture (pictured on pp 17; 118).

'... the practical geometry of nature [can be found in] the ellipses of her sea-bays in perspective; the parabolas of her waterfalls and fountains in profile; the catenary curves of their falling festoons in front; the infinite variety of ... curvature in every condition of mountain débris.'
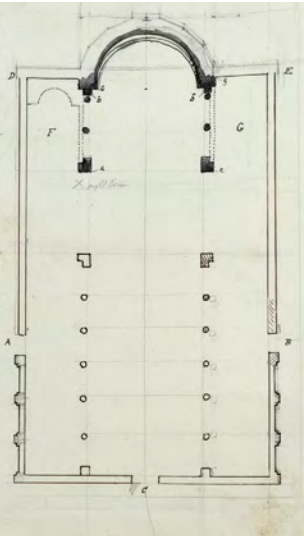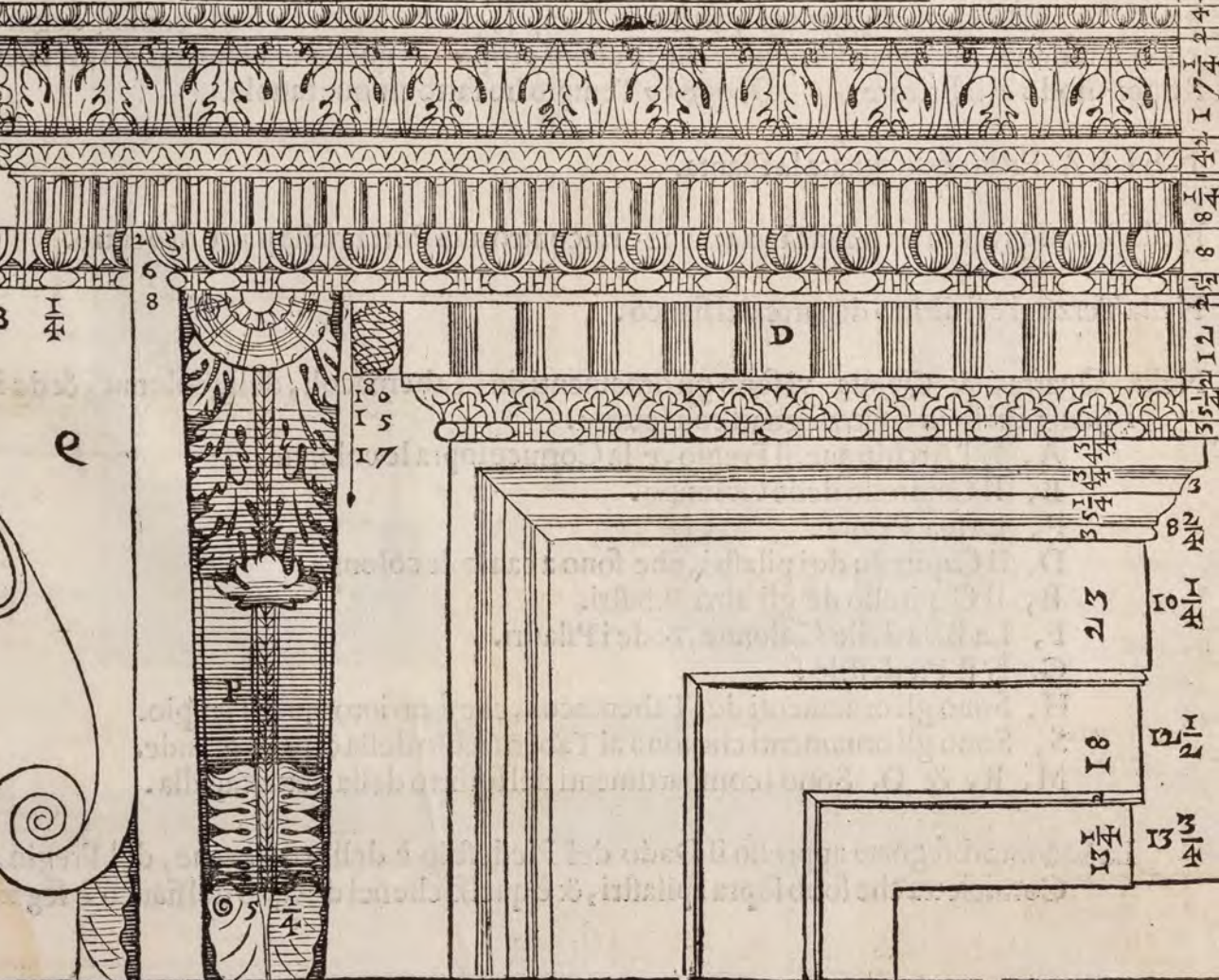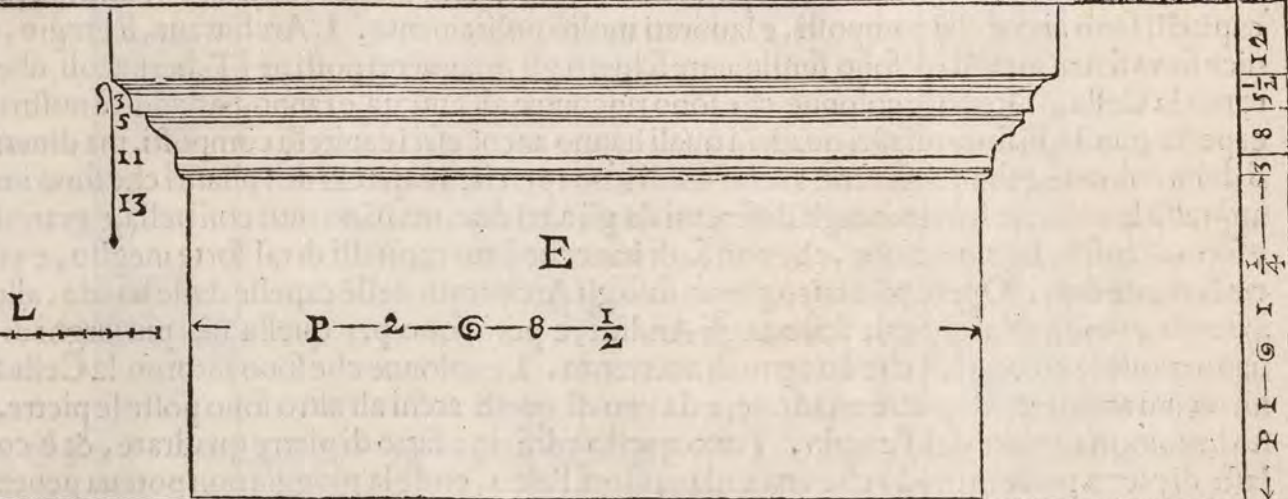
1
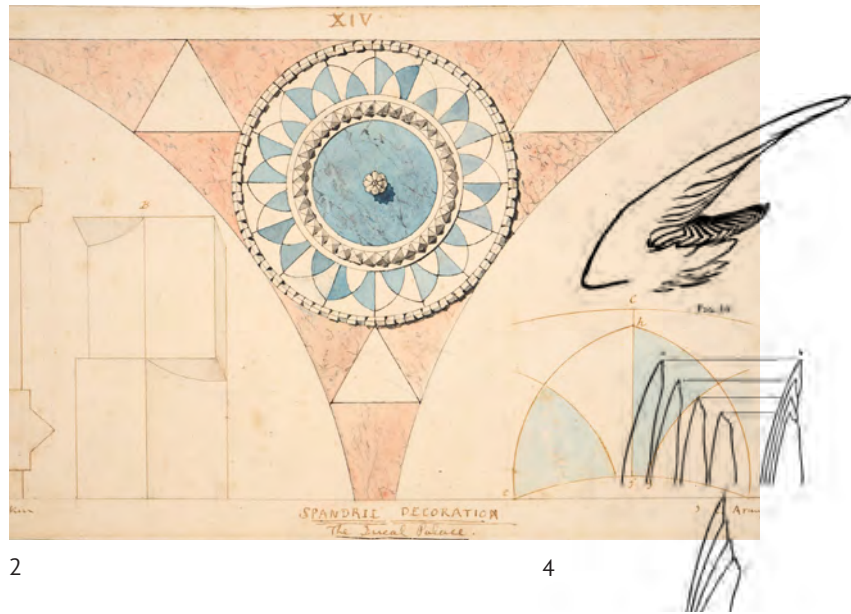
2

4

3

1   John Ruskin, ***Venice & Verona - Album of Sketches & Notes, Murano, Plate A,*** n.d.
    Ink on paper. 1996P1640 © The Ruskin, Lancaster University
2   John Ruskin, ***Stones of Venice: Spandril Decoration - The Ducal Palace,*** n.d.
    Pencil, ink and watercolour. Inscription in ink: 'XIV SPANDRIL DECORATION The Ducal Palace
    J Ruskin J C Armytage'. 148 x 265 mm. 1996P1041 © The Ruskin, Lancaster University
3   John Ruskin, John Hobbs, ***Venice. St Mark's. South Façade: Detail and Tetrarch Sculpture,*** 1850.
    Daguerreotype. 122 x 163 x 3 mm. 1996D0021 © The Ruskin, Lancaster University
4   John Ruskin, Figs. 9–11, ***Love's Meinie. Three Lectures on Greek and English Birds***
    (London: George Allen, 1881)
5   Albrecht Dürer, ***Underweysung der messung, mit dem zirckel un richtscheyt, in Linien ebnen
    unnd gantzen corporen,*** 1525.
    Book. Ref: 2114 © The Royal Society

E

L ← P — 2 — 6 — 8 — ½ →

D

e

P

E, Sono gli ornamenti de la cornice, de i maggiori del tempio.
e, Sono gli ornamenti che vanno intorno alla porta del tempio medesimo.
M, N, & O, Sono i compartimenti di esse tauolature del tempio predetto.

Ruskin's correspondence and diaries provide many descriptions of him climbing up ladders in palaces and cathedrals to obtain accurate measurements; for example, building a scaffold to view the Castelbarco tomb in 1869. Ruskin's *Stones of Venice* slip-books contain numerous worksheets made *in-situ*, capturing detailed drawings with precise measurements in ink, alongside more abstract sketches of architectural shapes highlighted in watercolour.

Elsewhere, Ruskin's drawings range in scale from those made in Venice between September 1876 and May 1877, which he described as 'little … sketches … by way of diary' and which are no more than 8 x 12cm, to large-scale lecture diagrams.[3] The latter, some as large as 120 x 180cm, were enlargements of Ruskin's original drawings: a process, he advised his student Anna Blunden (1829–1915), that 'must always be done mathematically by squaring'.[4]

Although he regarded himself as mathematically competent, Ruskin himself was not always correct – there are some fundamental errors in his textbooks – and he acknowledged the limitations of his knowledge. Despite being on a par with artists like John Constable RA (1776–1837) and J.M.W. Turner RA (1775–1851) in his sky and sea-scapes, Ruskin regretted that he did not have 'the mathematical knowledge required for the analysis of wave-action' (*LE* 13 1904, xx) to complete the chapters on sea-painting in *The Stones of Venice*, though he used some of the materials he had developed for this in his analysis of Turner's paintings in *The Harbours of England* (1856).

'When I dare to speak of the mathematics in art, people smile as if I were a fool. In our society, people see mathematics and art as opposites, just as they see science and religion.'
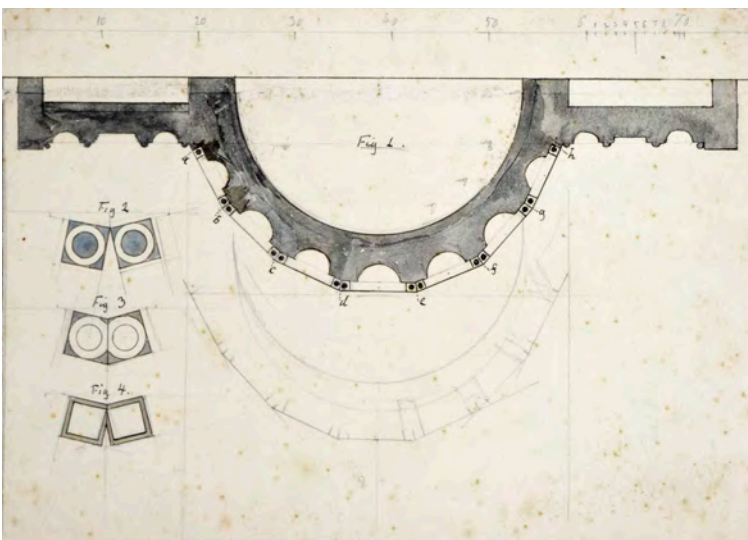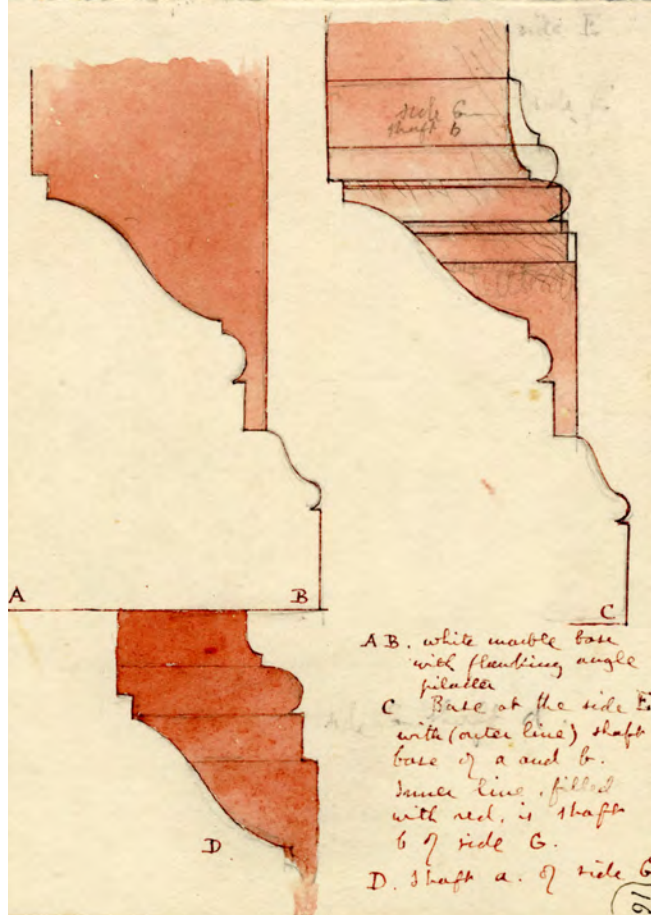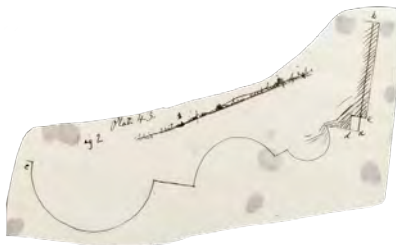
1
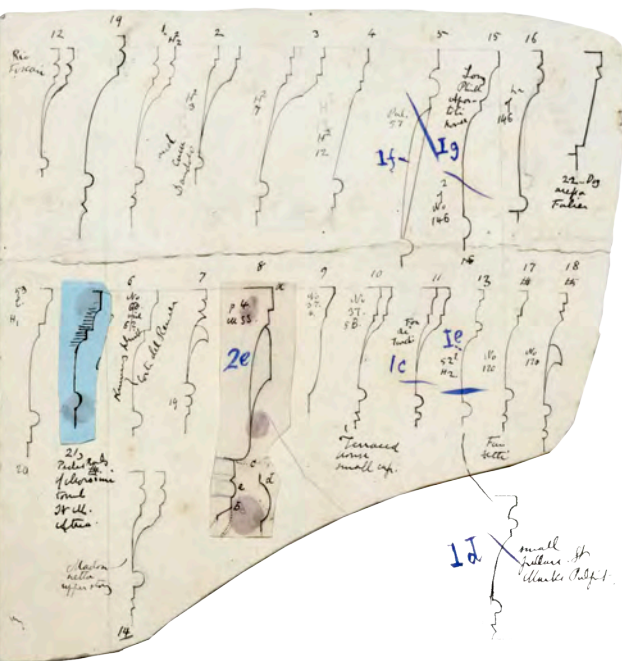
2

3

1 John Ruskin, 'Worksheet - unnumbered 46' *Venice & Verona - Slipcase of Sketches & Notes* n.d.
   Ink and wash on paper. 153 x 211 mm. 1996P1638 © The Ruskin, Lancaster University
2 John Ruskin, *Venice & Verona - Album of Sketches & Notes,* n.d.
   Ink and wash on paper. 1996P1639 © The Ruskin, Lancaster University
3 John Ruskin, *Venice & Verona - Album Of Notes & Sketches,* n.d.
   Ink and wash on paper, sealing wax. Various sizes. 1996P1642 © The Ruskin, Lancaster University
4 John Ruskin, *Venice & Verona - Album Of Notes & Sketches,* n.d.
   Ink and wash on paper. Various sizes. 1996P1642 © The Ruskin, Lancaster University
5 John Ruskin, *Venice & Verona - Album Of Notes & Sketches,* n.d.
   Ink and wash on paper. Various sizes. 1996P1641 © The Ruskin, Lancaster University

4

side E
side G
shaft b

A   B   C

A B. white marble base
with flanking angle
pilaster
C   Base at the side E
with (outer line) shaft
base of a and b.
Inner line, filled
with red, is shaft
b of side G.
D. Shaft a. of side G

D

5

2

2

No I

Ruskin's view of composition in art was clearly underpinned by this kind of requirement for precise measurement and 'command of line': 'Expression, sentiment, truth to nature, are essential', he wrote, 'but all these are not enough. I never care to look at a picture again, if it be ill composed, and if well composed I can hardly leave off looking at it' (*LE* 7 1903, 204). However, Ruskin also followed a long historical tradition of mathematics from Plato onwards: namely in the belief that nature is best understood as a mathematical structure designed by God.[5]

The usual language for expressing mathematical ideas is symbolic. Throughout its history, mathematics has traditionally described immaterial abstract objects – a realm of timeless geometrical forms such as circles and triangles that exist independently of human minds. As John Dee (1527–1608), who wrote a fifty-page 'Preface' to the first English translation of Euclid's geometry, remarked: 'A marvellous neutrality have these things Mathematical, and also a strange participation between things supernatural, immortal, intellectual, simple and indivisible and things natural, mortal, sensible, compounded and divisible.'[6]

The mathematical history of the nineteenth century is closely interwoven with the period's religious history and the traditional association of mathematics and divinity. Natural Theology[†] was the transcendental truth which mathematics was seen to describe, of which geometry was the exemplar. Mathematics began to separate from religion in the late nineteenth and early twentieth centuries. However, it retained its preeminent position in secular society because of its utility to rapidly developing news fields in science and industry, as well as architecture. The processes of separating the rational and the spiritual is played out in Ruskin's works in the dialectic between forms outside of space and time, only existing within systems of human thought, and those that embody shapes in the natural world.

[†] **Natural Theology** knowledge of God obtainable by human reason alone without the aid of revelation.

'The abstract - like the mathematical - is actually expressed in and through all things … the new painting achieved of its own accord a determined plastic expression of the universal, which, although veiled and hidden, is revealed in and through the natural appearances of things.'

1

2

3

1   John Ruskin, **Stones of Venice: Wall Veil Decoration At Casa Dario And Casa Trevisan,** n.d.
     Pencil, ink, watercolour and bodycolour. 207 x 105 mm. 1996P1069
     © The Ruskin, Lancaster University
2   John Ruskin, **Nautilus 1868 Wks XXI pl 31 CW 1183**.
     Glass negative © The Ruskin, Lancaster University
3   John Ruskin, **Le Cavalier Iller, Pistoia. Church of San Giovanni Fuorcivitas. Arcade wall,** 1846.
     Daguerreotype. 167 x 212 x 4 mm. 1996D0066 © The Ruskin, Lancaster University
4   John Ruskin, **Cockle Shell,** (detail), n.d.
     Watercolour and bodycolour. 145 x 240 mm. 1996P1510 © The Ruskin, Lancaster University
5   Drawn by John Ruskin, Engraved by George Allen. 'Schools of St George. Elementary Drawing.
     Plate IX. Perspective of First Geometry', **The Laws of Fésole** (London: George Allen, 1879)
6   Thomas Matthews Rooke, **Auxerre - Crypt and Tomb, St Germain,** 1886.
     Watercolour Inscription: 'T.M. Rooke / Auxerre. Crupt & Tomb of St Germain 1886. 317 x 270 mm.
     1996P0769 © The Ruskin, Lancaster University

5

4
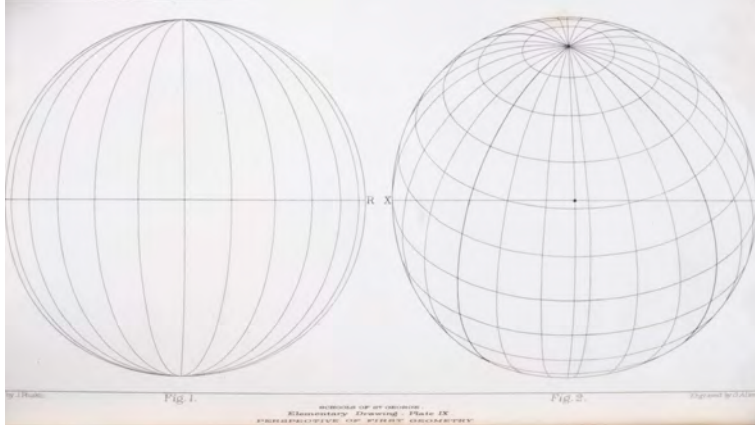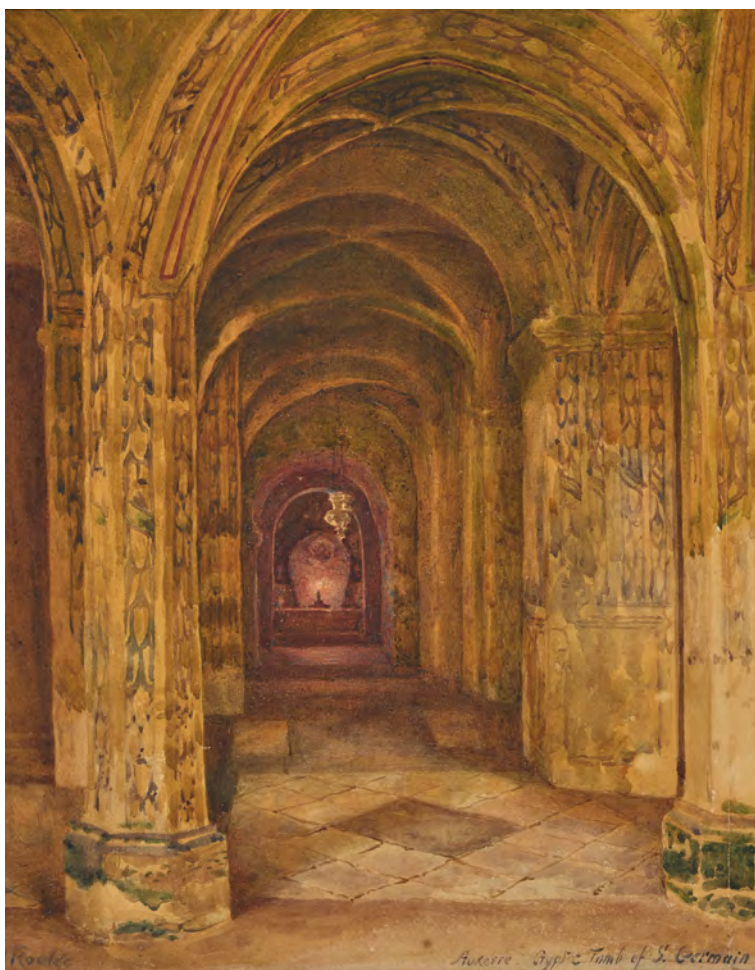
6

Ruskin called this 'real' or 'perpetual' form: an art that would look beyond appearances and reveal an underlying, abstract order. As so often, Ruskin turned to Turner in his own attempts to describe it, seeing 'perpetual form' epitomised in Turner's paintings of the skies. In watercolours such as 'Long Ship's Lighthouse, Lands End' (1834-5), Ruskin finds a pictorial representation of 'untraceable, unconnected, yet perpetual form, this fullness of character absorbed in the universal energy' (*LE* 6 1903, 404). And again:

'… there is a science of the aspects of things, as well as of their nature; and it is as much a fact to be noted in their constitution, that they produce such and such an effect upon the eye or heart … as they are made up of certain atoms or vibrations of matter. Turner … is the master of the science of aspects.'
(*LE* 6 1904, 387)

Ruskin didn't go so far as to tie himself to the mast of a ship in a storm, as Turner once did to experience wave motion. It is the case, however, that alongside the empirical attention to structure and segmentation, form and pattern, or 'the science of perspective', Ruskin sought 'science with feeling'. 'No science of perspective, or of anything else, will enable us to draw the simplest natural line accurately, unless we see it and feel it' (*LE* 6 1903, 475), he remarks. In Ruskin's view, both art and science failed in this respect. 'The natural tendency of accurate science is to make the possessor of it look for, and eminently see the things connected with his special pieces of knowledge; and as all accurate science must be sternly limited, his sight of nature gets limited accordingly' (*LE* 1903 6, 475), he complained. His view echoed the words of the philosopher, Arthur Schopenhauer (1788–1860):

'Therefore the problem is not so much that of seeing what no one has yet seen, but rather of thinking in the case of something seen by everyone that which no one has yet thought.'[7]

The first abstract or nonrepresentational art based on form, colour, line, tone and texture started in the late nineteenth century. Through the currency of science, artistic styles mirrored developments in the laboratory, where the methodology of formulating theories and then testing them now vied with more traditional forms of empirical field work, where collected data is tested for patterns and properties. As scientists worked by deduction, as well as empiricism based on observation and mimesis[†], these processes - logicism, formalism and abstraction - became part of the artist's methodology. For Ruskin this constituted an artistic exercise for 'truth expressed on narrow conditions':

'It makes us observe the vital points in which character consists, and educates the eye and mind in the habit of fastening and limiting themselves to essentials.'
(*LE* 22 1906, 60)

Ruskin moved swiftly from more conventional depictions of landscape to experimental investigations of vegetable growth, mineral evolution and records of the skies, noting key correspondences between the drawings themselves and the ways in which objects and processes were constituted. Ruskin denounced preconceptions about natural phenomena, lamenting the fact that 'we are constantly supposing that we see what experience only has shown us, or can show us, to have existence, constantly missing the sight of what we do not know beforehand to be visible' (*LE* 3 1903, 145). After all, as he points out in *The Elements of Drawing*, 'On First Practice', 'we also suppose that we see only what we know … Very few people have any idea that sunlighted grass is yellow' (*LE* 15 1904, 28).

