10.14324/111.2396-9008.012

Iron and bone: the skeleton architecture of the Oxford University Museum of Natural History

Kelly Freeman

The Oxford University Museum of Natural History (OUMNH), built between 1855 and 1860, remains today more or less in its original appearance. On stepping into the dimly lit entrance foyer and climbing the leaden-grey stone steps, a visitor may be unprepared for the architectural vision beyond the unassuming wooden doors. Natural light pours through the clear glass roof, illuminating the museum's central court. The daylight touches every surface – the specimens, the walls, the floors, corners and crevasses. Numerous stone and iron columns support a roof formed of overlapping glass scales, interwoven with iron cross work, added to which are the skeletons of great leviathans suspended from this extraordinary iron and glass ceiling. The juxtaposition of the cast-iron lancet arches that support the roof with the large curving rib bones of the various whale specimens hanging above creates a remarkable sight. As the bright midday sun reaches its zenith, the bones seem to appropriate the same steely-grey and ochre-yellow patina as the ironwork, making their individual forms, colours and textures indistinguishable from one another (figure 1).

This phenomenon of material slippage is striking, and it raises the question as to whether this chromatic conflation of bone and iron was an intentional part of the museum's original design. In the museum, the bone and iron both share the visual attribute of being relatively narrow and long, particularly when considering the rib bones, with their delicately curving processes, echoed in the roof's iron lancet arches. Both materials yellow over time, but they also express many other similar intrinsic properties that had not gone unnoticed by nineteenth-century scholars and academics.[1] They were considered to be ideal building materials, having the shared properties of being both light and incredibly strong. The intrinsic properties, physical

Figure 1 *Skeletons on display in the Oxford University Museum of Natural History (OUMNH)*, 2015. The large marine specimens are suspended from the ceiling by metal cables and wires. Courtesy of the Oxford University Museum of Natural History. Photograph taken by author, 2015.

resemblance and proximity of the two materials could then account for the material slippage perceived in the museum.

Yet there is another connection. Iron was necessary for the creation of both the osteological specimens, that is, the skeletons on display, and the architectural structure of the building's skeleton itself.[2] Iron – in the form of wires, hinges and struts – was used to articulate together the bones in the specimen as well as the bones of the architecture.[3] There is something quite extraordinary in the use of iron in the OUMNH, being both the innocuous material necessary for the creation of skeletons as natural-history specimens, as well as the metaphor-turned-homonym for its architectural frame. Surprisingly, however, there is no mention of the material relationship between bone and iron in the published literature on the OUMNH's architectural vision, design and execution. No scholar has addressed the museography beyond Neil McWilliams's supposition that the 'bleached bones [are] unconsciously paraphrasing the pattern of the glass vaults that rear above them'.[4] However, I would argue that the juxtaposition of iron and bone was far from unconscious. In this article, I will examine the skeletons within the OUMNH and consider the ways in which the concept of the skeleton, as both material and metaphor, was the device used to articulate various fundamental ideas about the natural world. The word 'articulate' itself can hold a variety of meanings: it can signify the process of joining bones together in an artificial, moveable synarthrotic joint; the joint between two separate parts in a plant, such as the root with the stem or branch with the trunk; and to clearly enunciate or express vocally.

Anthropologist Elizabeth Hallam utilizes articulation as a concept with which to explore the process of making skeletons (skeletopoeia). Described as an intimate, labourious, emotive, animative and pedagogic process, Hallam discusses the broader concepts concerning skeletopoeia and argues that 'different interactions with bones give rise to different affective materializations of these remains'.[5] In the museum, the bones are brought together and articulated with each other, the very act of joining being a kind of growth; and it is the very jointed nature of vertebral life that enables this process and the potential animation of the animal after death. This can be seen in the specimen of the northern bottlenose whale, which has been suspended from the museum's roof for over 150 years and seems to be floating through the air in the same manner that the living animal would swim through water.[6] The

iron wires hold the individual bones together and provide the semblance of life necessary for the reanimation of the once-living creature. Iron's ability to animate the specimen elevates its properties from the structurally mundane to something energized and potentially organic in its application and appraisal. In its aim to align and unify nineteenth-century natural philosophy with the Anglican church, the OUMNH itself is also a site of articulation, of objects and materials as well as of the architectural ideologies of the four main contributors to the museum's design and construction: Henry Acland, Benjamin Woodward, John Ruskin and John Phillips.[7]

This paper will discuss how the conception of the skeleton as an alleged 'organic' entity impacted on the Gothic construction and interior design of the museum. I will demonstrate that this concept was apparent in the skeletal structure of the iron architecture, the decorous iron spandrels and columns, the building's stones and geological specimens, the 'skeleton frames' of the display cabinets and the museum's collection of skeletons. In the OUMNH, the 'skeleton' became a unifying concept, guiding its design and construction. The museum's 'skeletons' were articulated to visitors through various strata of resemblance, be it the material, the visual or the metaphorical, generating for the viewer a living, organic vision of nature that combined architecture with the skeletal specimen. In this way, the individual architectural elements were blended into a unified organic whole able to suggest a harmony of nature and technology.