[†] ***Mimesis*** representing or imitating reality.

Joseph Mallord William Turner, ***Long Ship's Lighthouse, Land's End,*** c. 1834–1835.
Watercolour and gouache, scraped by the artist. 28.6 × 44 cm. The J. Paul Getty Museum,
Los Angeles, 88.GC.55. Digital image courtesy of Getty's Open Content Program.

Ruskin also experimented with micro and macro scales of perception, 'from hoar frost to high cloud' (*LE* 35 1908, 157). He was equally drawn to the down on a butterfly's wing and the filaments of a peacock feather, as to the structures of the Alps, which he described in *The Stones of Venice* from an aerial perspective: 'the variegated mosaic of the world's surface which the bird sees in its migration' (*LE* 10 1903, 186). To this end, Ruskin combined the processes of abstraction to the basic geometric forms (sphere, cube, pyramid, cone, and cylinder) with the core components of visual perception (colour, space, light and movement) in the composition of his works, explaining that: 'There is evidentially capability of separating colour and form, and considering either separately' (*LE* 10 1904, 186). Or, as his contemporary, Maurice Denis (1870–1943), wrote in 1890:

'Remember that a picture – before being a battle horse, a nude woman or some anecdote is essentially a flat surface covered with colours assembled in a certain order.'[8]

Ruskin's illumination of the familiar in moments of heightened perception by surprising analogy and compression is closer to later cubist and modernist concepts of 'inscape', and to Ezra Pound's (1885–1872) definition of an image as 'an intellectual and emotional complex in an instant of time.'[9] In the year of Ruskin's death in 1900, the impressionist artist Claude Monet (1840–1926) is reported as saying that 'ninety per cent of the theory of impressionist painting is clearly and unmistakably embodied in [Ruskin's] *Elements of Drawing*'.[10]

In the nineteenth century, alongside the development of new forms and technologies of visual expression and documentation, an understanding of what counted as a proper process of observation and record was at the centre of debate across the arts and sciences, shaping the conventions of today. Throughout his life, Ruskin remained preoccupied by the relation between pure or abstract form, and the divine and natural worlds. 'If there be any truth or beauty in the original conception of the spiritual being so introduced,' he wrote, 'there must be a true and real connection between that abstract ideal and the features of nature as she was and is' (*LE* 3 1903, 26).

'Mathematics, rightly viewed, possesses not only truth, but supreme beauty … and [is] capable of a stern perfection such as only the greatest art can show.'

Bertrand Russell, 'The Study of Mathematics', *The New Quarterly*, 1907
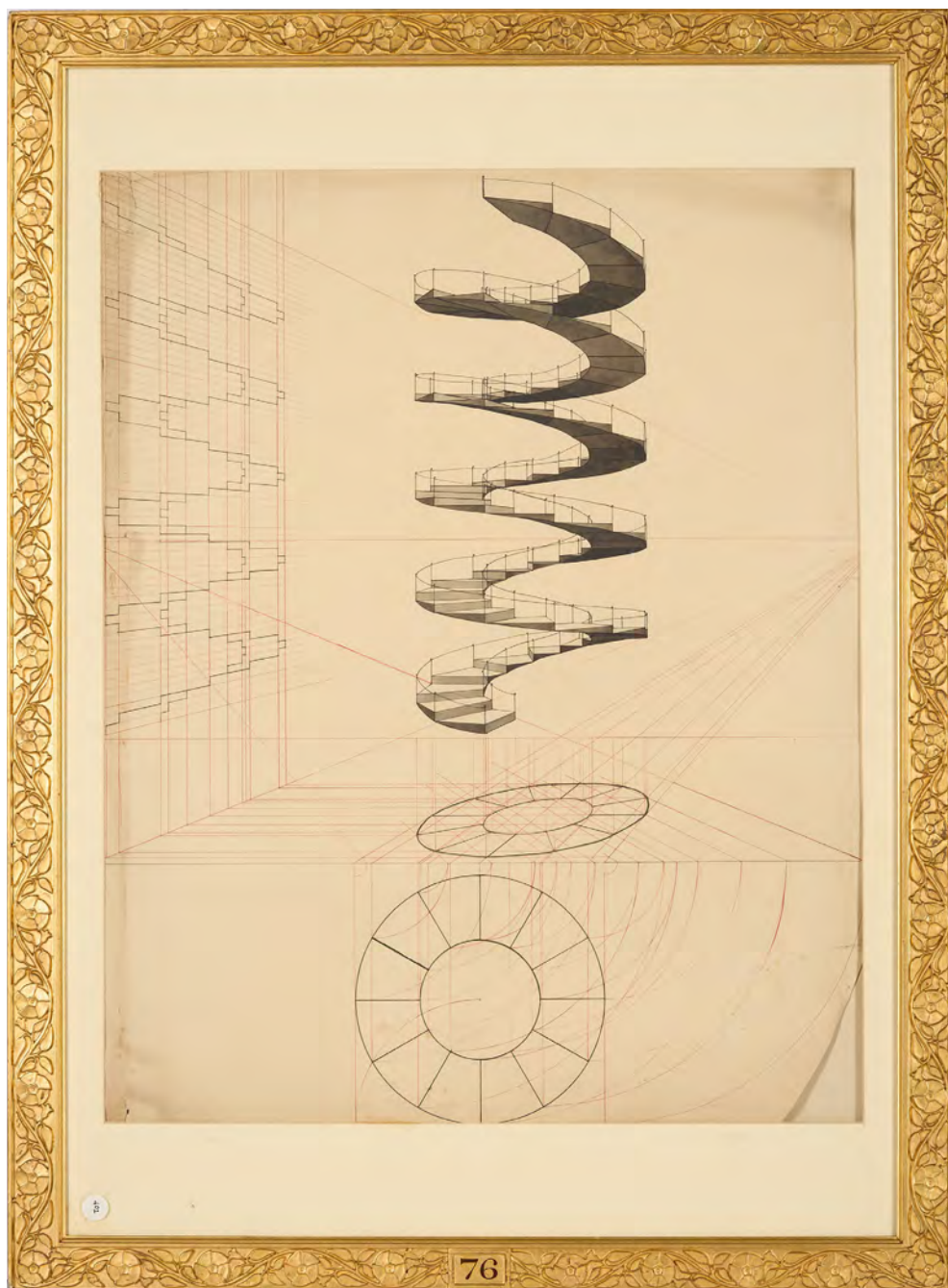
R. H.S., **Baden - Villa Chery - Perspective Study Of Spiral Staircase,** 1836.
Ink and wash. 591 x 476 mm. 1996P0402 © The Ruskin, Lancaster University
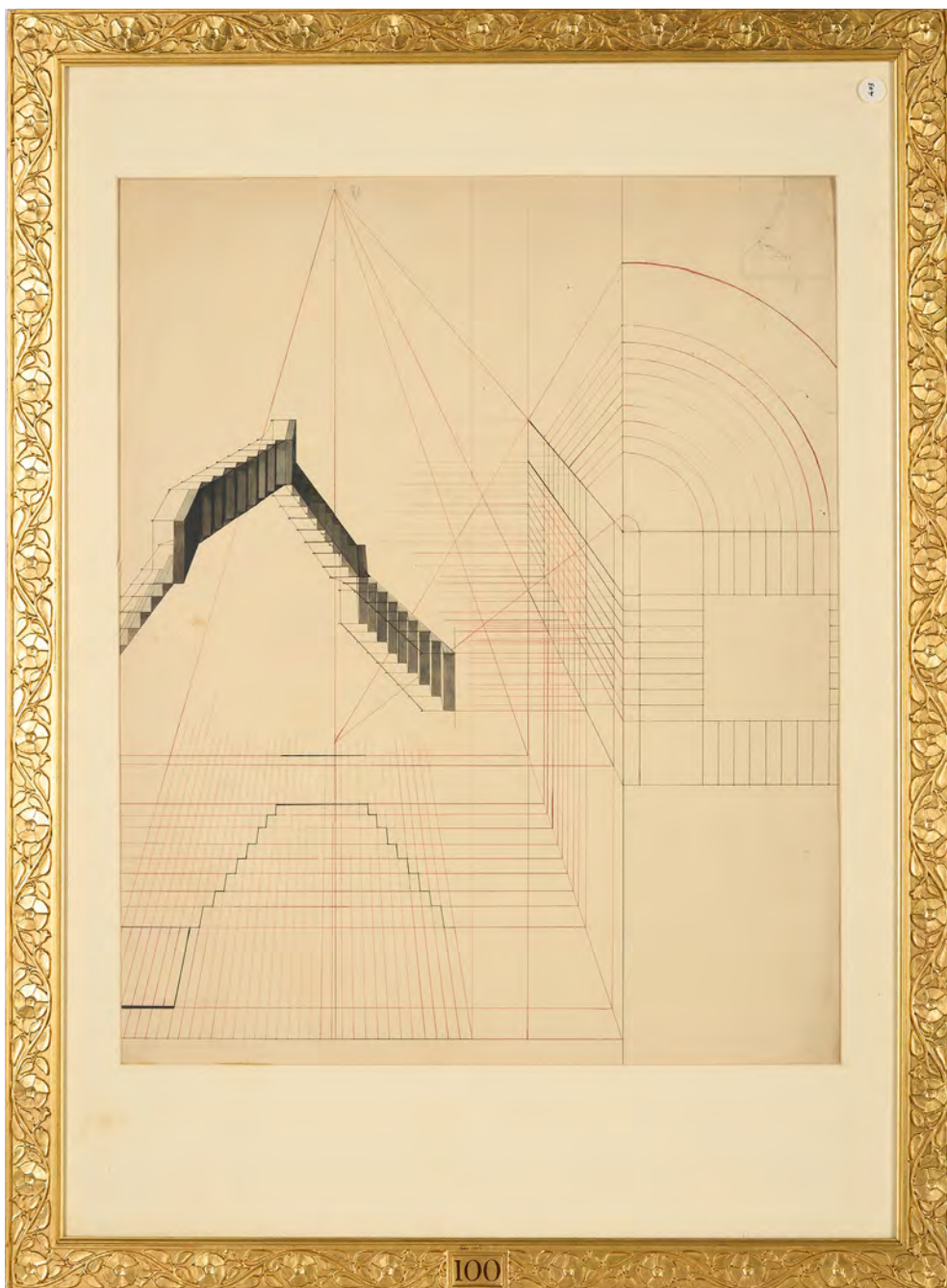
R. H.S., *Staircase - A Study In Perspective,* n.d.
Ink and wash. 591 x 476 mm. 1996P0403 © The Ruskin, Lancaster University

It has been a basic tenet of mathematics from as early as the sixth century BC, that the structure of the cosmos is based on proportion and symmetry, and key facts about the natural world, such as the position of the sun, moon and stars, can be expressed in numbers.[11] Some argue that this marks the beginning of the scientific world view in which nature is understood as embodying a mathematical structure that is discernible by human reason. For example, Lynn Gamwell claims that 'nothing has more profoundly shaped human culture than mathematics' cumulative knowledge of the interplay between pure mathematics and the structure of the physical world, which underlies all science and technology'.[12]

As we see in Ruskin's sketches, drawings and paintings, mathematical knowledge of perspective and abstraction is evident in the play between geometric and organic forms in nature. Regular patterns and symmetrical shapes are most often found in architecture and the built environment, although they are evident in the spheres of the planets and the hexagons of beehives and snowflakes. By contrast organic forms are irregular and difficult to categorise: clouds, tree branches, leaves. As Ruskin explains in his *Lectures on Art* to students at the University of Oxford in 1870:

'These abstract relations and inherent pleasantness, whether in space, number or time, and whether of colours or sounds, form what we may properly term the musical or harmonic element in every art.'
(*LE* 20 1905, 207)

In *The Fractal Geometry of Nature* (1982) the mathematician Benoit Mandelbrot (1924–2010) asked, 'Why is geometry often described as cold and dry? One reason lies in its inability to describe the shape of a cloud, a mountain, a coastline or a tree.' He continued: 'Clouds are not spheres, mountains are not cones, coastlines are not circles, and bark is not smooth, nor does lightning travel in a straight line.'[13] Mandelbrot's work would offer a framework for understanding geometry – and nature – differently. Ruskin had recognised the fractal[†] qualities of the natural world over a hundred years before. Grounded in a belief in the grand design of the universe by God, his apprehension of fractal forms links nature and aesthetics.

Ruskin claimed that his art started from his 'love of mountains and sea' (*LE* 3 1903, xxii). He renders rock surfaces with an extraordinary precision, capturing its fissures and layers, and draws larger mountain forms with extreme clarity of detail and complexity of colour. As the architect and critic Lars Spuybroek (1959–) points out of Ruskin's drawings: 'We see a mountain range, drawn with as much meticulous precision as if it were one of Mandelbrot's fractals'.[14] Ruskin compares rock features to larger mountain forms in a manner anticipating Mandlebrot's fractal geometry: 'No mountain was ever raised to the level of perpetual snow, without an infinite multiplicity of form' (*LE* 3 1903, 438). A rock is 'a mountain in miniature' (*LE* 6 1904, 368). Ruskin's diaries are full of diagrammatic images of particular rock formations in the bid to capture accurate outlines, and record his use of trigonometry to determine 'the angle of the right-hand precipice, which had for some half mile back shown its profile in the most magnificent way, overhanging in the blue sky'.[15]

[†] ***Fractal*** irregular mathematical shapes, with structures that are self-similar over many scales, and that infinitely repeat.
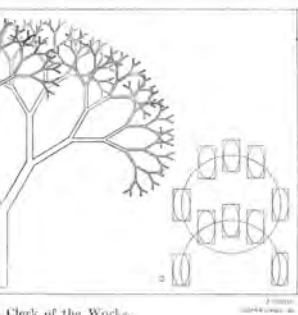
1
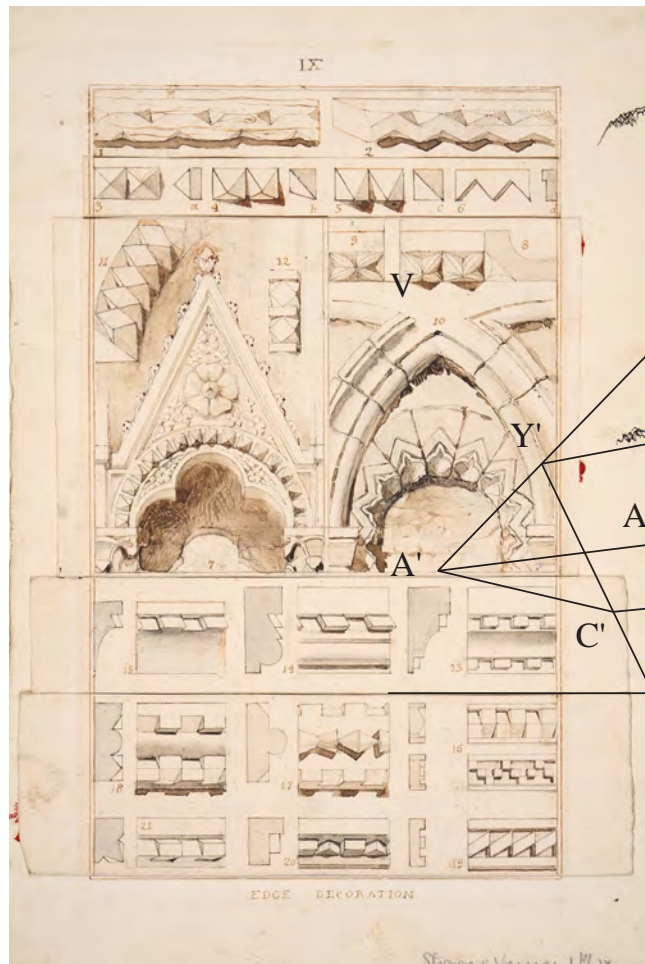
2

1 John Ruskin, *'Sketch by a Clerk of the Works', Modern Painters V, Plate 56*
(London: George Allen, 1905)
2 John Ruskin, *Stones of Venice, Edge Decoration,* n.d.
Pencil, ink and ink wash on six assembled pieces of paper. Inscription in brown ink: IX EDGE
DECORATION. 270 x 188 mm. 1996P1042 © The Ruskin, Lancaster University
3 John Ruskin, Fig. 45, *Elements of Perspective* (London: Smith, Elder & Co., 1859)
4 John Ruskin, *Le Cavalier Iller, Florence. Cathedral. Porte della Mandorla,* 1846.
Daguerreotype. 214 x 174 x 5 mm. 1996D0045 © The Ruskin, Lancaster University

P
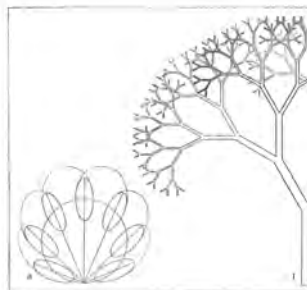
V

P'

4

56. Sketch by a

Fig. 45

Ruskin's mineral collections also feature prominently in his illustrated publications on the relations of art and science, including *Deucalion: Collected Stories of the Lapse of Waves and the Life of Stones* (1879). With a personal collection of over 2,500 specimens, he was one of the most prolific private mineral collectors of the nineteenth century. Ruskin had a particular passion for quartz and its many varieties, including agate, chalcedony, and coloured forms like amethyst, rose and citrine.

From the 16th century onwards, the study of crystals had been at the heart of investigation of the underlying structure of the natural world. In 1665, *Micrographia; or Some Physiological Descriptions of Minute Bodies*, by the natural philosopher Robert Hooke FRS (1665–1703), was the first illustrated publication to examine the geometric shapes of the outer faces of fragments of rock crystal. However, it was Ruskin's nineteenth century contemporary, the German mineralogist Christian Weiss (1780–1856), who created a classification of crystals based on symmetry. Weiss is credited with establishing the parameters of the scientific study of crystals and making it a branch of mathematical science. Weiss determined that the distinctive feature of the crystal was its internal **crystallographic axes of symmetry**[†].

In his own work, Ruskin was trying to capture the 'governing or leading lines' of natural features with respect to individual form: 'not because they are the first which strike the eye, but because like those of the grain of the wood in a tree-trunk, they rule the swell and fall and change of all the mass' (*LE* 6 1904, 231-32). He returned again and again to Chamonix, below the slopes of Mont Blanc, using the 'aiguilles' or beds of slaty crystalline rock, which form the peaks in the Alps, to illustrate his argument.

[†] **Crystallographic axes of symmetry** the lines about which rotations leave the crystal lattice unchanged

'Clouds are not spheres, mountains are not cones, coastlines are not circles, and bark is not smooth, nor does lightning travel in a straight line.'

Benoit Mandelbrot, *The Fractal Geometry of Nature*, 1982

Writing of the precipices of the Alps around Chamonix, he comments on the difficulty of this task; 'rocks of this kind, being found only in the midst of the higher snow fields, are not out of the general track of the landscape painter, but are for the most part quite beyond his power – even Turner's' (*LE* 6 1904, 293).

Ruskin believed that many forms of landscape knowledge emerged from observing the glacier in proximity, and that visual observation led to what he called 'vital truth' in the perception of the world. His physical engagement with landscape enabled him to draw prescient conclusions. In 1874 he wrote of the Glacier des Boissons:

'I was able to cross the dry bed of a glacier, which I had seen flowing, two hundred feet deep, over the same spot 40 years ago.'
(*LE* 6 1904, 126)

Ruskin's concern with the impact of climate on glacial erosion is a leitmotif in his work. 'Observing the changes of form brought about by these monuments of creation' (*LE* 4 1903, 135) underpins Ruskin's systematic documentation of the processes of change and transformation. Like time, glaciers fascinated Ruskin because they move yet seem not to move. His passion for geology brought him into contact with the leading scientific thinkers of the day, including the influential Scottish geologist Charles Lyell FRS (1797–1875), whose *Principles of Geology* (1830–1833) had sparked fierce debate. Ruskin repeatedly engaged with Lyell's thinking on dynamic and continuous natural processes in private correspondence to examine the integration of science and religious belief in his relationship to the environment, and to explore new notions of time and temporality. Ruskin's dynamic sense of temporality, which interweaves mathematics, art, myth, the divine, and the sublime, underpins all of his work.
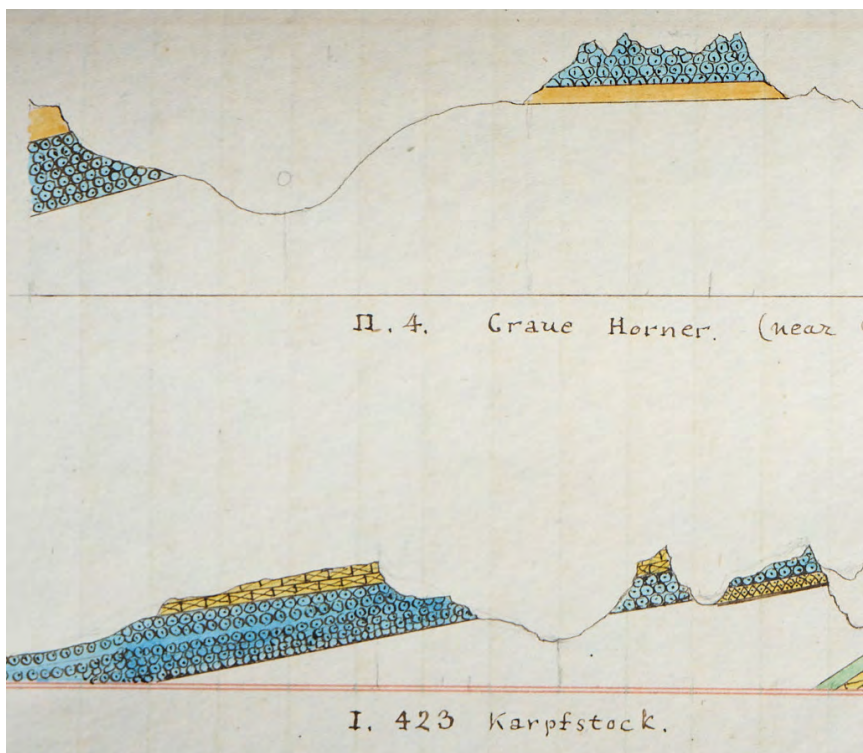
'How could drawing be of itself and not something else?'