The Museum's Gothic Skeleton

Dr. Henry Wentworth Acland (1815–1900) was appointed Professor of Anatomy and Lee's Reader at the University of Oxford in 1845, and heralded a new era in the study of science at Oxford. Since 1847, Acland had been active in his pursuit of a new site for the display of the University's scientific collections, and for the teaching of a range of subjects under the rubric of 'the Natural History of the Earth and its inhabitants', petitioning the Oxford University Convocation in July of that year for a new museum.[8] Over the subsequent five years, the voices advocating the new museum increased in volume and urgency as donations to the colleges' numerable collections were unrelenting.[9] In 1853, the University finally acquiesced to the scheme, securing land for a potential museum from Merton College. It was during this time that Acland's mission was brought to the ear of the

prominent art and social critic John Ruskin (1819–1900), a good friend and a regular correspondent of Acland's since their undergraduate days together at Christ Church. Ruskin had recently published his three-volume treatise on architecture, *The Stones of Venice* (1851–1853), in which he lauded Gothic architecture above all other styles of building, extolling the 'spirit' in which the European Gothic structures were crafted, and the homage to nature within the decorous natural forms carved in stone.[10] Alongside the Bible – the word of God – nature was, for Ruskin, the epitome of God's truth made manifest.[11] Yet, Ruskin's version of a neo-Gothic style went beyond the Victorian fashion for the romanticized medieval ruin.[12] He infused his admiration for the medieval Gothic with a dash of Protestant rationalism, wresting the style from its association with Catholicism, and presented a kind of divine realism as a method of engaging with the 'truth' in such Gothic monuments. It was a truth found in manual labour, in craftsmanship, in local and identifiable materials, and in nature.[13] Held within this truth, Ruskin saw the potential salvation of both the style and the nation from the immoral and duplicitous practices of material concealment and imitation.

It is difficult to know if Ruskin's aesthetics provided the general backdrop for the state of architectural theory in Britain at this point in the mid-nineteenth century, but Ruskin's works were certainly widely read by architects, scholars and the general reading public of Victorian society.[14] Many British architects and theorists were promoters of the Gothic style, however none had written so prolifically on the subject and, except for perhaps Augustus Welby Northmore Pugin (1812–52), no other British architect had imbued the style with such strong moral undertones.[15] The Gothic, for many nineteenth-century architects that preceded Ruskin such as Thomas Rickman (1776–1841) and William Wilkins (1778–1839), was simply a style of building from a certain period, from a certain geographical region and possessing certain architectural attributes such as vaulted ceilings, pointed arches and flying buttresses.[16] And although it was recognized that Gothic ornament imitated nature's forms, Ruskin's singular position was that ornament *was* architecture, and that pure imitation had no place in the true Gothic. Ruskin's Gothic was about the expression of 'spirit', the spirit of an organic nature expressed through ideal forms, materials and craftsmen.

The announcement of an open competition to design the new Oxford museum remained intentionally vague – a building 'two stories high, three

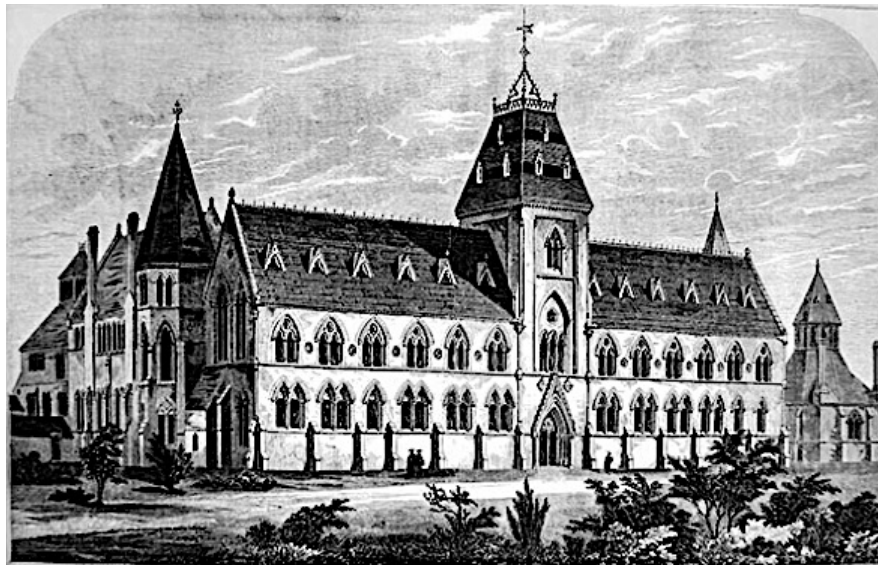

Figure 2 *Winning design 'Nisi Dominus' for the New University Museum in Oxford by architects Thomas Deane (1792–1871) and Benjamin Woodward (1816–1861).* Print. Image taken from *Builder*, 1855.

sides of a quadrangle with an area covered by a glass roof and the fourth side allowing for later expansion' – and gave the applicants free license, encouraging originality in design.[17] Acland readily consulted with Ruskin regarding the appropriate choice of style, and was easily swayed by his friend's arguments for the Gothic; however, Acland would have to fight for his preference within an appointed University Convocation. Thirty-two architects responded to the call, each proposing a distinctive architectural style, but in the end Acland got his wish and the Rhenish Gothic design, obsequiously titled 'Nisi Dominus aedificaverit domum' ('Unless the Lord built the house'), won the day.[18]

The 'Nisi Dominus' design (figure 2) by architect Benjamin Woodward (1816–1861), from the Irish firm Deane and Woodward, embraced the tenets of Ruskin's Gothic wholeheartedly. This architectural team of Thomas Newenham Deane (1792–1871) and Benjamin Woodward had lately found success building another University museum decorated in the Gothic style, the Trinity College Museum in Dublin (1853–1857). Elements of the design for both Trinity College and the projected new Oxford museum could have

been taken directly from Ruskin's *The Stones of Venice*, pictorially supporting the proposition that Ruskin's writings and drawings directly inspired Deane and Woodward's architectural designs.[19] On 12 December 1854, Acland informed his friend of the competition results, and Ruskin's interest in the project was immediately ignited. There is evidence that Ruskin already knew Woodward personally, even considered him a friend, and was sure of his own influence. Ruskin immediately wrote to Lady Pauline Trevelyan, a close confidante, that 'Acland has got his museum – Gothic – the architect is a friend of mine – I can do whatever I like with it [. . .] – & expect the architect here today'.[20] Indeed, once the commission for the new museum had been secured, communication ran thick and fast between the eminent art critic and the young architect, right up until Woodward's premature death from tuberculosis in 1861.

Ruskin championed a Gothic style that was not merely visually associative, comprising traditional and identifiable Gothic forms such as pointed arches and pinnacles. He advocated the moral 'truth' of the style, meaning that the building's fabric should be hewn by expert craftsmen, the adornments directly inspired by nature and the building's stones should originate from the region within which it was built.[21] The construction of the museum began in 1855, and most of the work was completed by 1861. In keeping with Ruskin's conception of the Gothic, as extensively detailed in 'The Nature of Gothic' from the second volume of *The Stones of Venice*, the museum's interior court was comprised of White and Red Mansfield and Forest of Dean Stone slabs.[22] The roof tiles were a combination of Greenmoreland and Blue Duchess slate, creating two bands of ornamental slating, and there were numerous voussoirs and stringcourses in both the interior and exterior stonework made from Bristol red sandstone (around some external windows) and bands of green Horton stone (in the interior arches). This polychromatic scheme was adopted from Venetian Gothic architecture.[23] A local Bath stone was sourced from the closest high-quality limestone quarry and used for the building's facing.[24] Bath stone is white when cut, imbuing the finish with a bony, chalk-like quality. The stone then yellows over time, producing the characteristic honey-hewed finish associated with Oxford's cityscape. The loss of the bone-white colour is a visual removal of the stone from its material composition as calcium carbonate (the layered remains of the fossilized shells and skeletal fragments of marine organisms). This choice in stone embraced

the spirit of Ruskin's Gothic. As well as being locally sourced, the Bath stone presented another geological stone type, for it was Acland's belief that the display of geological specimens was vital in a museum dedicated to the study of earth sciences.[25]

However, at this time, geology generated an acute theological quandary. The evidence produced on the bases of fossils of extinct species contradicted any literal interpretation of the Book of Genesis. If God had planned the whole of creation, why would God have made creatures that became extinct? Fossils generated intense geological and theological debate, mobilized as evidence to support atheism, evolution, and a teleological view of biodiversity. The literal interpretation of a seven-day creation was turned into a metaphorical proposition by Dr. James Cowles Prichard in 1815, and this interpretation was firmly established prior to the publication of Charles Lyell's influential book *The Principles of Geology* (1830–1833).[26] The evidence that planet Earth was millions of years old instead of mere millennia generated an enormous impact in secular society and dealt a massive blow to the prevailing theocratic powers.[27] It is therefore unsurprising that the Genesis metaphor became a zealot's anchor, a lifeline for literal believers in the biblical narrative. It is perhaps ironic that Earth itself – the original metaphor for God's creation – would provide the evidence for the undoing of this doctrine. The religious instability generated from geology, and the ever-expanding fossil record, incited natural philosophers to question all perceived dimensions of material space. Amid such religious contentions, it remains unclear exactly what theological position the museum's architects took during the building's design and construction; however, it is clear that an Anglican authority of University delegates, all of whom had signed the Thirty-Nine Articles, oversaw the design and execution of the museum's architecture and decoration.[28]

The Redemption of Iron

Although the OUMNH was officially opened in 1860, certain planned exterior elements remained unrealized, resulting in a sparse external décor that contrasted greatly with the richly decorated interior. Through the museum's entrance porch, the space opens into a light-filled court of iron columns. Like metallic trees, they reach the height of the structure and support the range of skylights. The central, open space dissolves the high