1

2

3

II. 4. Graue Horner. (near

I. 423 Karpfstock.
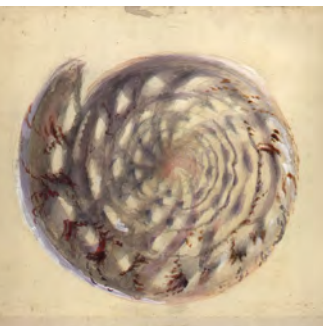
4

1   John Ruskin, *Shell: a spiral* (detail), n.d.
     Bodycolour and white. 365 x 476 mm. 1996P2047 © The Ruskin, Lancaster University
2   Carpenter, William B.; Parker, William K.; Jones, T. Rupert, *Introduction to the study of the Foraminifera,* 1862. Book. London: Ray Society. 31971 © The Royal Society
3   James Sowerby, *'Calx carbonata' (Ammonite with crystals) Plate 12 from Sowerby's British Mineralogy, vol. 1,* 1803.
4   John Ruskin, *Diary of John Ruskin 1861–1863* (detail)
     204 x 170 mm. MS 12 © The Ruskin, Lancaster University
5   James Sowerby, *Sowerby's British Mineralogy, vol. 1,* p. 88. 1804.
     Engraving, print illustration. 233 x 145 mm. R64216 © The Royal Society

(Pfaffers)

88
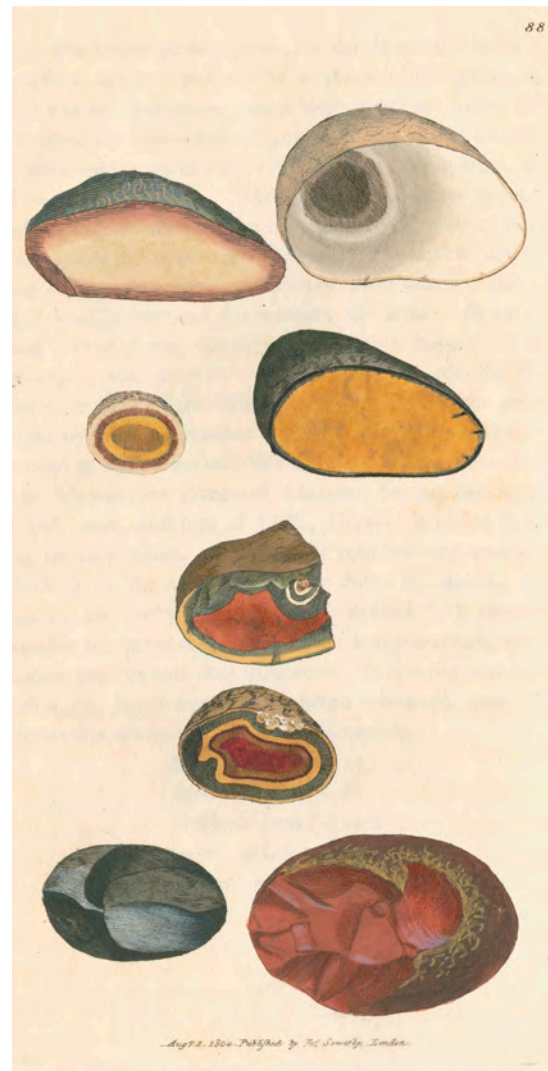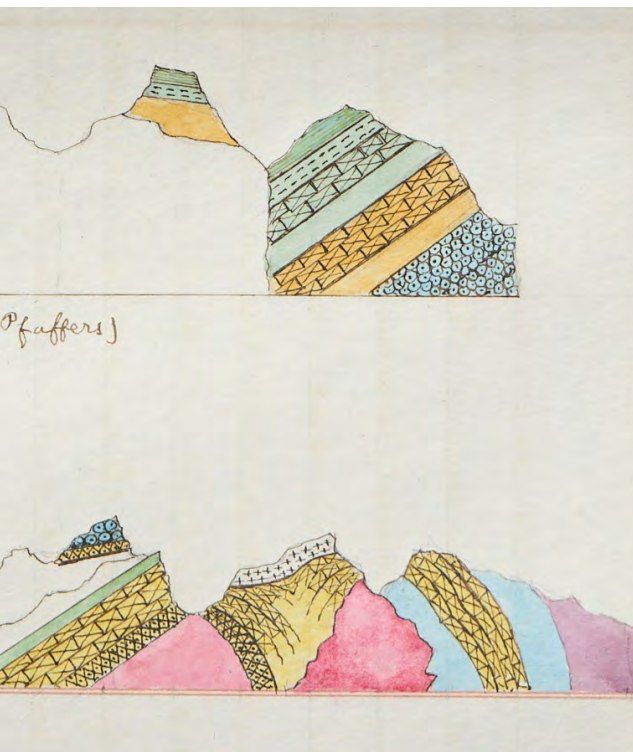
At the end of Ruskin's lifetime, at the turn of the century, revolutions in communications and transport technologies were transforming the connectivity of the world. Two centuries before, a similar technological revolution took place. In 1669, Isaac Newton FRS (1642–1727) and Gottfried Wilhelm Leibniz (1646–1716) invented a new mathematical tool, calculus[†], to describe continuous motion through space and time. They used this to more accurately predict the motion of astral bodies in the sky. In the seventeenth century, this was of great importance for navigation at sea, and the development of trade and travel. By the nineteenth century, mathematicians were still using calculus to try to understand pattern formation in dynamic systems, such as Henri Poincaré's (1854–1912) study of the solar system, or Hermann von Helmholtz's (1821–1894) study of vortices. Ruskin was fascinated by the challenge of observing movement in the water and the skies: he designed an observatory for the local school in Coniston, and kept several globes in his study at Brantwood. His works seek to capture an interconnected world governed by 'the great laws of change, which are the conditions of all material existence' (*LE* 6 1904, 176).

In the 1930s, the historian of mathematics, George Sarton (1884–1956), argued that 'the history of mathematics should really be the kernel of the history of culture.'[16] As this exhibition shows, the geometric imagination and the interaction of geometry, graduation and the layering of colour are the foundation of Ruskin's works. So too is the notion of art as a propositional or axiomatic[†] system, comparable to mathematics. Ruskin was not an artist in the conventional sense. He did not produce his works for the purposes of display, but as 'shorthand or symbolic work' (*LE* 15 1904, 129), or 'syllables of thought'. 'I fancy few artists can show a careful sketch in colour, made at 8000 feet above the sea when suffering under violent sore throat' (*LE* 5 1903, xxvii), Ruskin wrote in a letter to his father.

[†] **Calculus** the study of instantaneous rates of changes, as opposed to the study of static objects.
Axiom a statement that is presupposed to be 'true'.

These visual memoranda were part of his quest to understand 'the entire meaning and system of nature' (*LE* 3 1903, 367). This process is akin to Brian Rotman's description of mathematics as a quintessentially human construct; and its function as 'a symbolic activity conducted solely through thought experiments on ideal invisible objects', whose purpose was equally to understand the nature of humanity itself, and its place in the universe.[17] Beginning with Carl Friedrich Gauss (1777–1855), and followed by János Bolyai (1802–1860) and Nikolai Lobachevsky (1792–1856), nineteenth century non-Euclidian mathematicians took a very different approach. These new mathematicians felt free to develop alternative geometries that obeyed different rules to Euclid's: in spherical geometry, for instance, there are no parallel lines and the interior angles of a triangle sum to more than 180°. In their view, any alternative geometry was just as 'real' as Euclid's as long as it was systematic and internally consistent. Like Augustin-Louis Cauchy FRS (1789–1857) and Bernard Bolzano (1781–1848) in the case of calculus, the pioneers of non-Euclidean geometry insisted that the legitimacy of a mathematical system lies entirely in its own coherence and self-consistency.

Nevertheless, non-Euclidean geometries have real-world applications (to a first approximation, long-distance flights follow *great circles*, the straight lines of spherical geometry) and have their apotheosis in the general theory of relativity created by Albert Einstein (1879–1955) to describe gravity, where the geometry of space and time varies according to the presence of matter.

Chess set. White and red ivory and wood. R33 © The Ruskin, Lancaster University

At the heart of this exhibition sits Ruskin's chess board. This game is played using thirty-two pieces on a board comprising sixty-four squares, following a set of rules about how pieces can be moved across the board.

Just as Ruskin viewed art, chess can be thought of both as a representation of a world (the squares as a battlefield), and as a set of purely mechanical rules which follow their own logic. In this respect, the chessboard is an example of a formal axiomatic system. Like a computer, whose systems are also determined by meaning-free mechanical rules, the game of chess is analogous to the principles of mathematics. The limitations of such formal systems were better understood after the work of Kurt Gödel (1906–1978) and Alan Turing FRS (1912–1954), amongst others.

'Try always,' Ruskin urged his students in *The Elements of Drawing*: 'whenever you look at a form, to see the lines in it which have had power over its past fate and will have power over its futurity' (*LE* 15 1904, 91). Ruskin's works evidence the diffusion of mathematical ideas, methods, and materials through culture. From trade and travel, to the economy and decision-making based on statistics and probability, the socio-economic impact of mathematics on culture and society was immense. Its contribution to a much broader pattern of intellectual, cultural and material history and of individuals, networks and institutions is not yet fully acknowledged.[18]

© Professor Sandra Kemp

Director, The Ruskin – Museum and Research Centre, Lancaster University

Afterword

Mathematics is often seen as arid, fixed and reductive, with a mathematical description of phenomena robbing them of their beauty and wonder. The mathematician knows that this is far from true. New mathematical theories are constantly being developed and refined, thanks to the demands of science but also because of a desire to explore the intrinsic logical structure of the universe: the mathematician asks, if I assume the following axioms, what must follow from them? The choice of axioms and questions to put to them is vital, and why some choices are more fruitful than others is a mystery. As the analyst Karl Weierstrass (1815–1897) said, 'it is true that a mathematician who is not somewhat of a poet, will never be a perfect mathematician'.[19] Ruskin's interest in mathematics shows that the converse is also true: that for the poet, the artist, the wonderer, the use of mathematics provides a heightened appreciation of nature and a better understanding of its treasures, which can only bring greater joy in the world around us.

Professor Alexander Belton

Head of the Department of Mathematics and Statistics, Lancaster University

'The oldest examples of surface ornament are from Egypt. We do not know whether they had a mathematical theory of groups, but their figures are certainly a geometric achievement. Today our mathematical theories are written in the form of theorems and proofs, but this is the influence of Greek Mathematics.

But the geometric image is the real essence of logical reasoning.'

Andreas Speiser, *The Mathematical Way of Thinking*, 1932

Exhibition Guide

Perpetual Form: Mathematics in Culture

Mathematics was at the centre of nineteenth century culture, and a basic knowledge of its concepts was common amongst people of all classes. Mathematical understanding grew from the philosophy and science of classical Greece. Euclid's treatise *Elements* was used to teach mathematics from its publication c. 300 BC to the late nineteenth century.

Mathematics was closely interwoven with religion, and religious principles governed scientific inquiry. The laws of proportion and distribution of mass, alongside the symbolism of pure geometric forms like the circle or triangle, manifest in Gothic architectural style. Its defining feature – the pointed arch – represents the conjunction of science, philosophy, religion and art.

In Ruskin's lifetime, mathematics became separated from religion. This process – and the relationship between abstract forms outside of space and time, only existing within systems of human thought, and those that embody shapes in the natural world – is played out in his works.

Practical Geometry: Ruskin and Euclid

Ruskin taught drawing at school and university level and at Working Men's Colleges. He published many of the exercises he prepared for his students in his three textbooks: *The Elements of Drawing*, *The Elements of Perspective*, and *The Laws of Fésole*. *The Elements of Perspective* was written to be read alongside the first three books of Euclid. Ruskin had several editions of Euclid in his own library, along with books on practical geometry by John Bonnycastle (1751–1821), on differential equations by John Hymers (1803–1887) and on *Algebraical Problems* (1824) by Miles Bland (1786–1867), amongst others.

Euclid's treatise, *The Elements*, was the first to offer mathematical proof through the laws of logic, and not only determined the way later thinkers conceived of space and time, but also provided a blueprint for argument and debate in Western philosophy. As one of the most published and translated authors of all time, Euclid's works were central to nineteenth century culture. Tactile editions of Euclid were published on embossed paper to be used by people with visual impairments (pictured on p. 59). In 1833, Samuel Gridley Howe published a paper entitled 'Review of Education of the Blind' in *The North American Review*, stating 'The blind are indebted, we think, to the Rev. Mr. Taylor, of York, in England for a plan of embossing mathematical diagrams'.[20] Although students experienced difficulties in feeling the outlines of larger diagrams, the technique was a breakthrough in the teaching of mathematics.

In his 1847 edition, the mathematician, engineer and teacher Oliver Byrne (1810–1880) employed a distinctive red, yellow and blue primary colour scheme for the diagrams and geometric shapes that are used in place of letters to support learners: 'to assist the mind in its researches after truth, to increase the facilities of instruction, and to diffuse permanent knowledge'.[21] The diagrams, printed from woodblocks, result in visually playful pages that, to the modern reader, suggest the art of Matisse or Mondrian.
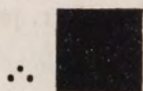
'The history of mathematics should really be the kernel of the history of culture.'

T O *inscribe a circle in a given square.*

Make ▬▬▬ = ········· ,

and ▬▬▬ = ▪▪▪▪▪▪▪ ,

draw ······▬ ‖ ▬····· ,

and ▬▬▬▬ ‖ ▪▪▪▪▪ ,

(B. 1. pr. 31.)

∴ ■ is a parallelogram ;

and since ▬▬···· = ▪▪▪▪▬ (hyp.)

▬▬▬ = ▪▪▪▪▪

∴ ■ is equilateral (B. 1. pr. 34.)

In like manner, it can be shown that

■ = ■ are equilateral parallelograms ;

∴ ▪▪▪▪▪▪▬ = ········· = ▬▬▬ = ▬▬ ,

and therefore if a circle be described from the concourse of these lines with any one of them as radius, it will be inscribed in the given square. (B. 3. pr. 16.)

Q. E. D.

58

Oliver Byrne (ed.), ***The first six books of the elements of EUCLID, in which coloured diagrams and symbols are used instead of letters for the greater ease of learners …*** (London: William Pickering,1847). Book with coloured plates/illustrations.
Ref: 38538 © The Royal Society

THE

DIAGRAMS

OF

EUCLID'S ELEMENTS OF GEOMETRY,

(ARRANGED ACCORDING TO SIMSON'S EDITION,)

IN AN

EMBOSSED OR TANGIBLE FORM,

FOR THE USE OF

BLIND PERSONS,

WHO WISH TO ENTER UPON THE STUDY OF THAT
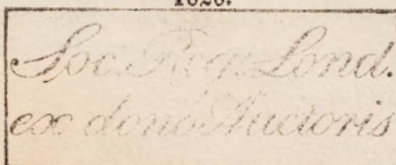
NOBLE SCIENCE.

BY THE REV. W. TAYLOR,
VICAR OF BISHOP BURTON.

PART I.

York:

PRINTED BY J. WOLSTENHOLME, GAZETTE-OFFICE.
SOLD BY W. JOY, 66, ST. PAUL'S CHURCH-YARD, LONDON; PARKER,
OXFORD; DEIGHTON, AND STEVENSON, CAMBRIDGE; AND
T. MARSH, MINSTER-GATES, YORK.

1828.

W. Taylor (ed.), *The diagrams of EUCLID's elements of geometry (arranged according to SIMSON's edition) in an embossed or tangible form, for the use of blind persons...; part I, by the Rev. W.TAYLOR*
(York: J, Wolstenholme, Gazette Office, 1828) Ref: 38537 © The Royal Society

Map Making: Geometry and Colour

Ruskin also used colour as a key component of the exercises in his textbooks. Two of the primary exercises he set his students were cartography and the drawing of spheres.

Although Ruskin never travelled further east or south than Italy, he drew maps of areas of interest to him throughout his life and he placed map-making 'first among the elementary exercises, which include subsequent colour' in his teaching manuals. Maps also feature amongst his lecture diagrams as exercises on working in grids, for example in *A Knights Faith - Map of India*, 1885. He explains: 'every chief exercise map is to be a square of ten, fifteen, or thirty degrees – European countries mostly coming in squares of ten degrees, India and Arabia in squares of thirty'.[22]

For Ruskin, map-making combined his interest in mathematically precise topography with his imaginative ability to see things 'in the round', and represent that vision with equal ability in word and image. A remarkable passage in *The Stones of Venice* invites the reader to fly with him from St Mark's Square, Venice, over the Alps and across France to a cathedral close in England. He uses the imagined aerial journey to observe the relations of topographical territories, local climate, and societal and cultural change.

The *Map of the Euxine Sea* (pictured on p. 54), now known as the Black Sea, was produced by Ruskin when he was a teenager. Ruskin later recalled mapmaking as child:

'These maps were a great delight to me; the colouring round the edges being a reward for all the tediousness of the printed names; the painting, an excellent discipline of hand and eye; and the lines drawn for the mountains and sea a most wholesome imitation of steady engraver's work.'[23]

In 1852, the South African mathematician and botanist, Francis Guthrie (1831–1899) proposed a new mathematical 'proof' which became known as the 'Four colour Theorem': that no more than four colours are required to colour the regions of any map so that no two adjacent regions have the same colour.

61
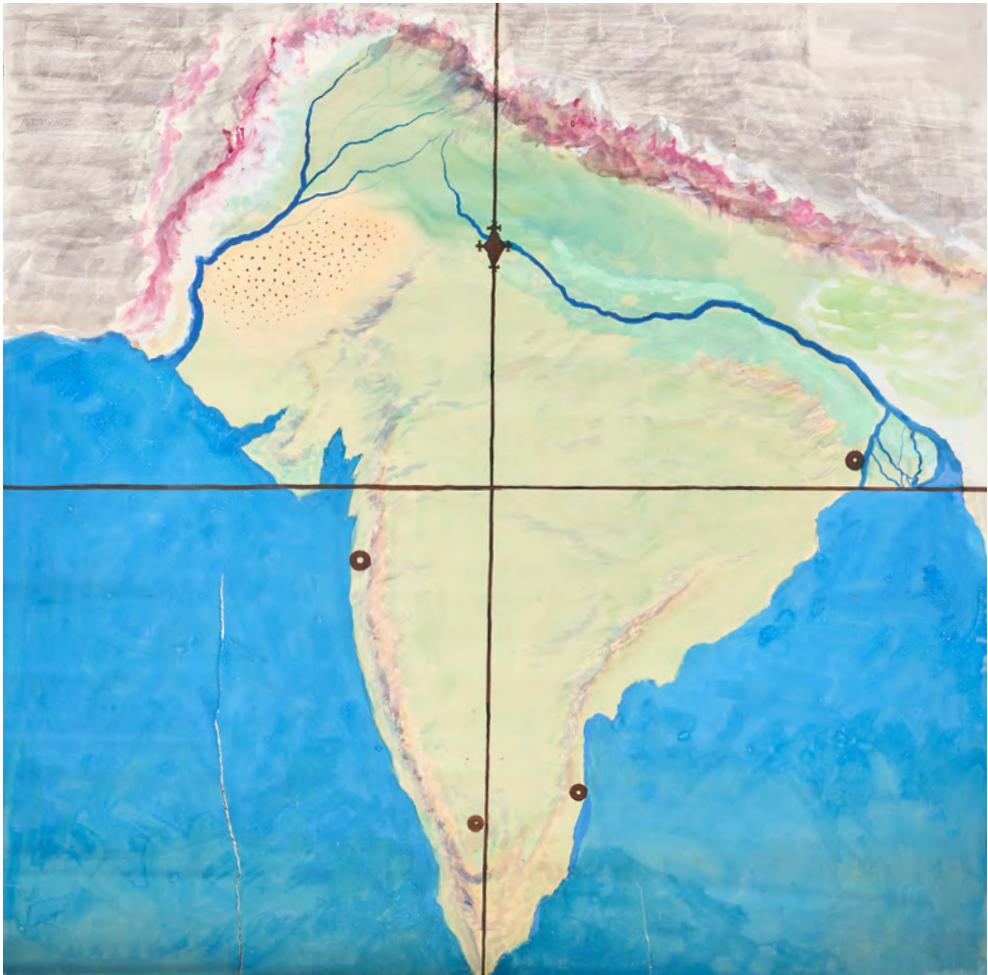
School of Ruskin, *A Knights Faith - Map Of India,* 1885.
Bodycolour On Paper Laid On Paper. 61 x 58 in. 1996P0462 © The Ruskin, Lancaster University

Spheres and Penumbras of Light

The most symmetrical of geometric forms is a sphere. One of the first tasks Ruskin set his students was to draw a sphere or spherical object, like an orange or a cricket ball, without using an outline to define it. Being able to represent the light travelling across curved surfaces allows the artist to progress from a limited vocabulary of lines, to an almost infinite subject matter, because the rules governing shading are also the rules governing light. Ruskin shows how the diminution of light striking a curved surface accelerates as it moves through the penumbra[†] in proportion to the reducing surface area that it can reach. The drawing pictured on page 8 is the basis for the first exercise or law in creating 'Light and Shade … on any curved surface whatsoever', and involves a complex interaction of geometry, graduation and layering of tint. The underlying role of geometry can be found in Ruskin's statement that 'curved lines … [are] made up of a series of right lines, afterwards considering these right lines as infinitely short' and in his insistence on students using quadrants to measure light (*LE* 9 1904, 473).

The problem of the quadrature (or squaring) of the circle (constructing a square equal in area to a given circle using only a compass and ruler) has preoccupied mathematicians since antiquity, including Euclid and Hippocrates. A demonstration of a possible 'solution' to the impossible problem of the quadrature of the circle, consisting of a circular brass plate with an equatorial bar and with attached steel angles, is pictured on page 2.

A solution cannot be realised with a ruler and compass, as was proven 1882 by the German mathematician Carl Louis Ferdinand von Lindemann (1852–1939).

[†] **Penumbra** the area closest to the fully shaded area

63
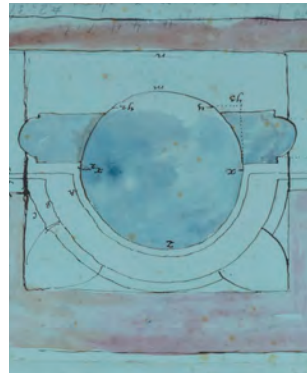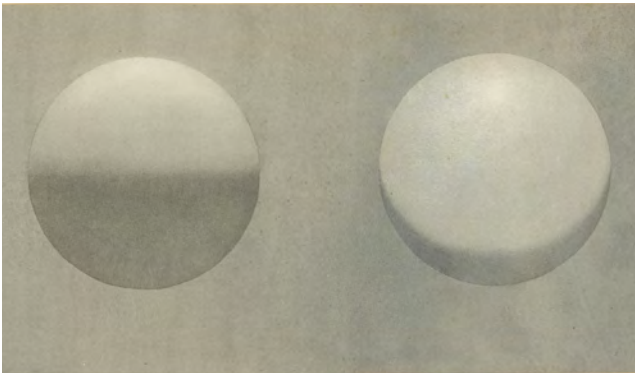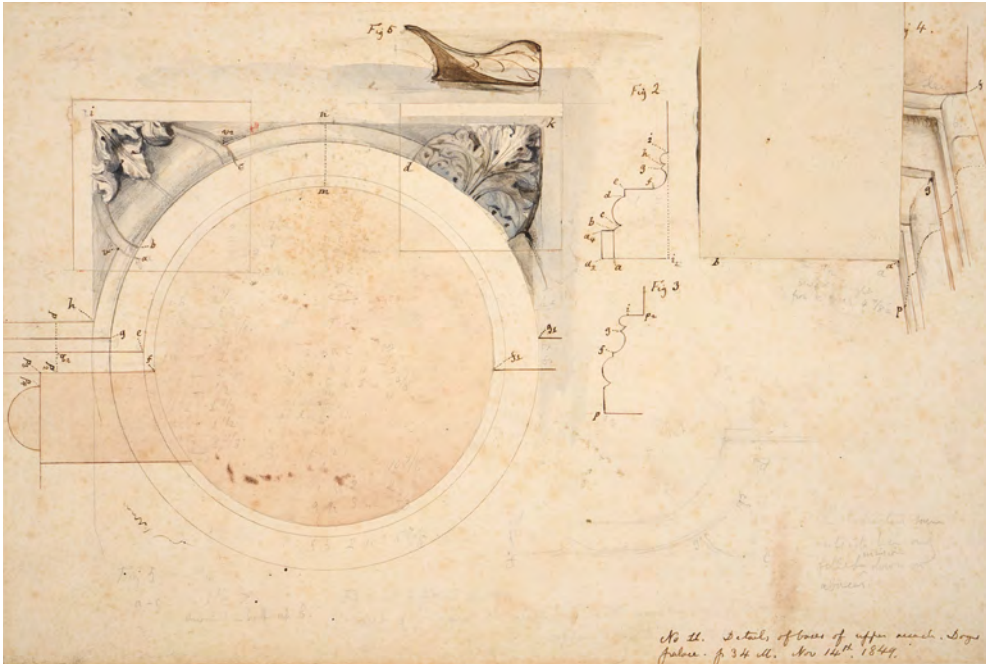
John Ruskin, ***Stones of Venice worksheet: Upper arcade of Doge's Palace,*** 1849.
Pencil, black ink and watercolour. Inscription in black ink: 'No 11. Details of bases of upper arcade, Doges Palace / p. 34. M. Nov 14th 1849'. 362 x 249 mm. 1996P1598
© The Ruskin, Lancaster University
Frank Randal, ***Two Studies of Spheres,*** 1881.
Pencil. 231 x 310 mm. 1996P0416 © The Ruskin, Lancaster University
John Ruskin, ***Venice & Verona - Slipcase of Sketches & Notes, Worksheet*** (detail), n.d.
Ink and wash on paper. 1996P1638. 329 x 217 mm © The Ruskin, Lancaster University
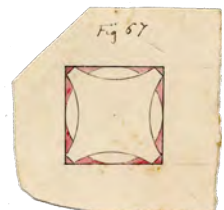
Instruments and Technology

From minerals to mountains, cornices to cathedrals, Ruskin's work was aided by scientific instruments of measurement and the most advanced technologies of the day. Ruskin owned an Armillary Sphere, an instrument used by astronomers to observe and calculate the measurement of the stars and planets. Plato had linked mathematics to the divine through the constellations of heavenly bodies and the belief that these moved only in perfect circles, like planetary orbits. In the early Renaissance, Leon Battista Alberti considered the circle the most perfect shape, although other polygons that could be inscribed within a circle were acceptable, as in Leonardo da Vinci (1452–1519)'s and Albrecht Dürer's semi-regular polygons in their drawings for churches.

In the nineteenth century, the daguerreotype was a new technology which could capture precise detail. As Ruskin explained: 'every chip of stone and stain is there, and of course there is no mistake about proportions'.[24] Ruskin read architecture as he read a mineral specimen, asking the fundamental question as to what forces brought it into being. Like a complex mineral, it embodied laws of construction specific to the environment out of which it grew and the materials of which it was made. Where one was chemical and geomorphic, the other was cultural and economic.

Ruskin used daguerreotypes extensively in the preparation of his works on church architecture in *The Seven Lamps of Architecture* (1849) and *The Stones of Venice* (1851–53). The Ruskin Whitehouse Collection contains 125 'sun pictures': one-off plates using the first popular process of permanent photography. Ruskin's manuscript catalogue, also part of the Ruskin Whitehouse Collection, lists 233 daguerreotypes in Ruskin's possession, the majority of which are of architectural subjects in Italy.

John Ruskin, *Venice & Verona - Album Of Notes & Sketches, p.34,* n.d. Ink and wash on paper. 1996P1641 © The Ruskin, Lancaster University

John Ruskin, Le Cavalier Iller, **Florence. Cathedral. *Porte della Mandorla (north door),*** 1846. Daguerreotype (detail). 214 x 174 x 4 mm. 1996D0045 © The Ruskin, Lancaster University
John Ruskin, Le Cavalier Iller, John Hobbs, ***Lucca. Church of San Michele. Detail of Principal Façade,*** 1846.
Daguerreotype (detail). 222 x 183 x 4 mm. 1996D0072 © The Ruskin, Lancaster University

The selection of daguerreotypes in this exhibition demonstrates the evolution of the Romanesque architectural style, characterised by the semi-circular arch on the Italian churches of San Giovanni Fuorcivitas, San Michele and San Zeno, into the Gothic, associated with the pointed arch seen in Ruskin's image of the Cathedral of Notre Dame, Rouen (pictured on p. 9). In a reproduction of the daguerreotype, the heightened contrast between light and shade emphasises the use of 'pure' shapes (circle, triangle) associated with divinity. The capacity of this new technology to render a building as a collection of shapes is most pronounced in Ruskin's daguerreotype of the South Façade of St Mark's, Venice: in high resolution, the image captures the graphic pattern on each Byzantine panel forming the grid embedded in the wall of the Basilica (pictured on p. 16).

The same interrogation of structural form is evident at macro-scale in Ruskin's daguerreotypes of San Giovanni Fuorcivitas, San Michele and San Zeno (pictured on pp. 24; 68).

In *The Seven Lamps of Architecture*, Ruskin cites the Church of San Giovanni Fuorcivitas as an exemplar of 'Living Architecture … which is exactly like the related proportions and provisions in the structure of organic form' (*LE* 8 1903, 204). Founded in the eighth century, the church in Pistoia, Tuscany was rebuilt between the twelfth and fourteenth centuries, when the distinctive green and white banded façade was added. The pattern, that repeats across three levels, features a diamond-shaped detail enclosed within an arch. It is likely that Ruskin's published description of the church was based on this daguerreotype, in conjunction with careful measurements. He focuses on the tricks of perception achieved by the geometric design:

'The eye is thus thoroughly confused, and the whole building thrown into one mass, by the curious variations in the adjustments of the superimposed shafts, not one of which is either exactly in, or positively out of, its place;

' … while the general effect is of a symmetrical arcade, there is not one of the arches the same height as another; their tops undulate all along the wall like waves along a harbour quay, some nearly touching the string course above, and others falling from it as much as five or six inches.'
(*LE* 8 1903, 205)

It is possible that this daguerreotype was shown at a meeting of the Graphic Society in London in February 1847, where Ruskin's drawings and watercolours of Tuscan churches were shown 'in juxtaposition' to 'a series of daguerreotype views of many of the Italian ecclesiastical buildings'.[25]

Ruskin's daguerreotype of the façade of the Church of San Michele, Lucca, captures the diversity of architectural features deployed, in a style fusing Romanesque and Gothic: columns, cornices, arches and loggia. At Lucca (pictured on p. 65), these elements work as one: the designs are not 'encrusted' on the walls, but 'incorporated with them'. 'Geometry,' writes Ruskin, 'seems to have acted as a febrifuge [a medicine to bring down fever] … the fragments have come together …' (*LE* 9 1903, 430).

67

Just as Ruskin sought out precision in the world around him, he delivered it in his own work. In response to readers who complained that the plates published in *Seven Lamps*, including a view of San Michele were 'hastily drawn', Ruskin said:

'But their truth is carried to an extent never before attempted in architectural drawing. It does not in the least follow that because a drawing is delicate, … it has been carefully drawn from the thing represented: in nine instances out of ten, careful and delicate drawings are made at home.… The sketches of which those plates in the Seven Lamps are facsimiles, were made from the architecture itself, and represent that architecture, with its actual shadows at the time of day at which it was drawn, and with every fissure and line of it as they now exist … I may depend on it just as securely as if I had gone back to look again at the building.'
(*LE* 9 1903, 431)

By contrast, the screen façade of San Zeno, Verona, features minimal obvious ornament, but was a model for subsequent Romanesque buildings. The tonality of the daguerreotype emphasises the division of the façade into three vertical components, the triangular pediment, and rose window in the shape of a Wheel of Fortune. Ruskin discusses the church in the chapter 'The Cornice and Capital' in *The Stones of Venice*, and in *The Seven Lamps of Architecture*: '… the bas-reliefs … are confined to a parallelogram of the front, reaching to the height of the capitals of the columns of the porch. Above these, we find an … arcade; and above that, only blank wall, with square face shafts' (*LE* 8 1903, 48). Ruskin approved of the simple geometry of the façade, that 'may serve for an example of the way to place little where we cannot afford much' (*LE* 8 1903, 48).

68 Ruskin Lace

A needlecraft traditionally practised in the Lake District, Ruskin Lace is a combination of cut linen work, drawn thread and needle made lace. Ruskin supported craft workers in the Lake District to establish the cottage industry of spinning and weaving through the charity he founded for the arts, craft and rural economy, the Guild of St George. The patterns were based on drawings of Italian lace, supplied by Ruskin to local lace makers.

As the teacher and lace maker Elizabeth Prickett describes, 'the pattern shapes come in the form of pyramids, bugs and picots; … weavings, needle woven over three columns; [and] bullion knots [that] form the centre of most patterns and the traditional edging.'[26] While the pattern components can be interchanged, the pattern must sit in the geometric grid characteristic of Ruskin Lace.

John Ruskin, Le Cavalier Iller, **Verona. Church of San Zeno,** 1846.
Daguerreotype (detail). 171 x 211 x 4 mm. 1996D0033 © The Ruskin, Lancaster University
Ruskin Lace made by Mrs H Dawson of Coniston, n.d.
Linen (detail). 250 x 62 mm. R196 © The Ruskin, Lancaster University

Books and Games

As well as text books and manuals of logic aimed at the general public, recreational mathematics in the form of games was current in Victorian Britain.

Entitled 'Arithmetical Improvement for Children and Amusement for Young and Old gentlemen in England', a mathematical game created by brewer and amateur mathematician, Henry Goodwyn FRS (1740–1824), introduced two interrelated problems preoccupying mathematicians at the time. In challenging players to create a specific set of 'vulgar [or common] fractions', the game touched on contemporary debate about first, the conversion of fractions to decimals (and vice versa) and second, the ordering of 'vulgar fractions' according to size. This game comprised thirty-two cards, along with the instructions:

'After the cards have been shuffled, it is required to arrange them regularly under each other, in such a manner that (adverting first to the Numbers on the Left Hand of each card) THE SUM OF THE TWO EXTREMES OF ANY THREE CONSECUTIVE NUMBERS SHALL BE EQUAL TO THE MEAN OR SOME ONE OF ITS MULTIPLIERS.

This having been done and the cards having been again intermixed, a similar arrangement of the Numbers on the right hand is required. When the cards of any set are all properly arranged, if the Numbers on the left had of each card be considered as the Numerators. And those on the right hand, respectively as the Denominators, and of so many vulgar fractions, then Tabby asserts that no Vulgar fraction of intervening value, can be interposed, of which the Denominator will not consist of, at least, four digits.'
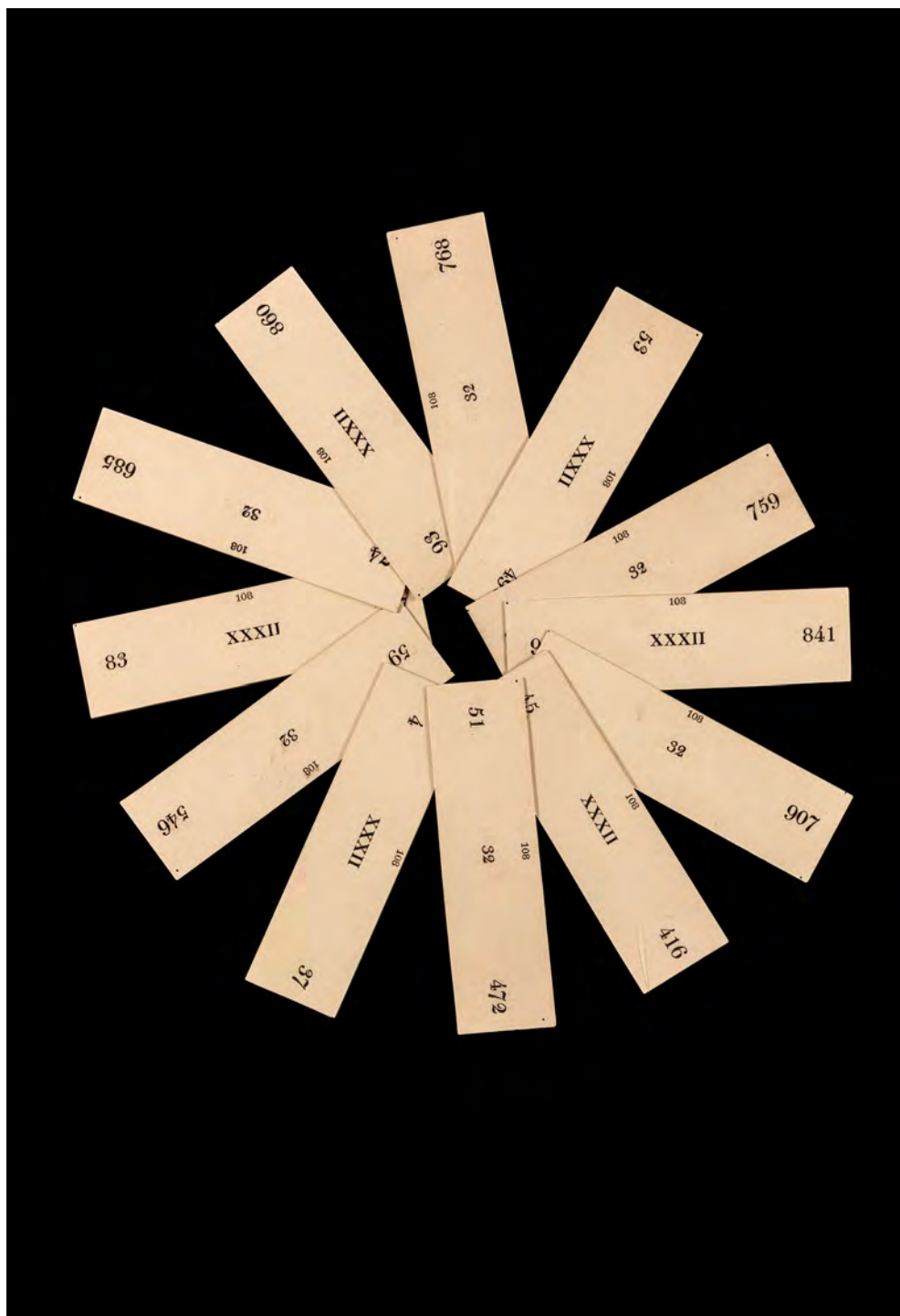
Henry Goodwyn, *Arithmetical Improvement for Children, and Amusement for Young and Old Gentlemen in England* (London: W Marchant, Ingram Court, Fenchurch Street), 1820.
Ref: MS/781 © The Royal Society

As France moved from an imperial to metric system in the wake of the French Revolution, converting fractions to decimals had become a pressing practicality for trade, as well as a theoretical problem. Goodwyn had submitted numerous tables including his epic 'Tabular Series of Decimal Quotients for all the proper Vulgar Fractions' to the Royal Society in 1822–23.

The related question of how to order fractions according to size was seemingly resolved by the creation of Farey sequences, where each number in the sequence is the mediant of its neighbours, and is attributed to the geologist John Farey (1766–1826). Although named after Farey, the development of the principle and the sequences has been traced back to others, including French mathematician Charles Haros and Henry Goodwyn. A month before Farey's letter 'On a curious Property of the vulgar Fractions' (published in *Philosophical Magazine* 1816), Goodwyn had presented his paper on 'all of the complete decimal Quotients … from 1 to 1024' to the Royal Society (25 April 1816) and had circulated a published copy privately a year earlier.

Victorian authors were also quick to respond to contemporary developments within mathematics, including non-Euclidean geometry. The writer Edwin A. Abbott's (1838-1926) novel *Flatland* (1884) is the best known of these. Narrated by A. Square, the novel satirises the famous thought experiment by the mathematician, Hermann von Helmholtz. In order to understand how humans know they are in a 3D world, Helmholtz imagined a world composed of a flat plane populated with intelligent flat creatures, and then reimagined that world shaped like the surface of an egg, which also enabled the perception of spheres and cubes. *Flatland* is located in a 2D world populated by Polygons whose social rank is determined by their number of sides. The high priests of this society comprise Circles (i.e. those with an infinite number of sides) who debar its inhabitants from imagining the world in three dimensions; while the ruling classes include octagons and polygons.

Lewis Carroll (Charles L. Dodgson (1832–1898)), a lecturer in Mathematics at the University of Oxford, invented a board game played with nine pieces on rectangles (*The Game of Logic*, 1886), and wrote books on trigonometry and geometry. In *Alice Through the Looking Glass* (1871), Alice climbed through a looking glass into a game of chess. According to Carroll, his games would develop 'clearness of thought – the ability to see your way through a puzzle, the habit of arranging your ideas in an orderly and go gettable form – and more valuable than all, the power to detect fallacies'.[27]

Ruskin himself was a keen chess player, exchanging letters on the subject with Alexander Macdonald (1839–1921), the Master of Drawing appointed by Ruskin when he was Slade Professor of Fine Art at the University of Oxford. They continued their games by correspondence.
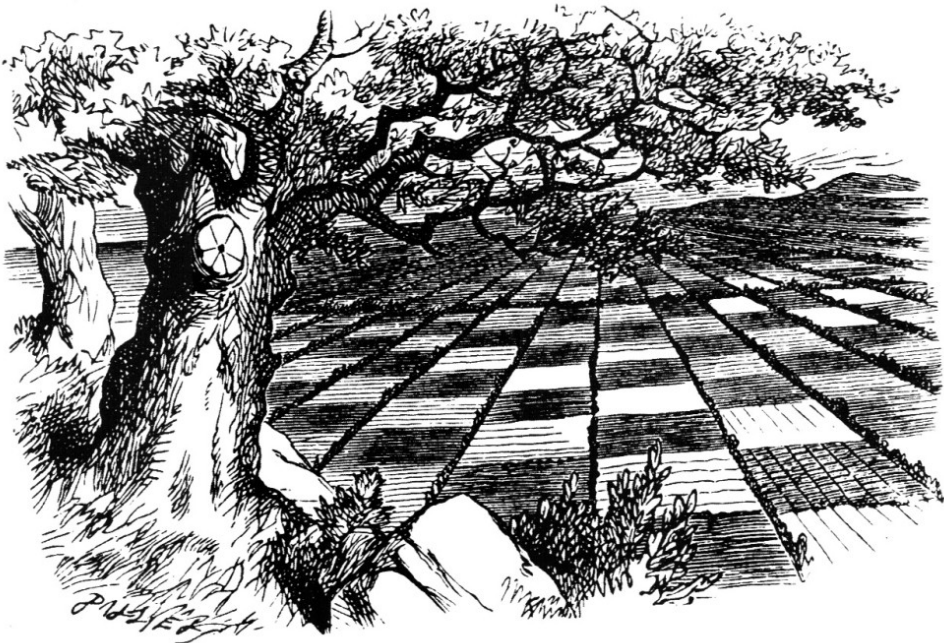

Sir John Tenniel, The Chessboard. Lewis Carroll, ***Through the Looking-Glass and What Alice Found There, Chapter II 'The Garden of Live Flowers'*** (London: Macmillan and Co., 1872)
Джон Тенниел, Public domain, via Wikimedia Commons

Harmonies: Harmonographs and Music

A harmonograph is a drawing instrument that employs pendulums to create a geometric image, typically Lissajous curves. It was one of many short-lived Victorian and Edwardian hobby-crazes based upon simple scientific principles that made it possible for people to produce 'automatic' art at home by the intervention of technology.

This sketch, on the back of a three-page pamphlet titled *Sound-Curve Tracings*, shows the principle of the harmonograph mechanism: a pendulum guides a pen across paper, which is itself mounted on a moving support controlled by a second pendulum. The combined effect can produce highly complex and beautiful patterns. The harmonograph depicted in the drawing, a twin elliptic pendulum harmonograph invented by Joseph Goold (1836–1926) of Nottingham, produced the outputs shown here. Goold contributed to a book on the subject *Harmonic vibration and vibration figures* in 1909.