concentration of iron, used in support and ornament, from an overwhelming metallic density into an airy, almost delicate impression. Employed in this way, iron connotes not the severe hammering of industrial production, which Ruskin so vehemently opposed, but the elevated neo-Gothic cadence of nature captured within a modern material. The ferrous material is visible and illuminated by the sky's seasonal and circadian shades, an exposure of materials and construction that Ruskin considered 'true'. Iron was also a practical choice. As a building material, it first gained prominence towards the end of the eighteenth century, when the method for casting large support beams had been perfected. Initially, iron was selected solely for its fireproof properties and, wherever feasible, replaced wood for this reason.[29] It was not long, however, before iron became the prime choice of construction material for numerous other reasons. Iron allowed buildings to grow larger whilst retaining slender support columns. Dubbed the 'plastic of the nineteenth century', iron remained considerably pliable when wrought and incredibly strong when cast.[30] It was also an economically viable choice, as manufacture and mass production allowed for a faster turnover of a product that could be tailored to very specific requirements, eliminating the concern of sourcing and acquiring expensive lengths of timber. It makes sense, therefore, that iron is to be found in the architectural structures of many nineteenth-century museums of natural history, such as the Natural History Museum in Dublin (1856–1857) and the Natural History Museum in London (1873–1881).

Along with the cast iron of the museum's supporting columns and roof, wrought iron was utilized in the capitals' organic forms, very much in accordance with Ruskin's Gothic aesthetic. This ornamental wrought iron was manipulated to imitate local botanical flora in minute detail and exactitude, and depicts various leaf formations, floral forms, buds and fern-like spirals (figure 3). The floral iron forms provoked a prosaic organic interpretation, yet the iron's materiality and its points of articulation (the sites where the cast iron-support column, wrought iron ornament and the roof's cast iron lancet arch are brought together) was intentionally exposed, shattering the forest canopy illusion by exposing the method of its making through riveted, twisted, hammered, bowed and pined metal.[31] These botanical forms were not simply positioned there to fill the articulating 'gap' in the museum's architectonics (the transition from iron-support column to

Figure 3 *Cast-iron columns with wrought-iron capital, imitating botanical forms*. Courtesy of the Oxford University Museum of Natural History. Photograph by author, 2015.

iron roof lancet arch) with representations of nature. In positioning these bouquets of plant life at the architectonics between column and roof, these sites of iron articulation are visibly filled with the metaphorical potential for organic life, beyond its mere representation.

The iron capitals are partially painted, and thus transition from a steely grey to an orchard yellow and autumnal orange. This choice of colour was perhaps made in homage to the oxidized iron, forming on the tips of the carvings like rays of sunlight upon a fertile garden.[32] The coloured mimicry of iron oxidization lends vitality to the ironwork, suggesting that the iron is breathing, as if reacting to the moisture in the air. The transition in colour continues into the cross-beams and spandrels of the roof which have been painted, or perhaps stenciled, with a decorative floral motif in various russet hues of yellow, orange and red, the colours of fire, of earth, of life, of oxidized iron. Ruskin described iron as the 'sunshine of light and landscape', adding colour to Earth and producing the brilliancies of yellow, orange and red found in the sand, soil and rocks of its topography.[33] In a lecture given at Tunbridge Wells in 1858, Ruskin considered iron as a natural material:

> [Iron] [. . .] sucks and breathes the brilliancy of the atmosphere; and as it breathes, softening from its merciless hardness, it falls into fruitful and beneficent dust; gathering itself again into the earths from which we feed, and the stones with which we build;– into the rocks that frame the mountains, and the sands that bind the sea.[34]

This praise of iron is at odds with the cold, mechanical and 'soulless' material described by the Scottish philosopher, historian and controversial essayist Thomas Carlyle (1795–1881). In his popular commentaries on modern culture, *Signs of the Times* (1829) and *Characteristics* (1831), Carlyle portrays iron as an emblem for the 'mechanical age' of industrialization.[35] His assessment of iron as soulless resonated deeply with critics of industrialization and the advocates of rural rights, including Ruskin himself, who believed that the British countryside was being exploited for its rich mineral deposits of iron and coal, materials necessary for feeding the machines of commerce and industry.[36] One would thus expect Ruskin to have rebuffed the use of iron in architecture, and some historians of the subject have assumed this.

They refer chiefly to his damning critique of Crystal Palace as a 'magnified conservatory', and the 'black skeleton and blinding square' of industrialized Britain's ferrovitreous architecture.[37] These scholars overlook, however, how Ruskin managed to shift the connotations of iron. In certain remarks he set aside his bias against the industrial element, and detected in iron an essential universality. Ruskin divined from iron a past, a present and a potential for the future in a single interaction, a connection with all things, at all times. Life on this planet may have been carbon-based, but iron gave life its colour, its 'vitality', a testament of which could be found in the diverse palate of Earth's geology:

> [T]he flush to all the rosy granite of Egypt [. . .] to the rosiest summits of the Alps themselves [. . .] Is it not strange to find this stern and strong metal mingled so delicately in our human life, that we cannot even blush without its help? Think of it, my fair and gentle hearers; how terrible the alternative – sometimes you have actually no choice but to be brazenfaced, or iron-faced![38]

This was iron's redemption from the 'ills' of industrialization, which allowed for both an appreciation of iron architecture and a Ruskinian interpretation of it. The riveted cast iron of the roof and the hammered wrought iron spandrels could now be understood as not only mimicking the organic but also as being organic. Iron thus became the ideal building material for a museum dedicated to the study of science and natural history. The yellowing Bath stone of the museum's façade may have been a visual dissociation from its bone-white composition, but its deepening buttery hue was testament to the building's life – its ageing – and a natural process of iron oxidation that Ruskin understood in terms of breathing.