The Lissajous or Bowditch curve constitute the graphic representation of a system of parametric equations which describe complex harmonic motion. This family of curves was first studied by the American mathematician Nathaniel Bowditch (1773–1838) in 1815, and investigated independently by the French mathematician Jules-Antoine Lissajous (1822–1880) in 1857–58. The visual patterns are created by the intersection of two sinusoidal curves placed in a right angle of each other, where varying frequencies and phase angles of the two originate different line patterns. From the title sequence of Hitchcock's *Vertigo* (1958), to the 2021 Facebook, Inc. relaunch as 'Meta', Lissajous curves are a recognised graphic element of contemporary popular culture.
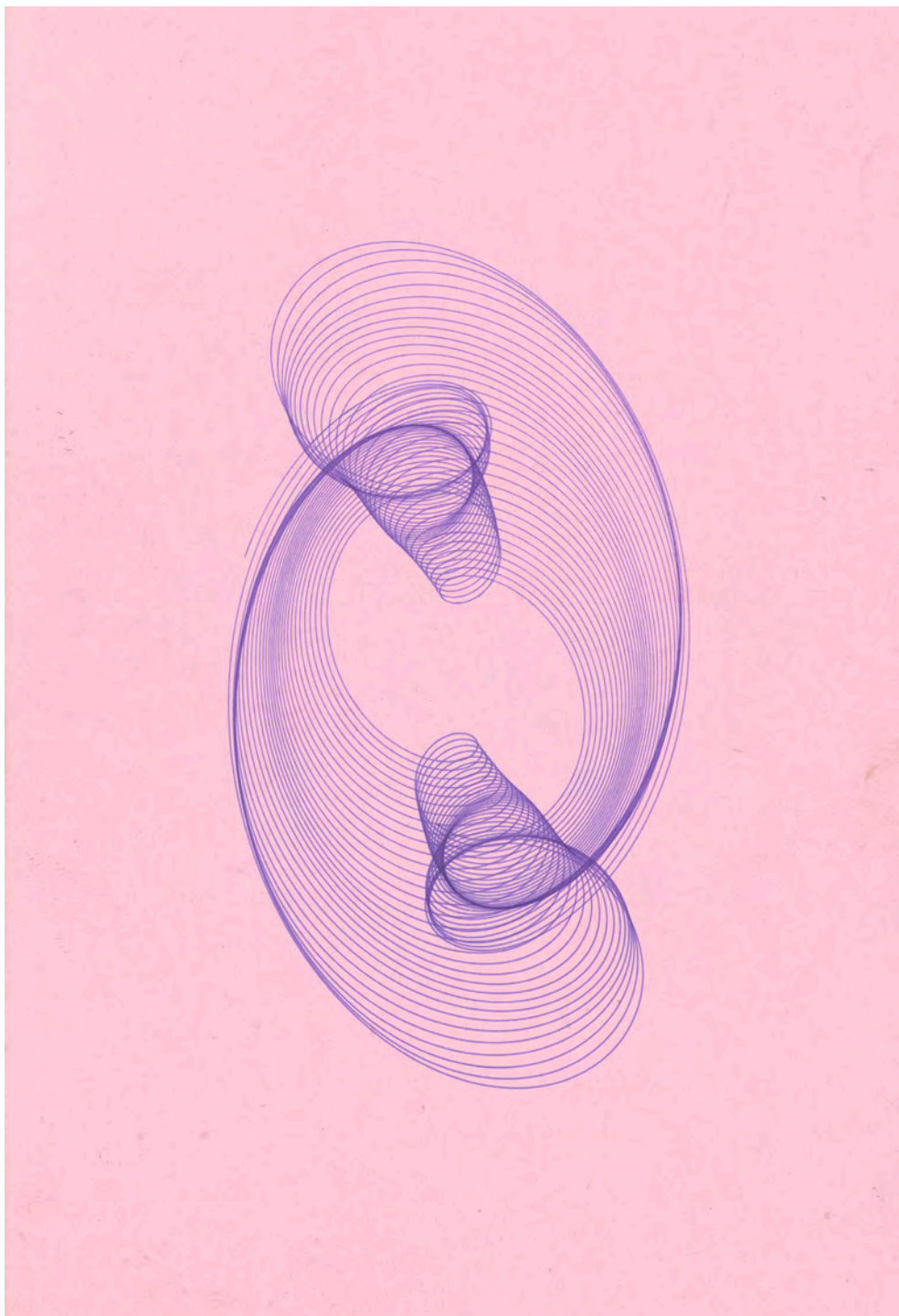
Joseph Goold, ***Harmonograph figure,*** 1901.
Drawing. Purple ink on pink paper. 114 x 76 mm. Ref: MM/22/86 © The Royal Society

Ruskin's love of music permeated his thinking both by way of analogy and guiding principle. In *Ruskin Relics* (1903), W. G. Collingwood describes Ruskin's musical studies while he was an undergraduate at Oxford. He later continued his tuition with the organist, composer and writer, George Frederick West (1812–1897), who also helped Ruskin pursue his interests as a composer. Ruskin wrote about music throughout his life, frequently employing musical analogies, often of a semi-technical nature, to frame his thoughts on drawing, painting and architecture.[28] In *The Stones of Venice* he uses musical description to illustrate the presence of a repetitive but monotonous motif relieved by regular (and irregular) variation. In *Modern Painters* (1883), Ruskin writes,

'Not only however in curvature, but in all associations of lines whatsoever, it is desirable that there should be reciprocal relation, and the eye is unhappy without perception of it. It is utterly vain to endeavour to reduce this proportion to finite rules, for it is as various as musical melody, and the laws to which it is subject are of the same general kind; so that the determination of right or wrong proportion is as much a matter of feeling and experience as the appreciation of good musical composition.

Not but that there is a science of both, and principles which may not be infringed; but that within these limits the liberty of invention is infinite, and the degrees of excellence infinite also.'
(*LE* 4 1903, 108)

Ruskin's interest in music extended to the making of instruments. At Brantwood, his experimental instrument which he describes as a 'ziffern' sits in the Drawing Room. Ruskin is known to have possessed at least four pianos at Brantwood, two of which are on display, and both of which were commissioned for Ruskin by his music teacher, West. Ruskin's last documented action before his death was the commissioning and delivery of a Broadwood grand piano in 1898.
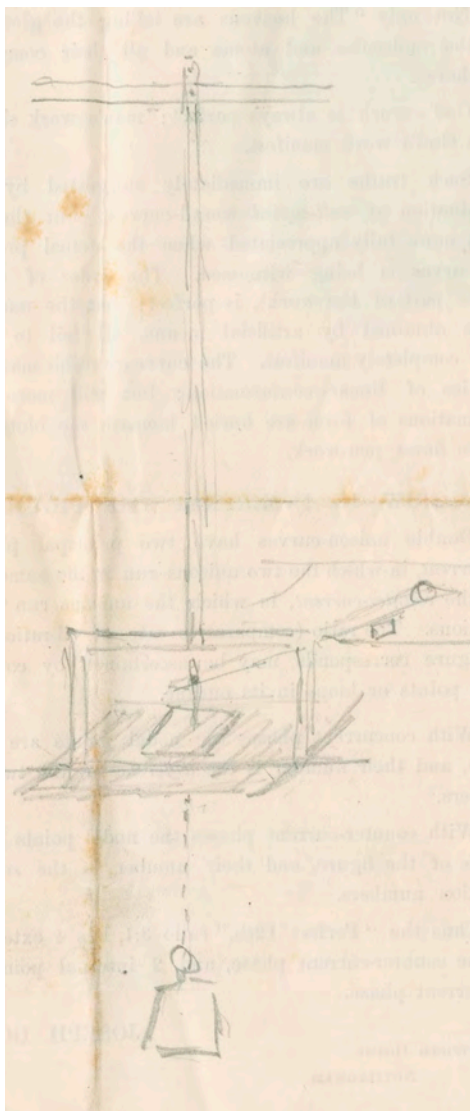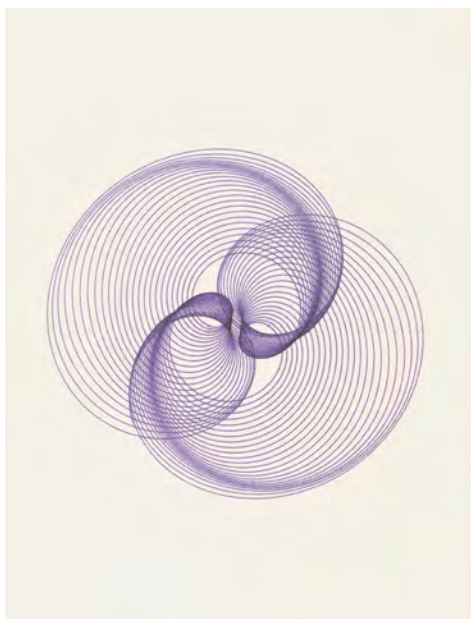
Joseph Goold, ***Harmonograph figure,*** 1901.
Drawing. Blue and green ink on paper. 114 x 76 mm. Ref: MM/22/85 © The Royal Society
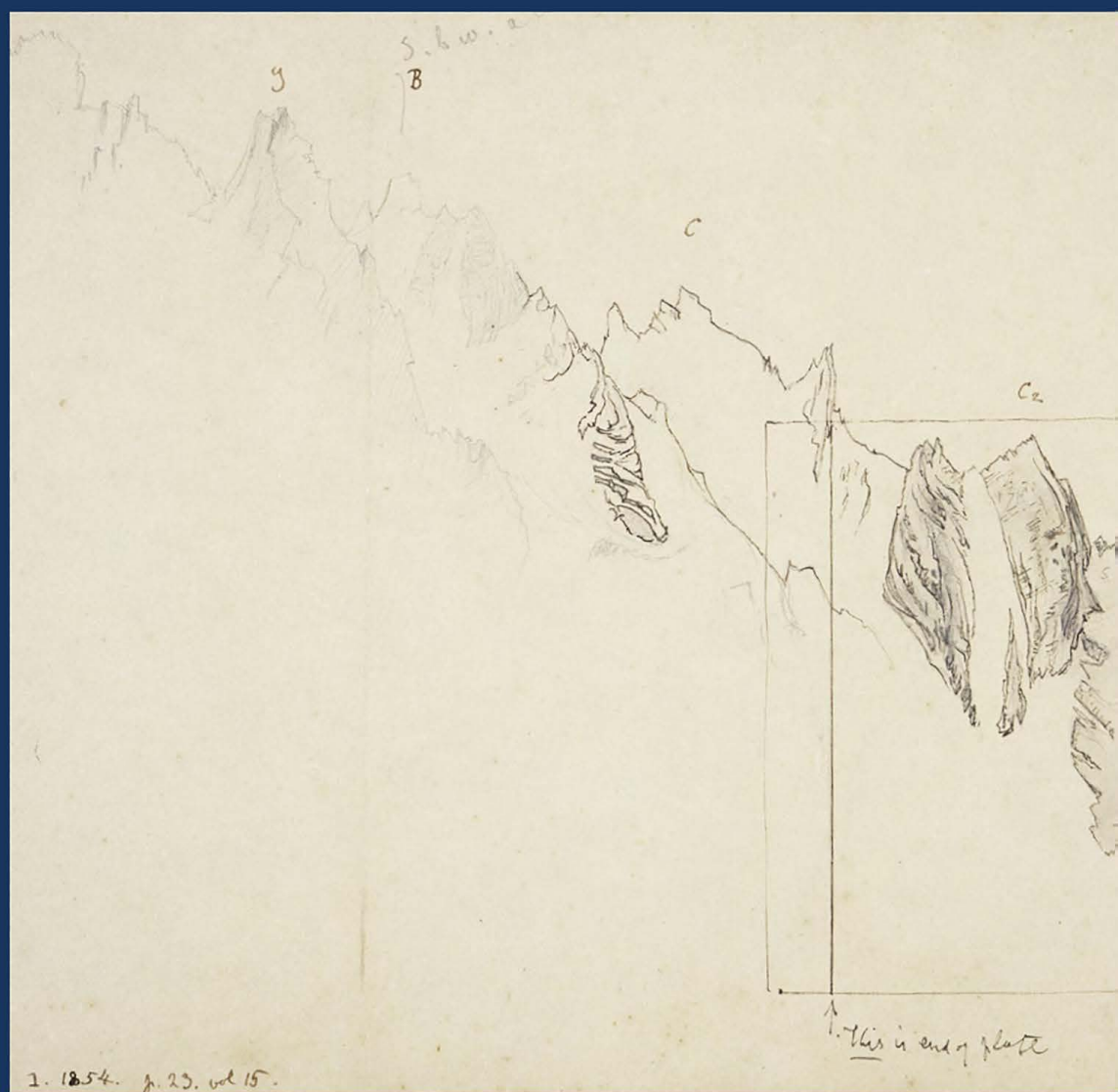Joseph Goold, ***Harmonograph figure,*** 1901.
Drawing. Purple ink on cream pasteboard. 114 x 76 mm. Ref: MM/22/84 © The Royal Society
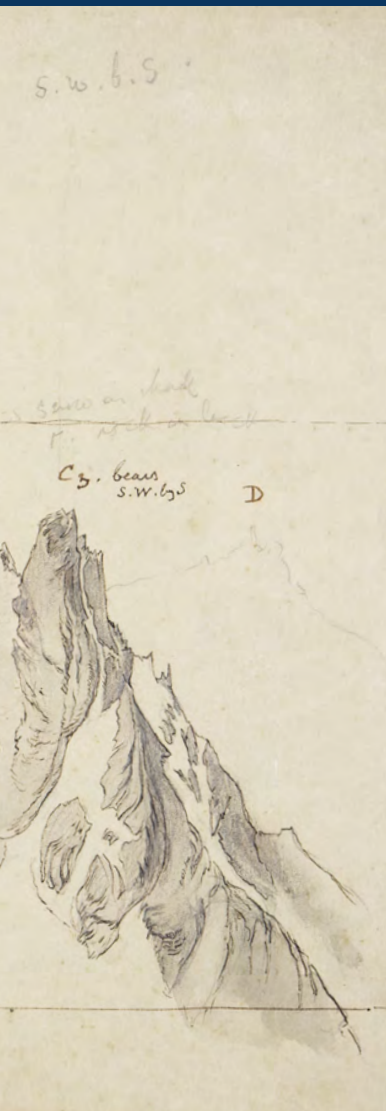Joseph Goold, ***Harmonograph,*** 1901.
Drawing. Pencil on paper [drawn on reverse of G's pamphlet Sound-Curve Tracings]
207 x 133 mm. Ref: MM/22/83 © The Royal Society

Leading Lines:
Mathematics in Nature

Since around the sixth century BC, people have studied the natural world through its structures, forms and patterns. Ruskin was fascinated by natural phenomena that epitomised mathematical principles. He used his knowledge of perspective and abstraction to interrogate geometric and organic forms, and communicate his findings. Ruskin photographed the elegant spiral structure of the Nautilus shell, that suggests the Golden Ratio, or 'divine proportion'. In his drawings, he captured the 'leading lines' of natural features, contributing to evidence of processes like glacial erosion.

Ruskin built a scientifically significant collection of 2500 minerals and rocks, that featured in his teaching and illustrated publications. 150 years ahead of the curve, Ruskin's comparisons of natural forms at micro and macro scale anticipate fractal geometry: the mathematical framework that changed the way we understand geometry and nature.

Shells

Ruskin's examination of botanical forms relied upon applying different modes of perspective for different purposes. As a writer on art and a teacher of drawing, he used Euclidian geometry to assist the depiction of complex curved forms in space. As a writer on nature, he used a wider range of numerical, spatial and temporal parameters to build a complete structural and behavioural model of plants.

Ruskin's shell box contains trays under construction for the display of small shells. His collection included over 2000 fresh water shells, the majority of them less than 10mm in size. They are catalogued by their rivers of origin in a notebook in Ruskin's own hand. These small shells stand in contrast to a collection of larger, mostly tropical marine shells housed in an elaborate display cabinet in the Drawing Room at Brantwood. Ruskin never visited the tropics, so these would have been sourced, like his minerals, from professional collectors. The growth patterns of shells reveal geometric progressions of curved forms expressible in defined mathematical sequences such as the Fibonacci[†] sequence. Ruskin explores similar forms and their mathematical progressions in geological formations in the Alps, in plants, and in the architecture of medieval Italy. The river shells offer an additional scientific benefit today, as they provide evidence of the ecology of British rivers in the late nineteenth century.

[†] **Fibonacci sequence** mathematical sequence in which each number is the sum of the two numbers that precede it (0, 1, 1, 2, 3, 5, 8, 13, 21...).

Wooden box containing various types of shells R76 © The Ruskin, Lancaster University

A letter to his father in June 1861 reveals the delights of a day spent beach-combing, and Ruskin's understanding of fossils as a visible, tangible and organic record of the continuous evolution of geological time:

'I was out a long while yesterday on the beach, —and carried a heavy block of stone five miles home — one mass of casts on shells in clear carbonate of lime, all their hinges and delicatest spirals preserved —shells of which the fish lived long before Mont Blanc existed, and while the crest of the Aiguille de Varens was soft mud at the bottom of [a] deep sea; yet the ripple mark of the sandstone that encompasses them is as fresh as that within fifty yards of it, left by the now retiring tide, and the modern living whelk and mussel hide in the hollows of shells dead these thirty thousand years.'
(*LE* 17 1905 xxxvii)

As in *Shell: a spiral* (pictured on p. 42), the shell of a marbled cone snail from the Indian or Pacific Ocean, Ruskin's studies are taken from nature. Although he produced many diagrammatic line drawings to explore the structure of natural forms, most capture the 'truth' of the moment of encounter.

His watercolour studies of Venice preserve the weeds growing in the cracks of masonry and the reflection of columns in water. The time of day is caught in the shadows. His studies of shells capture the effects of raking light across their features and the optical experience of such dynamic patterns. The spiral is a powerful motif in the decorative arts and has ancient cosmic symbolism in the mathematical structure that radiates outwards from its centre.

As well as collecting shells, Ruskin completed around two dozen studies of shells. As these presented several technical challenges, shell studies became useful teaching aids. The study opposite illustrates Ruskin's insistence on accuracy from first-hand observation as the guiding lines use perspective to ensure correct proportion.

Describing the difficulties of depicting shells, Ruskin wrote that:

'Shells are [...] easy up to a certain point [and] they look pretty as soon as you have rounded & patterned them. But to paint them in quite true perspective—and with their exact pearly lustre or grain, is beyond all skill but the highest.'[29]

None were more challenging than the cockle-shell, which Ruskin lamented as being 'in reality quite hopelessly difficult, and in its ultimate condition, inimitable by art' (*LE* 15 1904, 410). For example, In *Fors Clavigera*, Ruskin describes picking up a 'little grey cockle-shell (pictured on p. 25) … out of the dust of the Island of St Helena [Venice]; and a brightly-spotted snail-shell, from the thistly sands of Lido; and I want to set myself to draw these, and describe them, in peace' (*LE* 27-29 1907, 757). His diary for 16 November 1876 notes: 'Better after staying in all day resting, and painting cockle shell successfully; getting rhythms also into form'.[30]

John Ruskin, **Shell Study,** n.d.
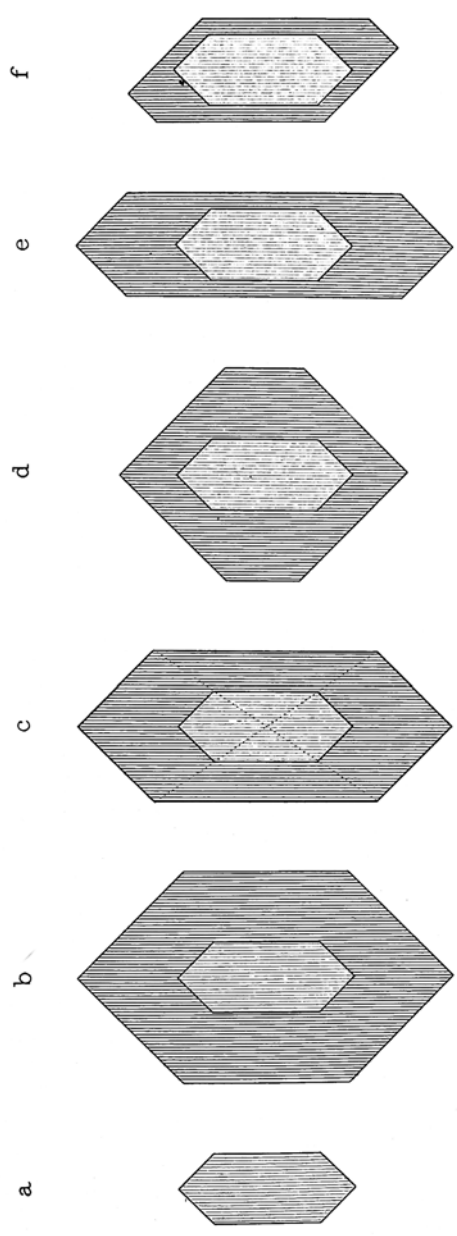Pencil, watercolour and bodycolour. 228 x 304 mm. 1996P0993
© The Ruskin, Lancaster University

Fig. 1

Fig. 2

Drawn by J.Ruskin.

Engraved by G.Allen.

John Ruskin, *Mode of Crystalline Increment, Deucalion* (London: George Allen, 1906)
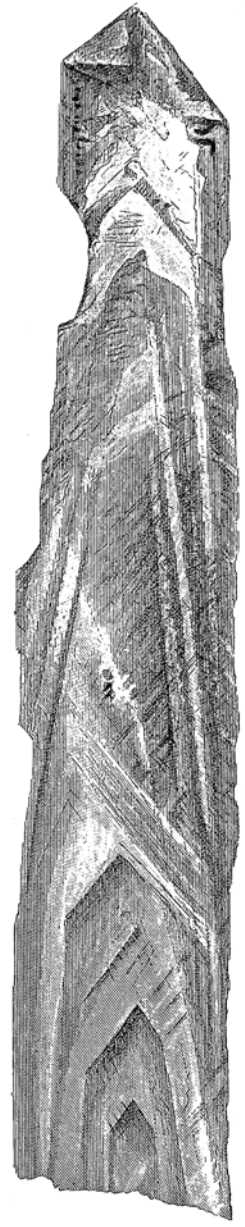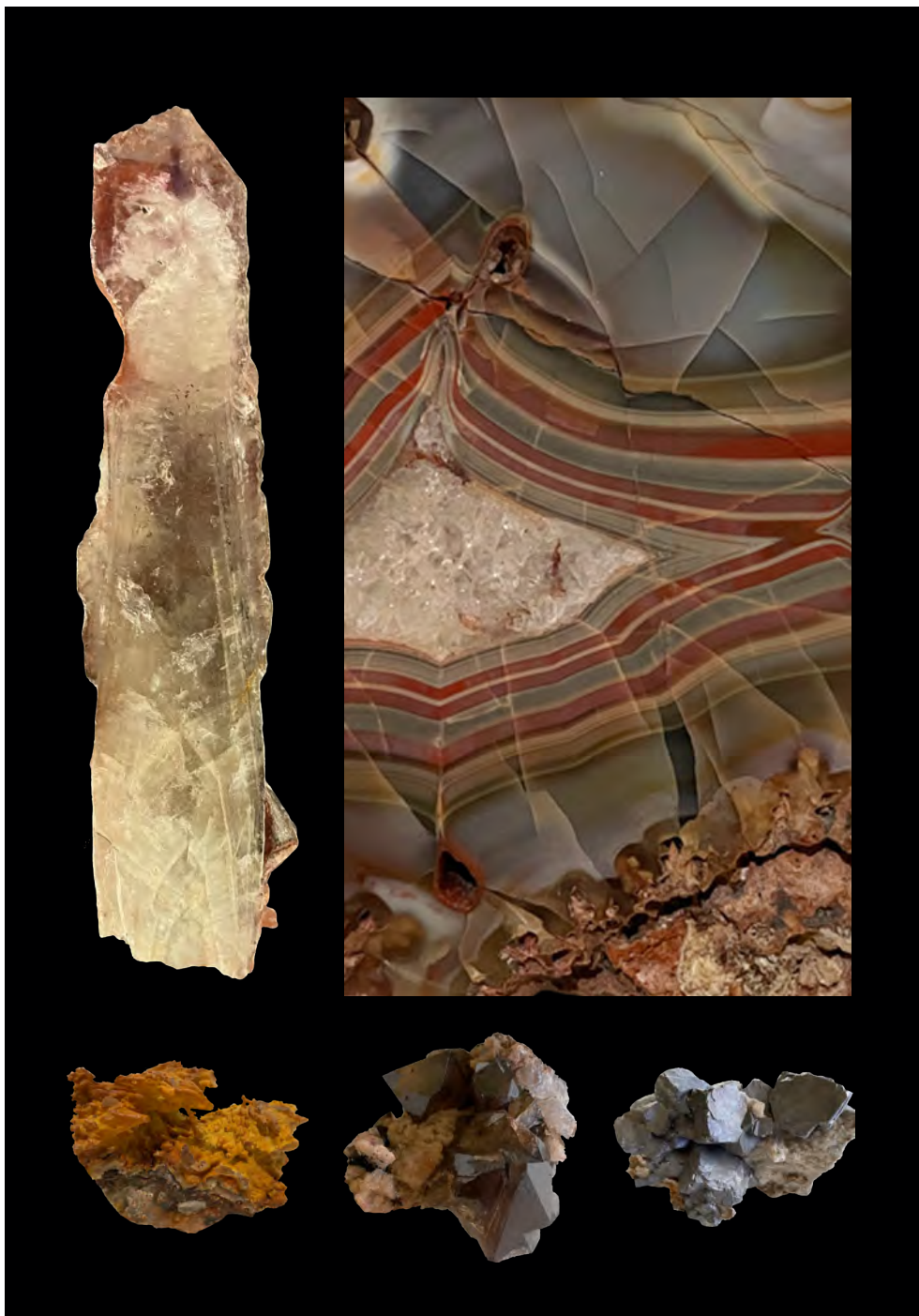
Quartz (part polished section) JR404 © Brantwood Trust
Agate (part polished) JR022 © Brantwood Trust
Chalcedony JR168 © Brantwood Trust
Smokey Quartz JR1319 © Brantwood Trust
Galena with Siderite JR019 © Brantwood Trust

Minerals

Of all the sciences, geology was the one in which Ruskin was most proficient and which meant the most to him. Geology was the most controversial of nineteenth century sciences because it raised questions about the origin of life and humankind. Ruskin spoke of looking out of his study window at the mountain opposite, and the 'Old Man of Coniston' asking him, 'How did I come here?'.