The Earth's Iron Skeleton

All rocks contain traces of iron. In geological formations iron can be seen to form reddish and yellow-coloured lines, and it is iron's oxidation that produces the vivid colours. These lines of hematite are easily discernable from the grey of the surrounding rock. They follow the sedimentary lines of deposition, differentiating them from the veins of the rock. In the fourth volume of *Modern Painters* (1856), Ruskin described these lines as 'abstract', in that they followed the general form of the rock topography as a whole

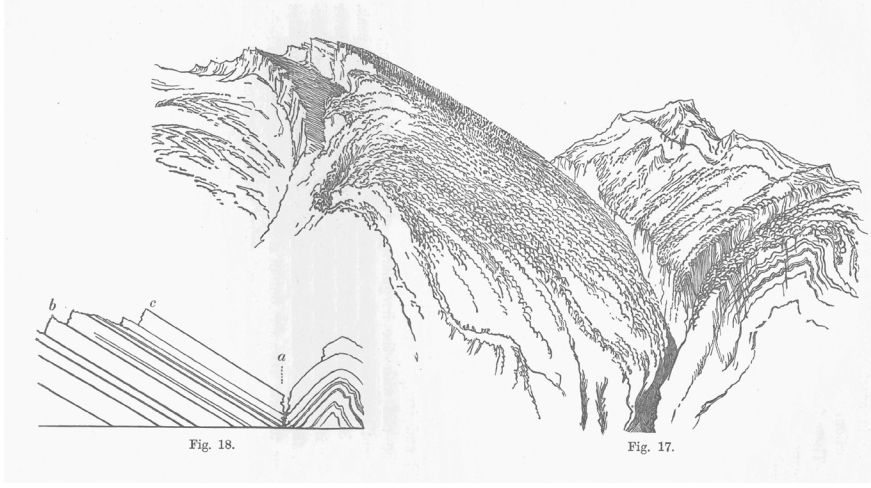

Figure 4 John Ruskin, *Skeleton lines made from the layers of rock*, 1856. Print. *Modern Painters* IV, London: Smith Elder. *'The gorge which leads from the village of Ardon, in the Valais, up to the root of the Diablerets, runs between two ranges of limestone hills, of which the rude contour is given in Fig. 17 (page 154). The actual order of the beds is seen in Fig. 18, and it is one of the boldest and clearest examples of the form of mountains being correspondent to the curves of beds which I have ever seen'*. Courtesy of the Ruskin Foundation (Ruskin Library, Lancaster University).

but could also describe this shape within a single line, in the same way that abstraction would be described in the twentieth century. One particular illustration by Ruskin (figure 4) represents, on the right, the geological topography of the rock's surface as it slopes downwards into a fissure and rises onto the other side. This is an example of tectonic convergence. As the rocks are pushed together, the resulting pressure causes subduction (one plate forced below the other) and creates a trench. The illustration to the left is a schematic rendering of the rock's interior, the lines indicating the layers of differential and sequential rock formation, which are visible through the coloration, typically yellow or red, caused by the iron. These abstracted lines clearly follow the rock striations present in the illustration on the right and were referred to by Ruskin as 'skeleton lines'. Thus, the skeleton becomes an important trope for Ruskin to describe all that is essential, and by essential I mean of the 'essence': the extracted fundamental nature or 'spirit' of a thing. Ruskin's use of the concept of the skeleton for geological formations could be described as his most prolific and synecdochical application of the

metaphor. In the text accompanying his poem 'Chamouni', published in *Poems* (1891), Ruskin wrote that 'the blue sky, shone calmly through their openings, and the laboring sun struggled strangely – now gleaming waterily on the red-ribbed skeleton crags'.[39] Here, 'the red-ribbed skeleton crags' are a visual metaphor for the iron hematite.

The preceding text shows how Ruskin took from the skeleton its line and form, utilizing its unique qualities as being strong yet graceful, natural yet man-made, dead yet active, organic whilst being inorganic, and applied it to forms that could also be deemed materially ambiguous. He further examined the concept within a literary genre that was considered to be freer from intellectual scorn, allowing his metaphors to be safely and innocently explored and expressed through the language of poetry:

> Till in the mountain's hardened heart it lies
> In nature, rock,—in form, a skeleton;
> Much for the feature valued by the wise,
> Or in some huge museum to be shown,—
> A mystery, as wonderful, at least,
> As that of apples conjured into paste![40]

In this poem, the mountain has a 'heart' in which resides rock with the form of 'a skeleton'. This skeleton is of rock and yet, paradoxically, rock is often comprised of the skeletons of organisms. Another interpretation could be that 'in form' is a reference to the human form, in which case the association between the rock and the skeleton would be a simile, i.e. the structure or 'heart' of a mountain is its rock, while the structure of the animal form is its skeleton. Either way, Ruskin made explicit the connection between rocks and skeletons, a connection that is manifest in certain fossils. He imagined these entities reunited in a museum. It is thus not clear which skeletal form was being referred to, the animal or the rock. The reference to the wondrous transformation of 'apples' into 'paste' is also of interest as it infers a change of material state, although perhaps not of essence. Downward force and pressure is needed to 'conjure' the former into the latter, perhaps a reference to the pressure required for fossilization or the formation of various stone types. Another possibility is that Ruskin was referring to the process of erosion and the geological cycle, of returning the dust, the rust

and the powdered stone to the earth; the mountains are 'fed by their ruin', creating new skeleton forms.[41] One could consider this geological cycle as an ecological model, a paradigm that emerged in distinction to the other natural sciences in the mid-nineteenth century.[42] Ruskin scholar Mark Frost has written that ecology 'valorizes the vital connectedness of heterogeneous phenomena – that which Ruskin perceived as early as 1843, when he noted that "there is indeed in nature variety in all things", and that "the truths of nature are one eternal change – one infinite variety"'.[43] Frost argues that one of Ruskin's methods for connecting all 'heterogeneous phenomena' is in a textual organicism, a means of organizing the realms of nature into a complete, organic, and unbroken whole. The connections made by Ruskin between art, natural philosophy, geology and architecture are unsurprising and perhaps even to be expected from a renowned art critic and earth-science enthusiast. However, his choice of the skeleton as his unifying concept is intriguing, especially when considered within the OUMNH, a building that reflects the influence of Ruskin's Gothic and a museum that held specimens of all three types of skeleton – bone, architecture and rock. Taken together, Ruskin's rocks of bone (as skeletal fragments) and the skeleton lines of iron produced a profound material convergence and divergence that was both literal and metaphorical in essence and, when taken in the context of the museum, enables a new appreciation and interpretation of the rocks, the bones and the iron in turn.

Ruskin's Organic Iron

It seems that for every shade of oxidized iron he came across, Ruskin had a controversial, and at times contradictory, remark.[44] This makes any Ruskinian interpretation of iron architecture of the OUMNH problematic, to say the least. Yet, for the most part, these conflicting utterances are rhetorical, and inflected by their context. Furthermore, in light of shifting secular attitudes and scientific debates regarding earth elements, the debunking of Vitalism Theory, and the categorization of organic and inorganic at an anatomical level, it is understandable that Ruskin's own appraisals of the material would fluctuate. At the time of the OUMNH's construction, iron was understood to be a necessary component for organic life on this planet. Hematological experiments had determined the quantity of iron in the hemoglobin molecule, confirming iron's essential role in the oxygenation of blood. Experiments

with magnetism utilized iron to prove the existence, placement and direction of magnetic lines.[45] Engineers were also examining the atomic structure of iron so as to enhance its properties to make a stronger structural lattice. With the addition of various quantities of coal to iron, a lighter yet stronger steel alloy was engineered.[46]

Iron, for Ruskin, had its place in architecture primarily as a decorative material, and he praised its appropriate use in the finely wrought details of external decorations, such as fences and balconies. Where brittle stone would fracture or erode with repetitive abrasions, iron was stronger and lasted longer; it maintained form and structural integrity whilst being finely wrought and slender, enabling the most delicate of details. Thanks to material properties that allowed for molding and welding, wrought iron could emerge free from structural cast iron, like a blade of grass emerging from the ground – part of the whole, yet distinct in form. The material of iron was functional in the context of mechanical and industrialized usage, yet it was the contrasting properties of slender form, malleability and vitality that enabled its ideal application to organic ornamentation. Ruskin was well aware of these properties, writing:

> [T]he quaint beauty and character of many natural objects, such as intricate branches, grass, foliage (especially thorny branches and prickly foliage), as well as that of many animals, plumed, spined, or bristled, is sculpturally expressible in iron only, and in iron would be majestic and impressive in the highest degree.[47]

One can see the expression of this sentiment in the various drawings carried out by Ruskin during his 1869 Italian tour. In these drawings (figures 5 and 6), the iron railing appears like a wall of thorny plants, imparting a sense of menace or violence, with vertical, spiky leaves enforcing the division of space. The lines are more dynamic than those found in the carvings of natural forms in stone, or marble Corinthian style capitals or plinths. However, it was Ruskin's intention that the OUMNH be a monument to a new Gothic architecture. This meant that ornament needed to be placed everywhere for, as Ruskin imparted, architecture *was* ornament.[48] It also meant reconciling the monastic past – the ancient stone Gothic cathedral – with the technological present, hence the use of traditional stone juxtaposed with contemporary iron

Figure 5 John Ruskin, *Can Signoro Tomb: ironwork*, date uncertain (probably 1869). Pencil, watercolour and bodycolour. RF1078. Ruskin has taken great care to capture the organic forms and 'action' of the wrought iron. Courtesy of the Ruskin Foundation (Ruskin Library, Lancaster University).

columns. And so floral and faunal details were hammered out of wrought iron and carved into stone pillars and corbels. Whilst many may view these stone carvings as mere imitations of nature, they seem to me to be filled with what Ruskin described as the 'spirit' of Gothic, almost to the point of being the living material captured in stone. They retain a sense of stillness and petrifaction within the stone from which they are rendered, like fossils