Ruskin was fascinated by the structures and composition of minerals, remarking that:

'… the force which crystallises a mineral appears to be chiefly external … it does not produce an entirely determinate and individual form, limited in size, but only an aggregation, in which some limiting laws must be observed.'
(*LE* 18 1905, 239)

His interest spanned the whole field of geology, but two areas particularly occupied him – mountain formation and mineralogy. Research into the latter, especially crystal behaviour, was within his reach due to his considerable wealth. Ruskin was one of the most significant mineral collectors of his time. His personal collection amounted to more than 2500 specimens, selections from which he gave for teaching collections to numerous educational establishments including the British Museum and the Guild of St George. Over 2000 remain at Brantwood.

Crystallography has its scientific origins in Johannes Kepler (1571–1630)'s *Strena seu de nive sexangula* (1611), posing the question of why snow crystals always exhibit six-fold symmetry. The field had not significantly progressed until Ruskin's era. In 1812, William Hyde Wollaston FRS (1766–1828) discovered the mathematical law of cleavage; or, the tendency of crystalline materials to split into fragments with identical faces.

This discovery marked the beginning of the scientific study of minerals which is intimately connected with plane and solid geometry, leading to the establishment of the law of constancy and the law of interfacial angles. Ruskin's collection, including plaster casts of the minerals, reveals a fascination with the interplay of different chemical or environmental factors causing one crystallising process to impact upon another. Ruskin had many of his specimens cut into sections so that he could study their structure more carefully. His earliest geological interest was in glaciers and he never forgot the fact that ice formed in crystals. He made studies of the diffusion of light through ice crystals in the upper atmosphere, evidence which he invoked to argue for human agency in atmospheric pollution.

Fossil evidence being presented in the early nineteenth century by British artists such as William Home Lizars (1788–1859) and James Sowerby (1757–1822), illuminated the long history of life in exquisite detail. Their work challenged accepted views that the present was governed by an unchanging set of laws.

The group of sixteen figures produced by British artist Lizars illustrates the intricate veined patterns of different specimens of amethysts viewed under polarised light (pictured on p. 88). It was published in the paper 'On the effects of compression and dilatation in altering the polarising structure of doubly refracting crystals', read by Scottish physicist David Brewster (1781–1868) on 17 November 1816 at the Royal Society of Edinburgh.

In his paper, Brewster notes 'The observations … are the result of an immense variety of experiments, which accidental circumstances put it in my power to make upon this interesting mineral. Having access to whole bagfuls of amethystine pyramids from the Brazils, in the possession of Mr Alexander, lapidary in Edinburgh, I have examined some hundred specimens.'[31]

William Home Lizars, ***Amethyst under polarized light,*** 1816.
Engraving/Print Illustration. Plate 10, inscribed with figure numbers and bottom right
'W.H.Lizars Sculpt. Edinr.' 262 x 192 mm. Ref: Tracts X69/1 © The Royal Society

Quartz with Adularia JR536 © Brantwood Trust
Quartz with Rutile inclusions (Ruskin autograph label) JR774 © Brantwood Trust
Crystal Model Plastercast Phenakite twinned crystal JR 1805 © Brantwood Trust
Crystal Model Plastercast Bismuth JR1795 © Brantwood Trust
Amethyst JR172 © Brantwood Trust
Amethyst with Chalcedony JR824 © Brantwood Trust

James Sowerby published the first volume of *British mineralogy, or, Coloured figures intended to elucidate the mineralogy of Great Britain* in 1804 (pictured on p. 42). In the preface to volume one, the author notes 'With regard to the figures, we have thought it quite proper to represent an original specimen, which is apt to give a more perfect idea than geometrical outlines alone; but, to make them more perfectly understood, have annexed magnified and geometrical figures'.[32]

One of those figures is of the 'Calx carbonata' (Ammonite with Crystals). The petrified example is, according to the text, 'abundant in many parts of Great Britain' found in limestone and 'marly places'. The shapes of the nautilus (the once living species) suggest logarithmic (or golden) spirals (pictured on p. 24). These spirals as they occur in nature have long fascinated mathematicians, and can be interpreted using Fibonacci's sequence. Their forms share characteristics that reveal their common parentage, while highlighting their dynamic nature. Those collecting, illustrating and studying minerals abstracted such fundamental structures and the evolutionary changes to which they have been subject. As a result of this new science, the present could suddenly be understood as belonging to an ever-expanding history of change and transformation. The language of its exploration was a language of distilled or 'abstracted' form.

'More interesting to Ruskin than school was the British Museum collection of minerals … He took the greatest pains over [cataloguing his own collection], and wrote elaborate accounts of the various minerals in a shorthand he invented out of Greek letters and crystal forms …. He had made a splendid collection, and knew the various museums of Europe as familiarly as he knew the picture galleries. In the *Ethics of the Dust*, he had chosen Cystallography as the subject in which to exemplify his methods of education; and in 1867, … he took refuge, as before, among the stones …'[33]

Installation view, 'Ruskin: Museum of the Near Future' (The Ruskin, 2019). Mineral specimens loaned by Brantwood Trust. Photo: Leon Chew

Plants

Spatial geometries exist everywhere in nature, from the distribution of land masses to flows of water, from ecosystems to territories. Each configuration is both a result and a determinant of such patterns. Ruskin's childhood appetite for drawing maps evolved into an acute sense of the relations between natural and human interactions. In his study of botany, he used his experimental gardens at Brantwood as a laboratory to understand how plants create mutually beneficial environments and adjust their own forms along mathematical axes to achieve optimum vitality. He made many detailed plant drawings when writing *Proserpina: Studies of Wayside Flowers* (1879-86).

Maurice Bartlett (1910–2002) was a Professor of Bio-mathematics at Oxford University. Bio-mathematics is a scientific field dedicated to the study of biological phenomena through mathematical models. The study of spacial distribution patterns in plant communities was one of the fields pioneered by Bartlett in applying mathematics and statistical analysis to deconstruct and understand the natural world and its biological processes and structures.

Ruskin's analysis of tree growth observed the bifurcation of branches according to a mathematical progression. He noticed that the mass of a tree at any given point of expansion remains consistent with the mass of the trunk at its base. The whole tree reaches a point at which the dividing of branches into twigs and thence smaller twigs inhibits the viability of its leaves to reach sunlight, at which point it achieves its optimum size.
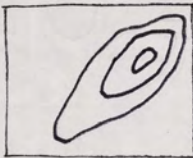
Ruskin realised that there are underlying rules at work which attempt to give primary form to the tree and accidental or life-history events which compromise its genetic blueprint. Close observation of the plate from *Modern Painters* pictured on page 95 reveals a three-dimensional perspective in which the branches overlay one another in space. However, Ruskin reached the limits of what it is possible to represent without computer animation or film.
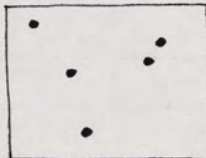
Situations

Processes

(1) Non-randomness

(1) $X(\underset{\sim}{r})$

(2) Stochastic models ✓

(2) $dN(\underset{\sim}{r})$ (point process)
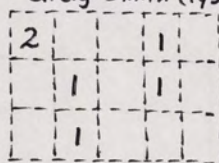
(3) Specialized situations

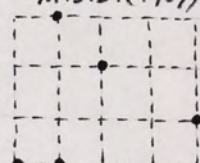(3) X_i (lattice process)

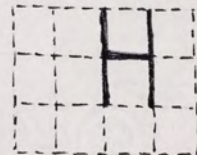M.S.B. (1964) Whittle (1954)

Pielou (1964) Greig-Smith (1952) M.S.B. (1967)

Mead (1967, 1969) M.S.B. (1967)

Maurice Bartlett, *The Statistical Analysis of Spatial Pattern,* 1974.
Loose leaf illustration. Ref: MSB/2/58 number 12 © The Royal Society
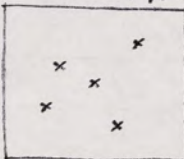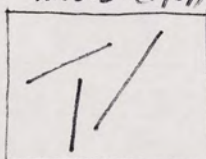
Closely observed drawings played a crucial part in the understanding and development of plant morphology and the mathematical principles by which they are governed. The disposition of masses in plants was of particular interest to Ruskin who produced detailed studies of the distribution of leaves along a stem or the arrangement of petals in a flower. As he explains in his *Lectures on Art:*

'The difficulty is not to carve quantities of leaves. Anybody can do that. The difficulty is, never anywhere to have an unnecessary leaf. Over the arch on the right, you see there is a cluster of seven, with their short stalks springing from a thick stem. Now, you could not turn one of those leaves a hair's-breadth out of its place, nor thicken one of their stems, nor alter the angle at which each slips over the next one, without spoiling the whole, as much as you would a piece of melody by missing a note. That is disposition of masses.'
(*LE* 20 1905, 160)

94

Ruskin devised his own nomenclature for his studies and teachings on botany, which he associated with elements of architecture: 'pillar' for 'pistil', 'volute' for 'stigma'. He observed, drew and dissected plants to understand the science of organic forms and patterns which he saw in 'the 'imitable forms of the four elements of nature': Forms of Earth (Crystals); Forms of Water (Waves); Forms of Fire (Flames and Rays); and Forms of Air (Clouds). He transposed this to architecture, noting that:

'… because Architecture has herself two forms of energy: one imitative, in which she copies natural organic forms as being able to imagine none fairer; the other disposing and modifying such forms to her own will'
(*LE* 8 1903, 285)
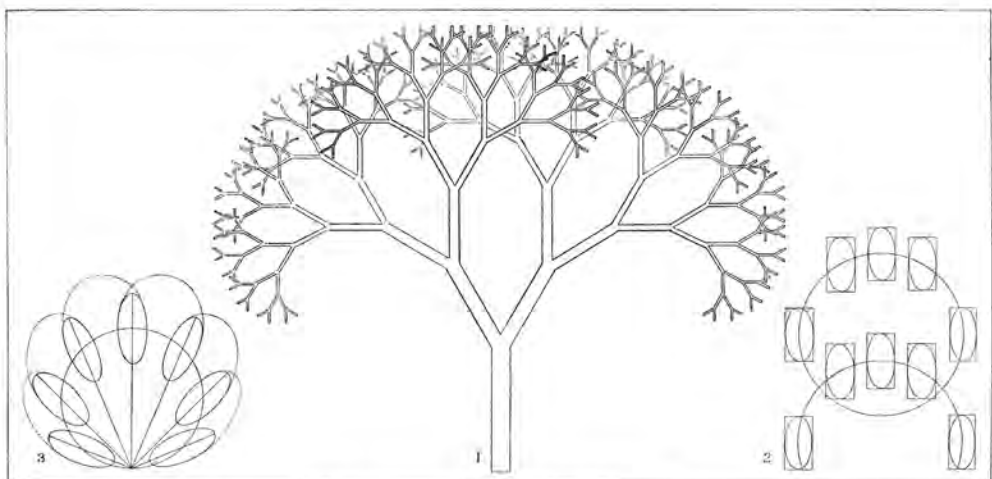
56. Sketch by a Clerk of the Works.

John Ruskin, *Flower studies; Prunella vulgaris (Common Self-Heal),* n.d.
1996P1278. 109 x 157 mm © The Ruskin, Lancaster University
John Ruskin, 'Sketch by a Clerk of the Works', Plate 56, *Modern Painters V,*
(London: George Allen, 1905)

Ruskin believed that we have an innate receptivity to certain shapes and introduces his written descriptions of landscapes with very precise instructions to the viewer. The tradition of the 'picturesque' relied upon such precise view-making from a given location, known as a 'station'. Ruskin was equally interested in the more complex arrangement of apparently random forms encountered outside the boundaries of the picturesque.

'The systems of [tree] branching are indeed infinite' claimed Ruskin in *Modern Painters V, w*here figure 67 (*LE* 7 1905, 97) aims to delineate the behaviour of two 'common types'. Ruskin then transforms behavioural patterns in nature into a metaphor for the development of society. In poetic prose, Ruskin explains that branching and leaf-formation emerge from a:

'… perfect fellowship; and a single aim uniting them under circumstances of various distress, trial, and pleasure. Without the fellowship, no beauty; without the steady purpose, no beauty; without trouble and death, no beauty; without individual pleasure, freedom, and caprice, so far as may be consistence with the universal good, no beauty.'
(*LE* 7 1905, 98)

The coincidence of similar forms appearing in widely different phenomena and at vast changes of scale teases both eye and brain. The similarity achieved between the two only exists here in the artist's selection of viewpoint, since any change in angle or addition of further context would render the visual 'punning' void. In the real world, the viewer is required to stand in a very exact position relative to this particular landscape to achieve this visual pairing or the shape of the bird's wing in the landscape disappears completely. Nonetheless, the form does, from this perspective, exist in both phenomena, and is not, therefore, simply an illusion. The question which arises is the degree to which the presence of such forms has a special appeal to the human eye, or significance to our understanding of the nature of things.
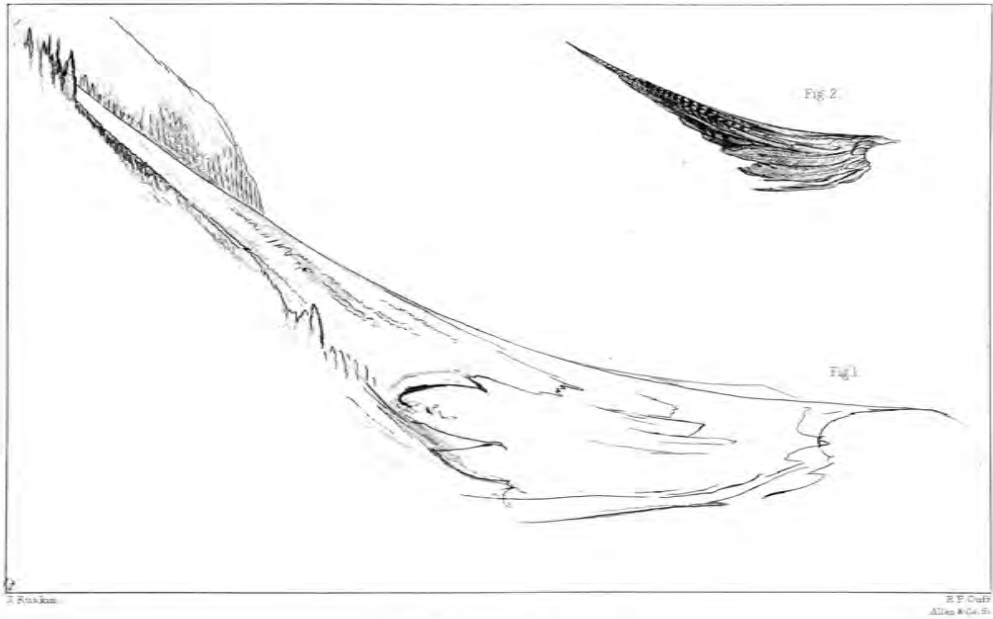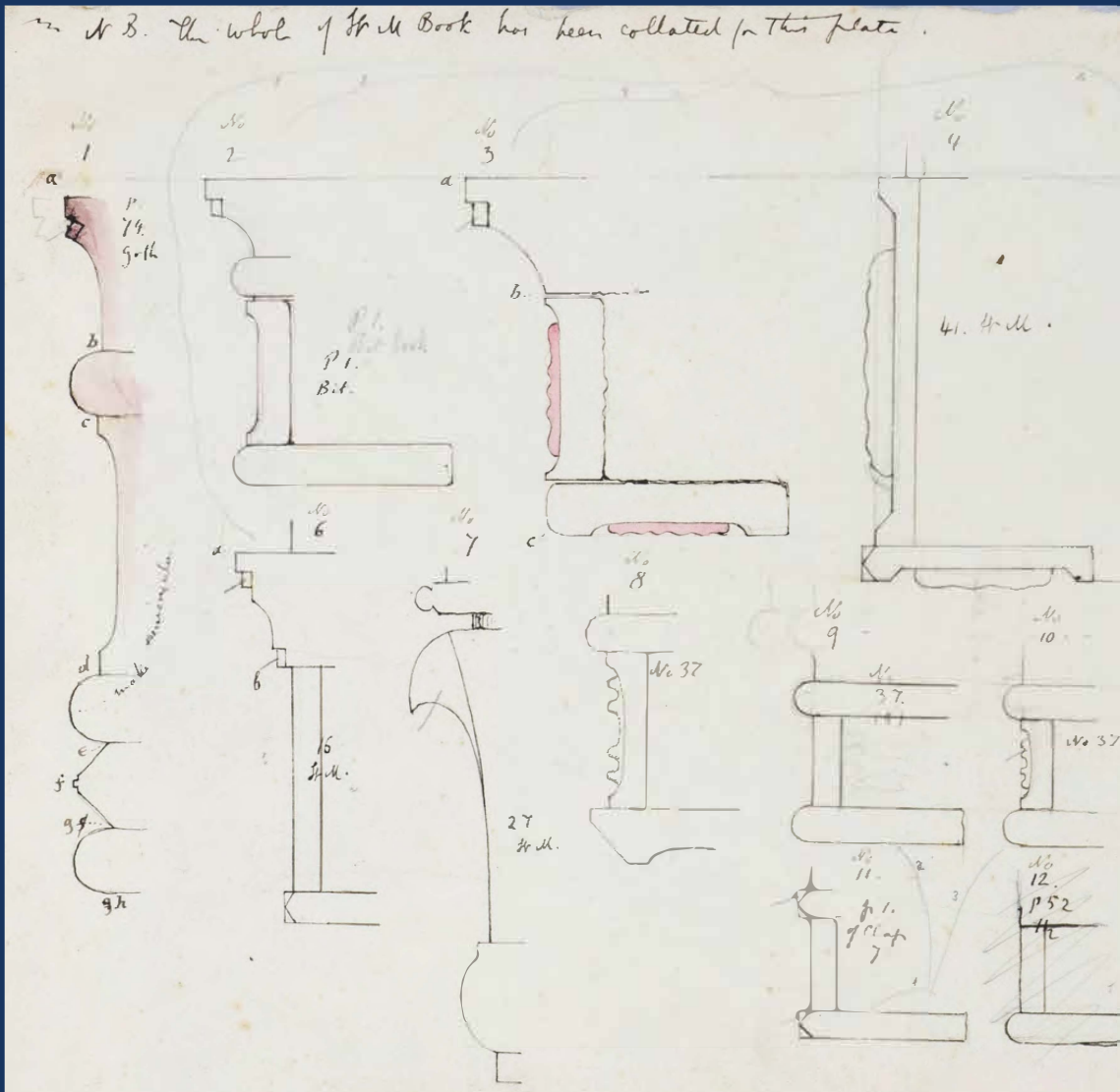
45. Debris Curvature

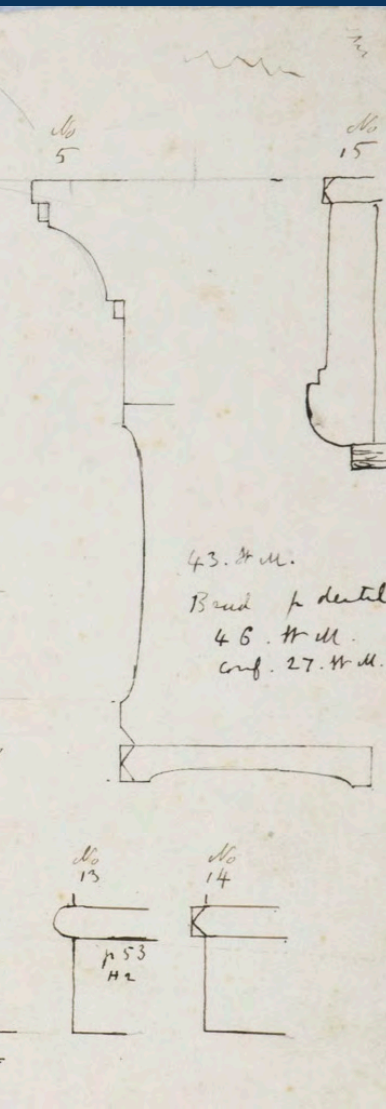John Ruskin, 'Debris curvature', Plate 45, ***Modern Painters IV,*** (London: George Allen, 1905)
John Ruskin, ***Dead Bird (Jay?),*** n.d.
Pencil, ink, watercolour and bodycolour. 100 x 175 mm. 1996P0875
© The Ruskin, Lancaster University

Syllables of Thought:
Mathematics in Art

From the Renaissance onwards, the science of mathematics had led to a new form of making art based on geometry. Ruskin studied Albrecht Dürer, the German painter, printmaker and architect who published the first known scientific treatment of perspective.

Ruskin worked from reality: documenting detail, land and cityscapes in the open air, rather than in a studio. He produced architectural and technical drawings that feature precise shapes, calculations and observations. These illustrate his insistence on accuracy of measurement. Drawing on a range of techniques to reveal underlying principles that structure the world around us, his works show the familiar in a new way.

In 1900, the year of Ruskin's death, the impressionist artist Claude Monet is reported as saying that ninety per cent of the theory of impressionism is contained in Ruskin's textbook, *Elements of Drawing*.

John Ruskin, *Cathedral of San Martino, Lucca,* 1882.
Pencil & Watercolour. 120 x 198 mm. 1996P0938 © The Ruskin, Lancaster University

John Ruskin, ***View on the upper reach of the Grand Canal, Venice with the Palazzi Corner and Pesaro,*** 1876.
Pencil and bodycolour. 368 x 522 mm. 1996P1612 © The Ruskin, Lancaster University

Perspective and Abstraction

With *The Elements of Perspective*, Ruskin contributed to a science which had revolutionised Western art. In 1525 Albrecht Dürer produced the first practical, illustrated manual of 'two-point' perspective which promoted the illusion of depth in landscape painting without reliance on the hazy effects of greater distance used in aerial perspective. Ruskin's exemplar J.M.W. Turner lectured on perspective at the Royal Academy, but Ruskin used his own experience as an artist to build on the classical theorist of the underlying geometry of perspective: Euclid. The examples of his own studies in this exhibition show that Ruskin used shadow as an important supporting force in his representation of space. Calculating the fall of a shadow is challenging but follows the same rules as perspective, its outline re-enforcing the shape of a given object as if seen from another angle.

Drawing in perspective is an investigative exercise that scans all the surfaces in the visual field. The aesthetic effects of the mix of lines, marks, colour and shading defining a single surface can in themselves be complex, but they are greatly magnified when the surface appears to recede. The mind is engaged imaginatively, projecting the viewer into an illusory space in which two-dimensional information is articulated across three-dimensionally imagined forms. Ruskin recognised that with the right prompts from the artist, the viewer can imaginatively complete underworked areas of a picture, based on its detailed sections. Many of Ruskin's drawings of Venetian and Alpine scenes employ this technique to great effect. Allowing the viewer to make this step avoids over-crowding the picture with a level of detail which, in real life, the eye and brain act together to filter.