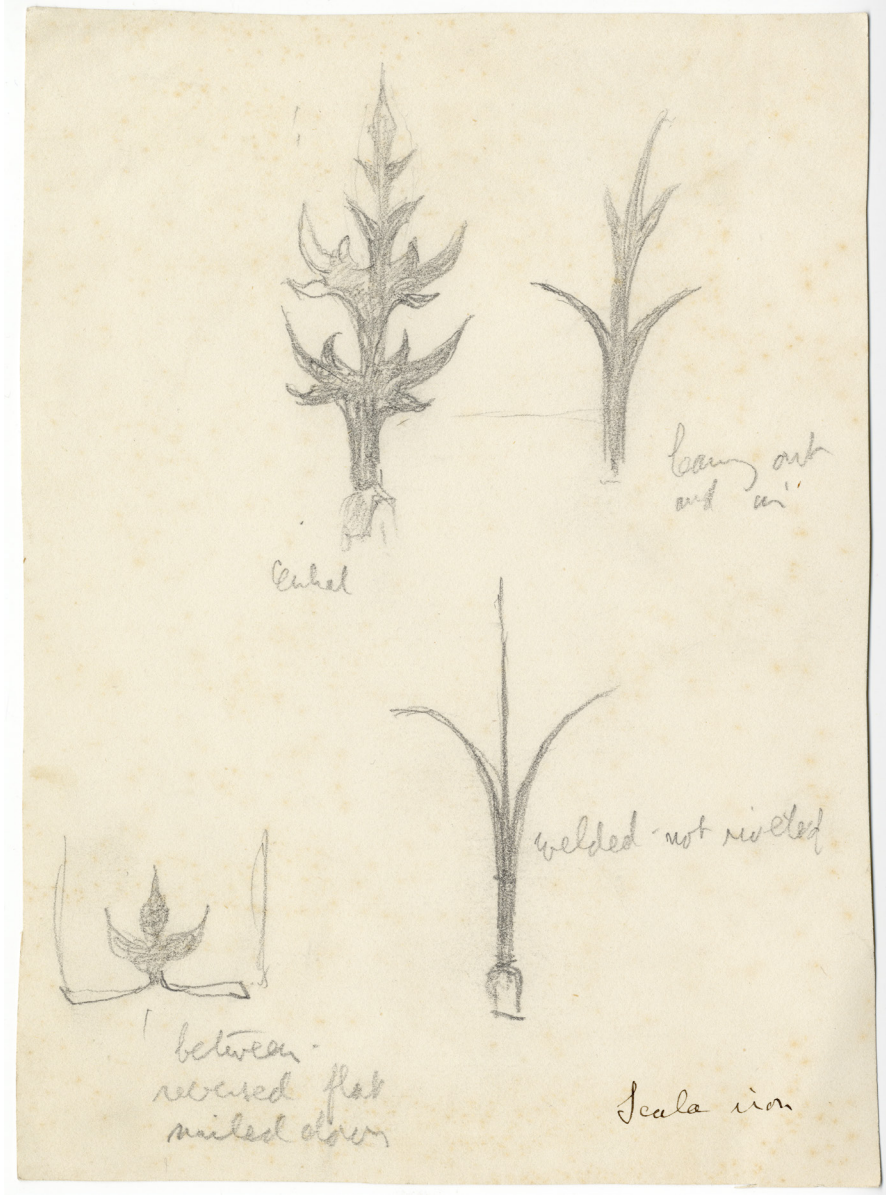

Figure 6 John Ruskin, *Scaliger Tombs: details of ironwork*, date uncertain (probably 1869). Pencil. RF 1663. Courtesy of the Ruskin Foundation (Ruskin Library, Lancaster University).

emerging from their rocky prisons. This inability to escape and emerge, free and whole, from the stone keeps their materiality in check. However, these forms also act as another reminder of the material slippage between bone and stone, the geological life cycle in which layers of skeletal fragments, under extreme pressure and over millennia, form sedimentary rocks. I consider this an example of what Ruskin meant by the idea of an infinite organic nature (as interpreted by Mark Frost), perhaps influenced by the writings of the renowned Scottish geologist James Hutton (1726–1797), who described the Earth as a 'superorganism', and who, in his attempt to describe the process of geological time (or 'deep time') proposed the infinite geological cycle in which 'we find no vestige of a beginning, no prospect of an end'.[49]

The OUMNH acted as a site of temporal mediation between the organic nature of iron and stone. Encountering nature's forms in the wrought and chiseled materials provided a connection with the divine – as nature was considered by Christians to be the painted canvas of God – as well as providing a unifying concept that structured and governed the building.[50] It is an organicist conception of nature as theophany. Architectural historian Caroline van Eck, in her research on the organic in architecture, analyzes the various conceptions of nature manifested in this museum. Van Eck considers the OUMNH a prime example of 'organic architecture' and sees there an expression of the unifying concepts of organicism. She argues that the whole structure was made of parts, which influenced and unified each other, and that these parts expressed the form of living beings.[51] Van Eck critically endeavours to interpret the OUMNH's functional elements via an analysis of its organic 'wholeness', achieved through its unifying architectural structures and forms. Yet, by limiting her focus to nature's external morphology as echoed in the museum's decorous splendour, van Eck fails to consider the relations between the architecture and the objects displayed in the museum. Architectural historian Philip Steadman attempts to bridge this gap between the internal and external via a 'biological analogy', which he proposes as an alternative to the organic analogy. This proposition is appropriate given that biology was a newly emerging scientific discipline in the nineteenth century. His analogy allows for an analysis of the functional as well as physiological elements of building construction.[52] However, Steadman's biological analogy deals more with biological processes and systems in architecture. He neither engages with the physical skeleton nor with any of the skeleton's material,

visual or metaphorical associations.[53] Although both van Eck and Steadman's approaches to nineteenth-century architectural theory have merit, both share an underlying disregard for materials, directing their analyses instead to the morphological or physiological elements. The material of construction and the material on display in the museum were of the utmost importance to the architects, whether for reasons of morality, truthfulness, naturalness or pedagogy.