John Ruskin, ***View on Grand Canal, Venice,*** 1876.
Pencil, watercolour and bodycolour (detail). 171 x 260 mm.
1996P1067 © The Ruskin, Lancaster University

Columns and Code

The mathematical laws governing the perspective of an object represented in a picture are fixed, but they act as a framework for a fundamentally different set of laws governing the depicted object to be imagined. Achieving the faultless representation of a three-dimensional form such as a staircase that rises from beneath the viewer and ascends above them is difficult: the two studies exhibited from Ruskin's teaching collection are a *tour de force* of the technique (pictured on pp. 32-33). Modern computers use mathematical code to build such structures and to articulate them, but their calculations are derived from the same geometric principles at work in these drawings.

104

'No one had ever drawn the traceries of the Ducal Palace till I did it myself...; and not a soul in England knew that there was a system in Venetian architecture at all, until I made the measured (to half and quarter inches) elevation of it, and gave the analysis of its tracery mouldings and their development, from those of the Franciscans at the Frari...'
(*LE* 10 1904, liii)
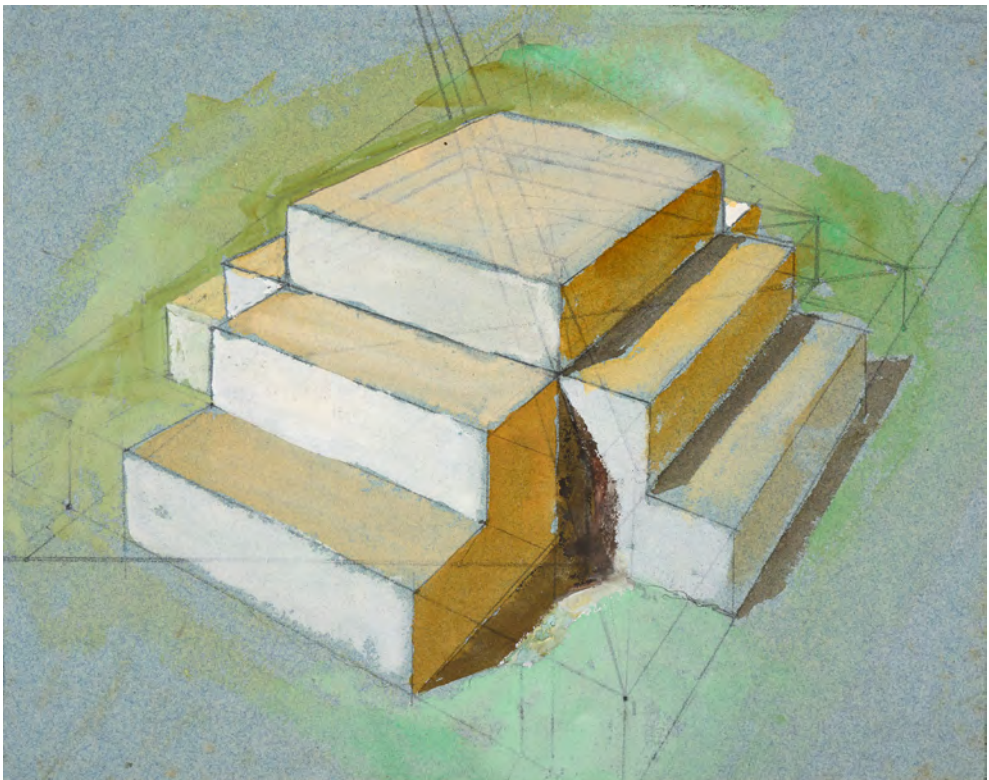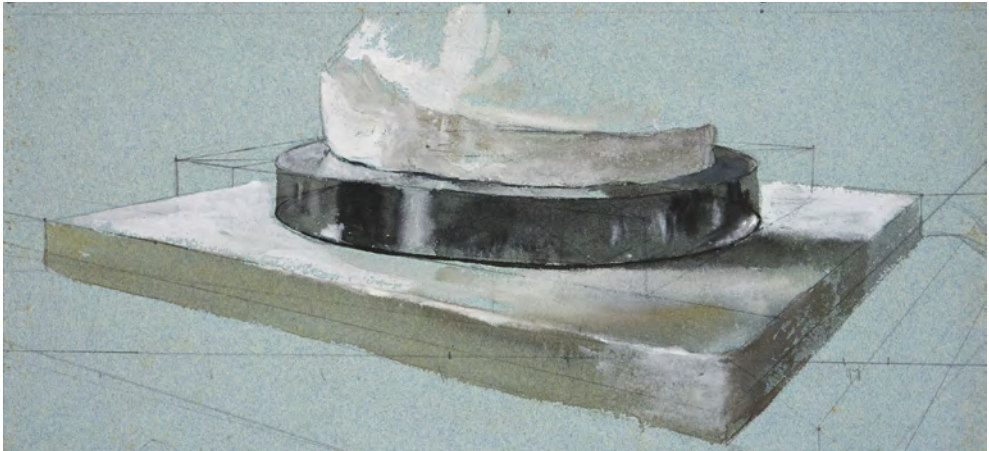
John Ruskin, ***Perspective Study: Column Base and Plinth,*** n.d.
Pencil, ink wash, watercolour and bodycolour on blue paper. 138 x 283 mm.
1996P2039 © The Ruskin, Lancaster University
John Ruskin, ***Perspective Study: Four-sided Plinth,*** n.d.
Pencil, watercolour and bodycolour on blue paper. 166 x 208 mm.
1996P2040 © The Ruskin, Lancaster University

John Ruskin, ***Part of the Facade of San Miniato al Monte, Florence,*** 1846.
Pencil and watercolour. 416 x 370 mm. 1996P0913 © The Ruskin, Lancaster University
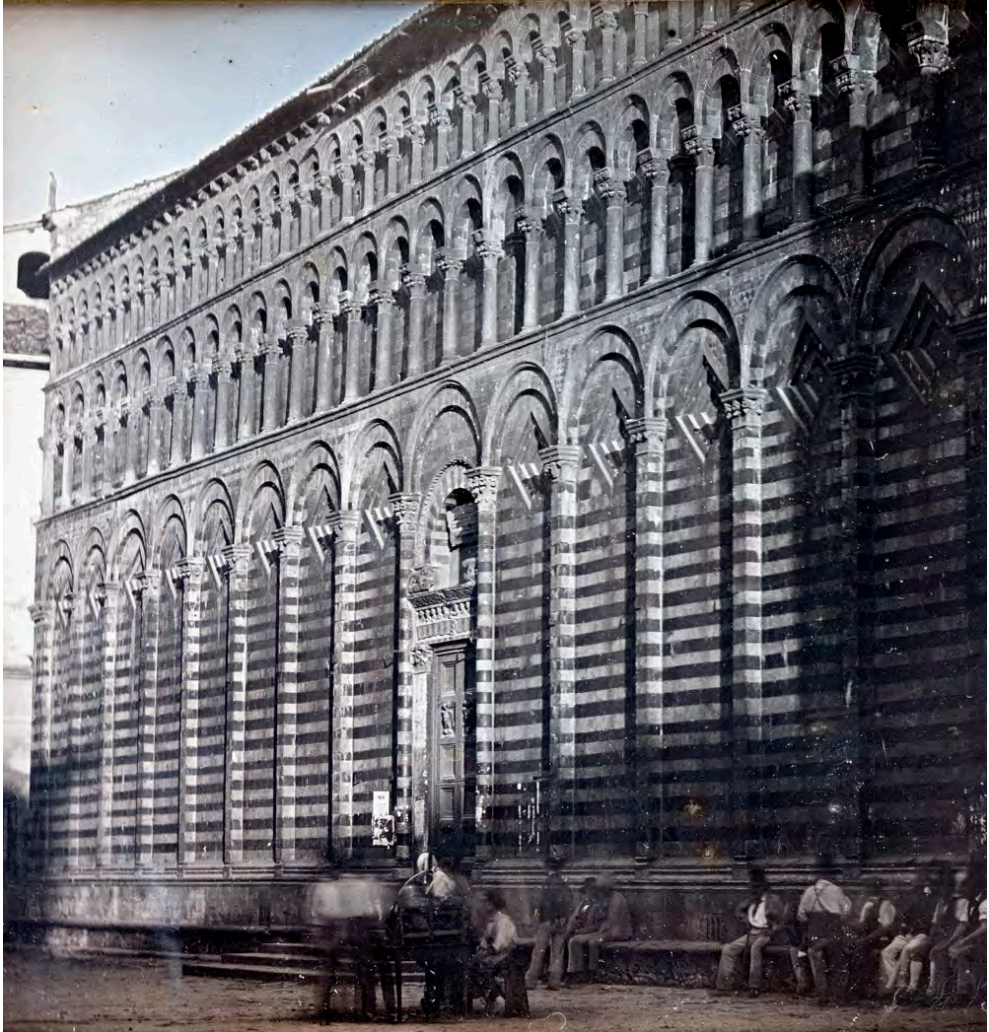
John Ruskin; Le Cavalier Iller, **Pistoia. *Church of San Giovanni Fuorcivitas. Arcade wall***, 1846.
Daguerreotype (detail). 167 x 212 x 4 mm. 1996D0066 © The Ruskin, Lancaster University

The Seven Lamps of Architecture (plates pictured on pp. 122; 126) was Ruskin's first serious attempt to classify the essential ingredients of Gothic architecture and many of his observations were to provide enduring themes throughout his subsequent career. The pointed arch was a particularly significant area of study as it united strength with decorative opportunity. Mimicking the organic forms found in nature, stone could be pierced to produce an intricat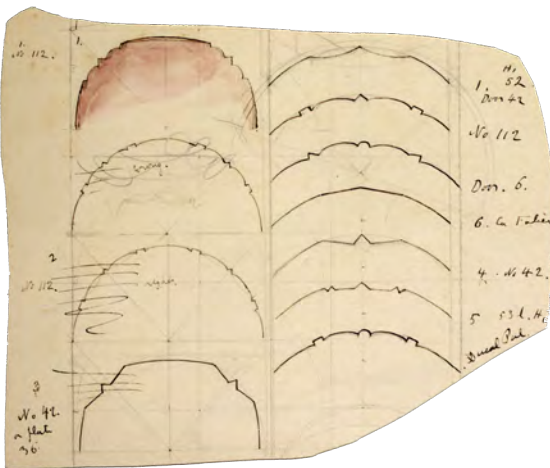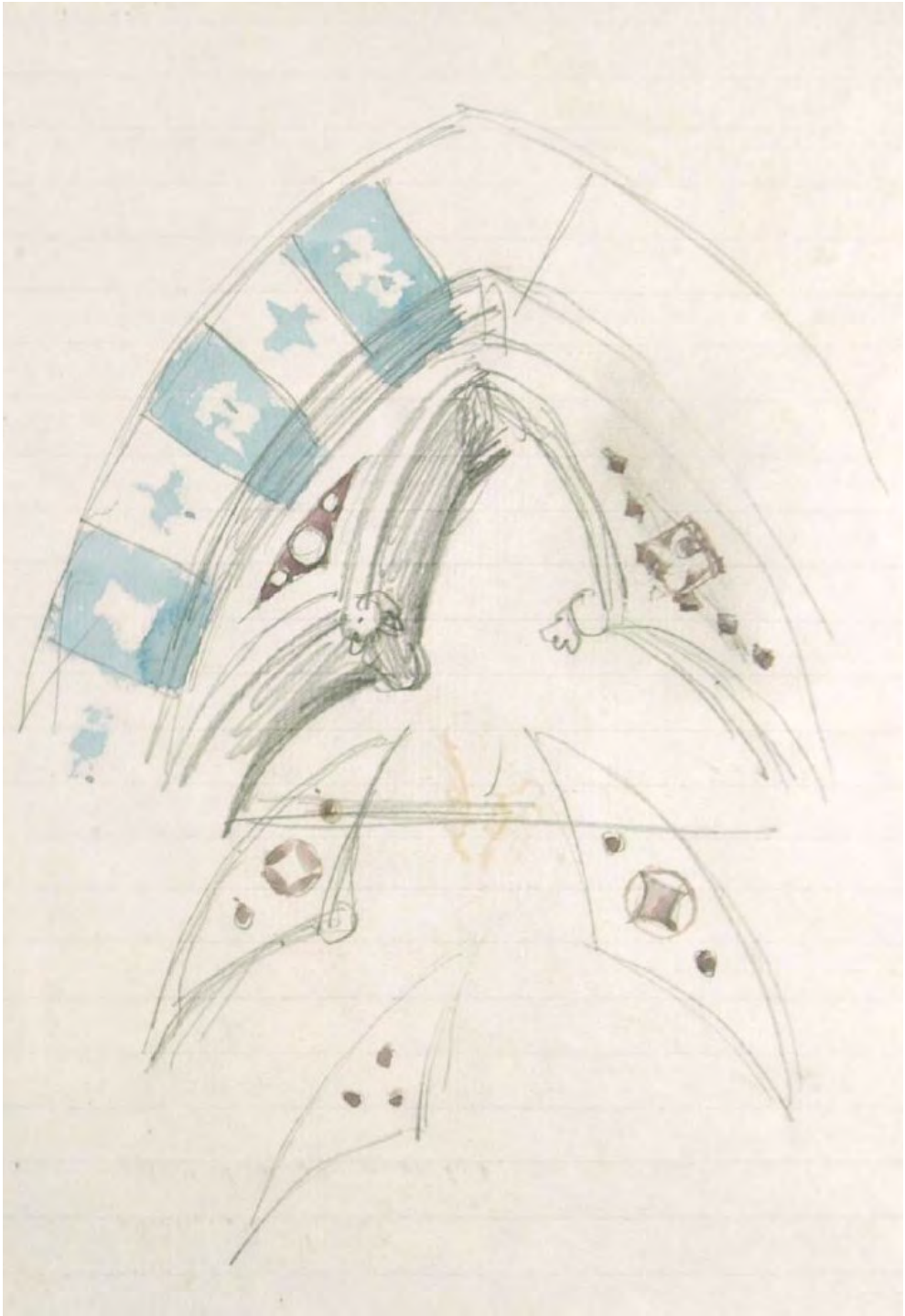e design without losing its structural integrity. The distribution of weight that could be achieved with this approach enabled huge loads to be supported above slender pillars, allowing the building to admit natural light and paving the way for astonishing achievements in stained glass.

Ruskin's analysis of arches, doors and windows in *The Stones of Venice* follows his interest in the aesthetic qualities of variation in both primary form and detailing. However, it also examined the engineering implications of different forms of load bearing spans. In his 1854 lecture on architecture in Edinburgh, Ruskin observed the inherent weakness in Georgian neoclassical door and window lintels, something he explored in depth in Venice when analysing the inherent structural superiority of the Gothic arch. Throughout his career, Ruskin looked to the strength of natural forms both by way of descriptive analogy and practical example.

John Ruskin, ***Venice & Verona - Album of Sketches & Notes,*** n.d.
Ink and wash on paper. 1996P1639 © The Ruskin, Lancaster University

John Ruskin, ***Study of decorative motif and gothic arch, in Diary of John Ruskin - 1851–1852.***
Pencil and watercolour on paper. MS 8 © The Ruskin, Lancaster University

Measurement and Calculation

The crowded streets of Lucca, Florence and Verona and the canals of Venice afforded Ruskin many opportunities to capture the essential atmosphere and **topographical**[†] features of Northern Italy. His rapid sketches have the freshness of the moment and an apparent carelessness, but his underlying knowledge, gained through years of precise observation and thought, is revealed in the confident perspective, precise reflections and detailed inventory of arches, windows and doorways. Ruskin sought to understand gothic construction at a level of detail as profound as those who built it. Accurate measurement and intricate calculation were at the heart of his studies, as his notebooks and worksheets testify.

The 'N book' is the first of a series of ten notebooks in which Ruskin recorded the measurements, shapes, decorations and colours of Venice, cross-referencing them with worksheets and drawings. He named each notebook after an architectural feature: 'House book', 'Door Book', 'Gothic Book'. The 'Palace' notebook is a dedicated study of Venetian palaces, including the Ducal Palace.

[†] **Topographical** relating to the study and accurate representation of physical features (both natural and man-made) of the landscape, or a given area.
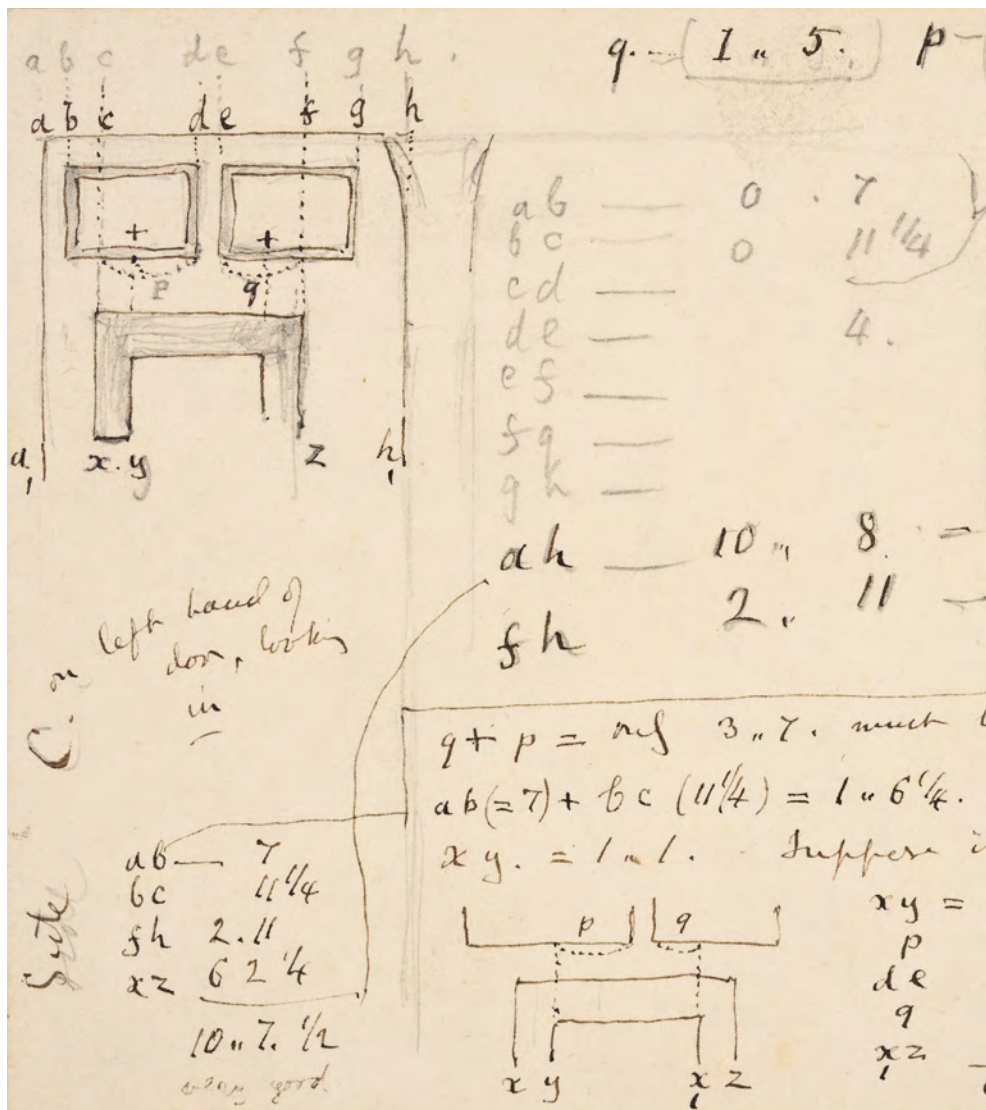
John Ruskin, *Venice - Notebook 'Palace Book' [page 48]*, n.d.
Ink and wash on paper. 193 x 122 x 10 mm. 1996P1620 © The Ruskin, Lancaster University
John Ruskin, *Measurements & Profiles* (detail), n.d.
Pencil and ink on white sketchbook leaf. 127 x 174 mm. 1996P1386 © The Ruskin, Lancaster University

Bit. Book — 1614

Door Book — 1615

112

Palace Book — 1620

S.t M. Book — 1621
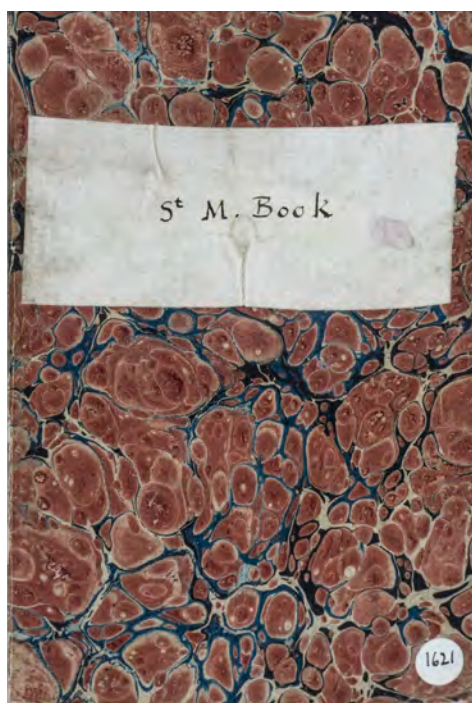
John Ruskin, *Venice - Notebook: "Bit Book",* n.d.
Green marbled binding. 193 x 122 x 12 mm. 1996P1614 © The Ruskin, Lancaster University
John Ruskin, *Venice - Notebook - "Door Book",* n.d.
Green/red marbled binding. 192 x 123 x 10 mm. 1996P1615 © The Ruskin, Lancaster University
John Ruskin, *Venice - Notebook "House Book 1",* n.d.
Green marbled binding. 192 x 123 x 10 mm. 1996P1617 © The Ruskin, Lancaster University
John Ruskin, *Venice - Notebook: "House Book 2",* n.d.
Purple marbled binding. 192 x 123 x 10 mm. 1996P1618 © The Ruskin, Lancaster University
John Ruskin, *Venice - Notebook "Palace Book",* n.d.
193 x 122 x 10 mm. 1996P1620 © The Ruskin, Lancaster University
John Ruskin, *Venice - Notebook "St M. Book",* n.d.
Red/black marbled binding. 192 x 123 x 16 mm. 1996P1621 © The Ruskin, Lancaster University

Pattern and Decoration

Ruskin said, 'The best art of pottery is acknowledged to be that of Greece, and all the power of design exhibited in it' (*LE* 16 1905, 328). Ruskin's collection of Cypriot pottery included pots and shallow dishes, jugs, flasks and an oil jar in reddish brown clay. The functional forms feature decorative elements, like concentric circle design, that reference basic shapes.[34]

Abstract pattern is among the oldest, most persistent and universal aspects of the decorative arts. Early pattern making was heavily influenced by the geometric grid of textile production, favouring straight lines and angular forms. However, as applied to ceramics or worn on the body, such forms also acquired curvature while retaining a simple straight line construction.

The presence of stylized botanical features in architecture is a language of formal abstraction that has very ancient roots, most emphatic and persistent in the capitals and pedestals of columns. Ruskin studied such features in depth. Meanwhile, classical architecture further refined the mathematical purity of circle, triangle and square into its essential forms such as the sphere, tetrahedron, and cube.

These building blocks were capable of producing buildings of great scale and stability whose primary aesthetic quality was simplicity and harmonious proportion in the basic construction. While complex levels of variation in repetitive forms can create symbolic meaning and decorative beauty, Ruskin felt that strict classical adherence to these fundamental forms was limiting and instead turned towards the expression of more elaborate and intricate organic forms for inspiration.

Cypriot Pottery Flask, n.d.
Terracotta. R56 © The Ruskin, Lancaster University

1

2

3

4
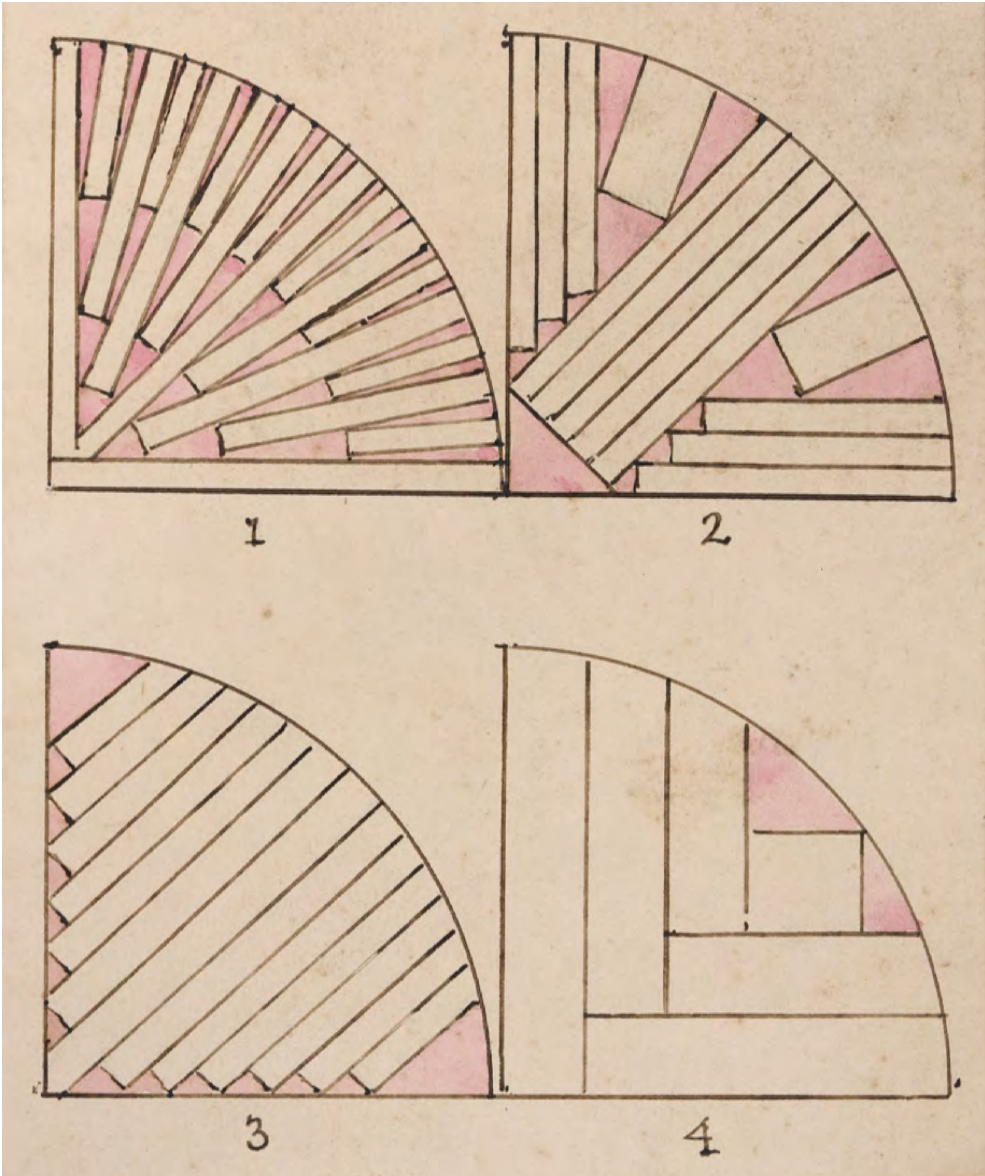
John Ruskin, *Venice & Verona - Album Of Sketches & Notes, p12 – xxiii,* n.d.
Ink and wash on paper. 1996P1641 © The Ruskin, Lancaster University
John Ruskin, *Wall-veil decoration,* 1851.
Watercolour. 123 x 204 mm. 1996P1083 © The Ruskin, Lancaster University
John Ruskin, *Como - Arch Masonry,* n.d.
Pencil and bodycolour on green paper. Inscription in ink: Como. 181 x 260 mm.
1996P1222 © The Ruskin, Lancaster University

Albrecht Dürer, ***Underweysung der messung, mit dem zirckel un richtscheyt, in Linien ebnen unnd gantzen corporen,*** 1525.
Book. Ref: 2114 © The Royal Society

In *The Stones of Venice* Ruskin was particularly interested in architectural decoration which achieved its effects through repetition and variation. In the motifs on the facades of the Casa Dario (c. 1487) and sixteenth century Casa Trevisan, he studied the use of colour as a means of disrupting underlying structural symmetries in the carving (pictured on p. 25). For Ruskin, this disruption, which elsewhere he elaborated in relation to the Ducal Palace, alleviated the monotony he found in classical architecture, and allowed the vitality and creative personality of the maker to express itself, turning what is otherwise a building into a true work of architecture.

The drawing pictured on page 24 (no. 1) was reproduced as Plate I of the first volume of *The Stones of Venice*, to illustrate Ruskin's reference to the traveller Philippe de Commines's response to the coloured marbles decorating the new palaces seen on his visit to Venice in 1495. Ruskin particularly liked this kind of inlaid architectural decoration, which he called 'Renaissance engrafted on Byzantine'.

Venice captivated Ruskin, and over the course of his life-time, he visited the 'City of Water' eleven times. Between 1849 and 1852, Ruskin undertook a number of studies of the city's architecture in preparation for his major work, *The Stones of Venice*. The Ruskin holds seventy-eight of the 206 numbered worksheets made by Ruskin (pictured on pp. 20-21).

Throughout *The Stones of Venice*, Ruskin used a detailed analysis of the range of architectural styles in Venice to provide a cultural and social history of the rise and fall of the city, and as a springboard for his own vision of an ideal society. However, with little historical information forthcoming from the authorities, the Ducal Palace proved a fascinating, and at times frustrating, puzzle, with Ruskin complaining to a friend in May 1859 that the 'Ducal Palace itself, worst of all, … wouldn't be found out, nor tell one how it was built' (*LE* 9 1903, xxviii).

Ruskin's Venetian worksheets and notebooks are crammed with detailed measurements and calculations. He traced lineages of increased elaboration over time and produced charts of their evolutionary development which he saw as indicating the prevailing values of society at the time of their creation. Coinciding with the period in which Darwin was developing his theories of natural evolution, Ruskin was producing a parallel reading of cultural change.

Throughout his career, Ruskin used large-scale lecture diagrams to further his visual arguments. He directed their preparation and choreographed their display. Against an established tradition of lecture diagrams in the scientific disciplines, Ruskin's are part of a lesser-known trajectory within the architecture and the arts. The diagrams reproduced at macro-scale a smaller original drawing, often of a microscopic component of the natural world: a feather, or a plant in bud.

In his capacity as Turner's executor, Ruskin annotated J.M.W. Turner's lecture diagrams on angular and aerial perspective, reflection and refraction, light and shade and colour perspective between 1811 and 1828. Of Turner's 200 diagrams (c. 1809–1828), some were diagrammatic, but many were finished drawings and watercolours: 'truly beautiful … illustrations of aerial perspective and the perspective of colour'.[35]

While many of Ruskin's drawings and watercolours were designed as teaching aids or as illustrations for his writings, others were for pure research. In all cases Ruskin combined the investigative with the aesthetic and often produced drawings designed for practical demonstration which were of great beauty. One aspect of Ruskin's artistic style is its restraint. Although he works to great detail, he rarely paints beyond the detail which is luminous of the idea or necessary to conveying the point. This distillation is itself a sort of purposeful abstraction so completely at odds with the crowded detailing of the Pre-Raphaelites.

School of Ruskin, *Segment Of Arch With Fresco Surround,* n.d.
Lecture Diagram Grey and colours on paper, laid on canvas.
1996P0484 © The Ruskin, Lancaster University

Endnotes

John Ruskin, ***Seven lamps, original engraving plate for plate 2***
R186 © The Ruskin, Lancaster University

LE: All references are to *The Library Edition of John Ruskin's Works*, 39 vols., eds. E. T. Cook and Alexander Wedderburn (London: George Allen, 1903–1912).

1. For cultural histories of mathematics, and for the impact of geometry in particular on culture, see Joan L. Richards, *Mathematical Visions: The Pursuit of Geometry in Victorian England* (London: Academic Press, 1988); Lynn Gamwell, *Mathematics + Art: A Cultural History* (Oxford; Princeton: University Press, 2016) to whom I am indebted. See also n.16 below.

2. John Ruskin, *Sublime & Instructive: Letters From John Ruskin to Louisa, Marchioness of Waterford, Anna Blunden and Ellen Heaton*, ed. Virginia Surtees (London: Michael Joseph, 1972), 57.

3. John Ruskin, *The Correspondence of John Ruskin and Charles Eliot Norton*, ed. John Lewis Bradley (Cambridge University Press, 1987), 387.

4. Ruskin, *Sublime & Instructive Letters*, 133.

5. For religion and mathematics, see Daniel J. Cohen, *Equations from God: Pure Mathematics and Victorian Faith* (Baltimore: John Hopkins University Press, 2007); and Snezana Lawrence and Mark McCartney, eds., *Mathematicians and their Gods: Interactions between Mathematics and Religious Beliefs* (Oxford University Press, 2015).

6. Euclid, *The Elements of Geometrie of the Most Ancient Philosopher Euclide of Megara*, trans. Henry Billingsley (London: John Daye, 1570), Preface.

7. Arthur Schopenhauer, *Schopenhauer: Parerga and Paralipomena: Short Philosophical Essays* vol. 2, trans. E. F. J. Payne (Oxford: Clarendon Press, 1974), 110.

8. Maurice Denis, 'Notes d'Art. Définition de Néo-Traditionnisme', *Art en Critique*, 65 (23 August 1890), 540–42 and 66 (30 August 1890), 556–58.

9. Pound, Ezra. 'A Retrospect', in *Literary Essays of Ezra Pound*, ed. T. S. Eliot (London: Faber and Faber, 1954), 3–13, 4.

10. Wynford Dewhurst, 'What is Impressionism?', *Contemporary Review* 99 (1911), 286–302, 295–96.

11. See: Charles H. Kahn, *Anaximander and the Origins of Greek Cosmology* (New York: Columbia University Press, 1994).

12. See Gamwell, *Mathematics + Art*, 70.

13. Benoit Mandelbrot, *The Fractal Geometry of Nature* (San Francisco: W.H. Freeman, 1982), 1.

14. Lars Spuybroek, *The Sympathy of Things: Ruskin and the Ecology of Design* (London: Bloomsbury, 2015), 246.

15. John Ruskin, *The Diaries of John Ruskin: 1848–1873*, eds. Joan Evans and John

123

Howard Whitehouse (Oxford: Clarendon Press, 1956), 422.

16. George Sarton, *The Study of the History of Mathematics* (Cambridge: M.A.: University of Harvard Press, 1936), 4.

17. Brian Rotman, *Becoming Beside Ourselves: The Alphabet, Ghosts, and Distributed Human Being* (Durham; London: Duke University Press, 2008), 57.

18. For an overview of the diffusion of mathematical ideas through culture see, Alice Jenkins, 'Mathematics', in John Holmes and Sharon Ruston, eds., *The Routledge Research Companion to Nineteenth-Century British Literature and Science*, (London; New York: Routledge, 2017), 217–34; and Raymond Flood, Adam Rice and Robin Wilson, eds., *Mathematics in Victorian Britain* (Oxford University Press, 2011). See also n.1 above.

19. Letter to Sofia Kovaleskaya 27 Aug 1833, quoted in Gösta Mittag-Leffler, *Compte rendu du deuxième Congrès international des mathematiciens tenu à Paris du 6 au 12 août 1900* (Paris: Gauthier-Villars, 1902), 149.

20. Samuel Gridley Howe. 'Education of the Blind', *The North American Review*, vol. 37, no. 80 (July 1833), 20–58, 38.

21. Oliver Byrne, ed., *The First Six Books of the Elements of Euclid in Which Coloured Diagrams and Symbols Are Used Instead of Letters for the Greater Ease of Learners* (London: William Pickering, 1847), vii.

22. John Ruskin, *Notes by Mr. Ruskin* (London: Chiswick Press, 1878), 111.

23. Ruskin, *Notes*, 111.

24. Letter to John James Ruskin, 7 October 1845, quoted in John Ruskin, *Ruskin in Italy: Letters to his Parents, 1845*, ed. Harold Shapiro (Oxford University Press, 1972), 220–25.

25. *Athenaeum* 20 February 1847, quoted in Jeanne Clegg and Paul Tucker, eds., *Ruskin e la Toscana* (Lucca: Fondazione Ragghianti, 1992), 55.

26. Elizabeth Prickett, 'What is Ruskin Lace?', https://www.ruskinlace.org.uk/.

27. Lewis Carroll, *Symbolic Logic: Part 1* (London: Macmillan and Co., 1896), xiii. See also: Francine F. Abeles, 'Lewis Carroll's Visual Logic', *History and Philosophy of Logic* 28 (2007), 1–17.

28. For Ruskin and Music, see Paul Jackson, 'Ruskin, Music and the Health of the Nation', in Valerie Purton, ed., *John Ruskin and Nineteenth-Century Education* (Cambridge: Cambridge University Press, 2018), 115–28.

29. Letter to John James Ruskin, March 1859, quoted in John Ruskin, *The Winnington Letters: John Ruskin's Correspondence with Margaret Alexis Bell and the Children at Winnington Hall*, ed. Van Akin Burd (Harvard University Press, 1969), 108.

30. *The Diaries of John Ruskin: 1874–1889*, eds. Joan Evans and John Howard Whitehouse (Oxford: Clarendon Press, 1959), 915.

31. David Brewster, *Transactions of the Royal Society of Edinburgh*, vol. 8 (1818), 281–86.

32. James Sowerby, *British mineralogy, or, Coloured figures intended to elucidate the mineralogy of Great Britain* (London: R. Taylor & Co., 1804), vii.

33. W. G. Collingwood, *The Life of John Ruskin* (Houghton-Mifflin, 1902), 41, 91.

34. The Ruskin Pottery was named in recognition of Ruskin's support of craft industries and his social ideals. Founded in 1898 by Edward R. Taylor, the first principal of both the Lincoln and Birmingham Schools of Art, it was one of a group of English art pottery studios established in the late nineteenth century. See Edward R. Taylor and William H. Taylor, 'The Ruskin Pottery Catalogue' (1905), https://collections.vam.ac.uk/item/O77911/vase-taylor-william-howson/.

35. Richard Redgrave and Samuel Redgrave, *A Century of British Painters* (Ithaca: Cornell University Press, 1981), 257.

Bibliography

126

John Ruskin, **_Seven lamps, original engraving plate for plate 9_**
R185 © The Ruskin, Lancaster University

Abbot, Edwin. *Flatland: A Romance of Many Dimensions* (London: Seely & Co., 1884).

Abeles, Francine F. 'Lewis Carroll's Visual Logic', *History and Philosophy of Logic* 28 (2007), 1–17.

Brewster, David. *Transactions of the Royal Society of Edinburgh*, vol. 8 (1818), 281–86.

Byrne, Oliver, ed. *The First Six Books of the Elements of Euclid in Which Coloured Diagrams and Symbols Are Used Instead of Letters for the Greater Ease of Learners* (London: William Pickering, 1847).

Carroll, Lewis. *Symbolic Logic: Part 1* (London: Macmillan and Co., 1896).

---. *Through the Looking-Glass and What Alice Found There* (London: Macmillan and Co., 1872).

Cohen, Daniel J. *Equations from God: Pure Mathematics and Victorian Faith* (Baltimore: John Hopkins University Press, 2007).

Clegg, Jeanne and Tucker, Paul, eds. *Ruskin e la Toscana* (Lucca: Fondazione Ragghianti, 1992).

Collingwood, W. G. *The Life of John Ruskin* (Houghton-Mifflin, 1902).

Denis, Maurice. 'Notes d'Art. Définition de Néo-Traditionnisme', *Art en Critique*, 65 (23 August 1890), 540–42 and 66 (30 August 1890), 556–58.

Dewhurst, Wynford. 'What is Impressionism?', *The Contemporary Review*, 99 (1 Jan 1911), 286–302.

Euclid. *The Elements of Geometrie of The Most Ancient Philosopher Euclide of Megara*, trans. Henry Billingsley (London: John Daye, 1570).

Flood, Raymond, Adam Rice, and Robin Wilson, eds. *Mathematics in Victorian Britain* (Oxford University Press, 2011).

Gamwell, Lynn. *Mathematics + Art: A Cultural History* (Oxford; Princeton: Princeton University Press, 2016).

Howe, Samuel Gridley. 'Education of the Blind', *The North American Review*, vol. 37, no. 80 (July 1833), 20–58.

Ings-Chambers, Caroline. *Louisa Waterford and John Ruskin: 'For You Have Not Falsely Praised'* (Abingdon: Routledge, 2017).

Jackson, Paul. 'Ruskin, Music and the Health of the Nation', in Valerie Purton, ed., *John Ruskin and Nineteenth-Century Education*, (Cambridge University Press, 2018), 115–28.

Jenkins, Alice. 'Mathematics', in John Holmes and Sharon Ruston, eds., *The Routledge Research Companion to Nineteenth-Century British Literature and Science*, (London; New York: Routledge, 2017), 217–234.

Kahn, Charles H. *Anaximander and the Origins of Greek Cosmology* (New York: Columbia University Press, 1994).

Lawrence, Snezana and Mark McCartney, eds. *Mathematicians and their Gods: Interactions between Mathematics and Religious Beliefs* (Oxford University Press, 2015).

Mandelbrot, Benoit. *The Fractal Geometry of Nature* (San Francisco: W.H. Freeman, 1982).

Mittag-Leffler, Gösta. *Compte rendu du deuxième Congrès international des mathematiciens tenu à Paris du 6 au 12 août 1900* (Paris: Gauthier-Villars, 1902).

Mondrian Piet. "Neo-Plasticism: The General Principle of Plastic Equivalence" [1917] in *The New Art, the New Life: The Collected Writings of Piet Mondrian*, ed. Harry Holtzman (New York: Da Capo, 1993), 134–47.

Plato. *The Dialogues of Plato: Parmenides. Theaetetus. Sophist. Statesman. Philebus* (New York: Oxford University Press, 1892).

Pound, Ezra. 'A Retrospect', in *Literary Essays of Ezra Pound*, ed. T. S. Eliot (London: Faber and Faber, 1954), 3–13.

Prickett, Elizabeth. 'What is Ruskin Lace?', https://www.ruskinlace.org.uk/.

Redgrave, Richard and Samuel Redgrave. *A Century of British Painters* (Ithaca: Cornell University Press, 1981).

Rockburne, Dorothea. 'Drawing Which Makes Itself', Bykert Gallery, 1973, quoted in Karen Rosenberg, 'Mathematical Ratios, Papered, Folded and Cut', *The New York Times*, 13 Dec. 2013. https://www.nytimes.com/2013/12/13/arts/design/dorothea-rockburnes-drawings-at-the-museum-of-modern-art.html.

Rotman, Brian. *Becoming Beside Ourselves: The Alphabet, Ghosts, and Distributed Human Being* (Durham; London: Duke University Press, 2008).

Ruskin, John. *The Correspondence of John Ruskin and Charles Eliot Norton*, ed. John Lewis Bradley (Cambridge University Press, 1987).

---. *The Diaries of John Ruskin: 1848–1873*, eds. Joan Evans and John Howard (Oxford: Clarendon Press, 1956).

---. *The Diaries of John Ruskin: 1874–1889*, eds. Joan Evans and John Howard Whitehouse (Oxford: Clarendon Press, 1959).

---. *The Library Edition of John Ruskin's Works*, 39 vols., eds. E. T. Cook and Alexander Wedderburn (London: George Allen, 1903–1912).

---. *Notes by Mr Ruskin* (London: Chiswick Press, 1878).

---. *Ruskin in Italy: Letters to his Parents, 1845*, ed. Harold Shapiro (Oxford University Press, 1972).

---. *Sublime & Instructive: Letters From John Ruskin to Louisa, Marchioness of Waterford, Anna Blunden and Ellen Heaton*, ed. Virginia Surtees (London: Michael Joseph, 1972).

---. *The Winnington Letters: John Ruskin's Correspondence with Margaret Alexis Bell and the Children at Winnington Hall*, ed. Van Akin Burn (Harvard University Press, 1969).

Richards, Joan L. *Mathematical Visions: The Pursuit of Geometry in Victorian England* (London: Academic Press, 1988).

Russell, Bertrand. 'The Study of Mathematics', The *New Quarterly* 1 (Nov 1907); repr. in *Mysticism and Logic and Other Essays (*London: Longmans, Green, and Co., 1918), 58–73.

Sarton, George. *The Study of the History of Mathematics* (Cambridge: M.A: University of Harvard Press, 1936).

Arthur Schopenhauer, *Schopenhauer: Parerga and Paralipomena: Short Philosophical Essays* vol. 2, trans. E. F. J. Payne (Oxford: Clarendon Press, 1974)

Sowerby, James. *British mineralogy, or, Coloured figures intended to elucidate the mineralogy of Great Britain* (London: R. Taylor & Co., 1804).

Speiser, Andreas. *Die Mathematische Denkweise* [*The Mathematical Way of Thinking]* (Zurich: Rascher, 1932).

Spuybroek, Lars. *The Sympathy of Things: Ruskin and the Ecology of Design* (London: Bloomsbury, 2015).

Taylor, Edward R. and William H. Taylor. 'The Ruskin Pottery Catalogue' (1905), https://collections.vam.ac.uk/item/O77911/vase-taylor-william-howson/.

Taylor, W. *The Diagrams of EUCLID's Elements of Geometry (arranged according to Simson's edition) in an embossed or tangible form, for the use of blind persons …; part I, by Rev. W. TAYLOR* (York; J Wolstenholme, 1828).

Weyl, Hermman. *Symmetry* (Princeton University Press, 1938).

John Ruskin, ***Worksheet No. 180, San Zeno: shafts in crypt,*** 1849.
Pencil, black ink and ink wash. 356 x 240mm. 1996P1588 © The Ruskin, Lancaster University

'Geometry seems to have acted as a febrifuge [a medicine to bring down fever] … the fragments have come together.'

John Ruskin in the Age of Science
April – December 2022

A series of exhibitions in London and the Lakes showcasing works from the collections of the Royal Society, London and Lancaster University's Ruskin Whitehouse Collection.

Ruskin's Perspectives: The Art of Abstraction
30 June to 11 September 2022

Curated by Sandra Kemp (The Ruskin), with Howard Hull (Brantwood) and Keith Moore (the Royal Society), these exhibitions place Ruskin alongside his nineteenth century scientific contemporaries, exploring his influence on science and society, in his time and our own.

Exhibition and graphic design by lombaert studio.
Installation by arciform.

With thanks to Alexander Belton, Harriet Hill-Payne and colleagues at The Ruskin, Brantwood and the Royal Society.

The Ruskin Whitehouse Collection was purchased by Lancaster University in 2019, with generous support from the National Heritage Memorial Fund and others. The Collection is on permanent display at both The Ruskin and Brantwood, John Ruskin's former house, garden and estate on the shore of Coniston Water.

While The Ruskin is closed for major refurbishment, this series of exhibitions displays the Ruskin Whitehouse Collection in London and the Lake District. The Ruskin will reopen in 2024.

Lancaster University · THE ROYAL SOCIETY · John Ruskin's home Brantwood