The Skeletons in their Cupboard

Indeed, Henry Acland designed the museum primarily as a temple to natural science, as is well documented in his small book, *The Oxford Museum* (1859), originally published with contributions by Ruskin. Although, as Acland wrote, 'we see them darkly as in a mirror', everything the eye touches should inspire awe in the beauty, power and organization of nature, and a firm belief in the truth of God's creations, and one man was made entirely responsible for this: John Phillips.[54] Previously Professor of Geology and the Keeper of the Ashmolean, he was appointed as the OUMNH's Keeper in 1857.[55] Despite the fact that Phillips was a member of the appointed delegation responsible for drafting the architectural specifications for the new museum, his contribution has remained overshadowed by the indomitable figures of Acland and Ruskin. His influence on the 'museumscape' is poorly documented, his position relegated to footnotes and appendices of the literature published on the museum. Phillips was dubbed the unofficial overseer in the arrangement and display of the enormous museum collection as well as the entire museum's interior décor. The chiseled-stone floral capitals are attributed to Phillips's designs, the preparatory sketches for which have been analyzed by architectural historians for their remarkable botanical resemblance to various plant species (figures 7 and 8). He is also credited for the design and arrangement of the central court's elegant polished stone colonnettes.[56] The stones are a pedagogical device, both geological specimens of British marble and architectural supports, and are evidence of Phillips's conceptual understanding of material as specimen and vice versa.[57] While Phillips's sketches for the specimens' arrangement and display remain disregarded and unpublished until now (figures 9–13), his designs were precisely the hinge between the architecture and specimens; in a sense, they 'articulated' the correlation of the museum's iron and bone

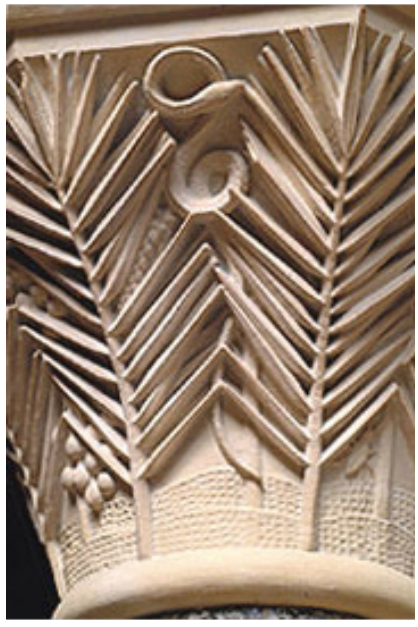

Figure 7 *Capital 'Phoenix dactylifera (with animals)' at the OUMNH*, c. 1858. (http://www.oum.ox.ac.uk/learning/pdfs/columns.pdf). Courtesy of the Oxford University Museum of Natural History. Photograph by George P. Landow, 1977.

Figure 8 John Phillips, *Design for capital 'Phoenix dactylifera (with animals)'*, c. 1857. Pencil, ink and watercolour on paper. © Oxford University Museum of Natural History (HBM02-173).

Figure 9 John Phillips, *Sketch of the display cases with mezzanine level*, c.1858–1860. Ink on paper. © Oxford University Museum of Natural History (HBM02-047).

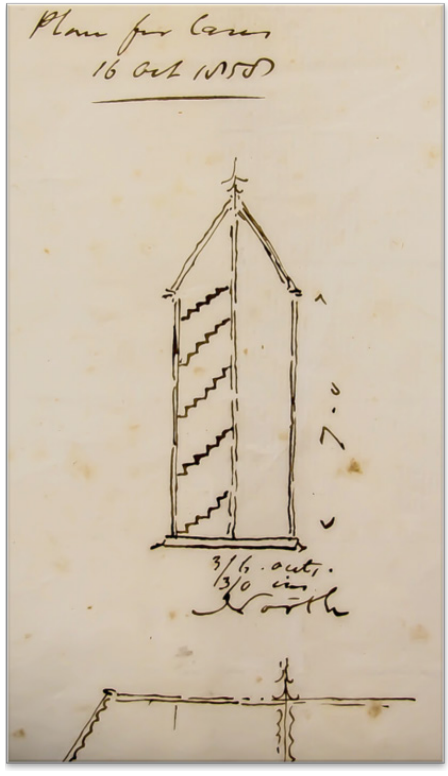

Figure 10 John Phillips, *Sketch of the 'plan for cases*, c.1858–1860. Ink on paper. © Oxford University Museum of Natural History (HBM08-008).

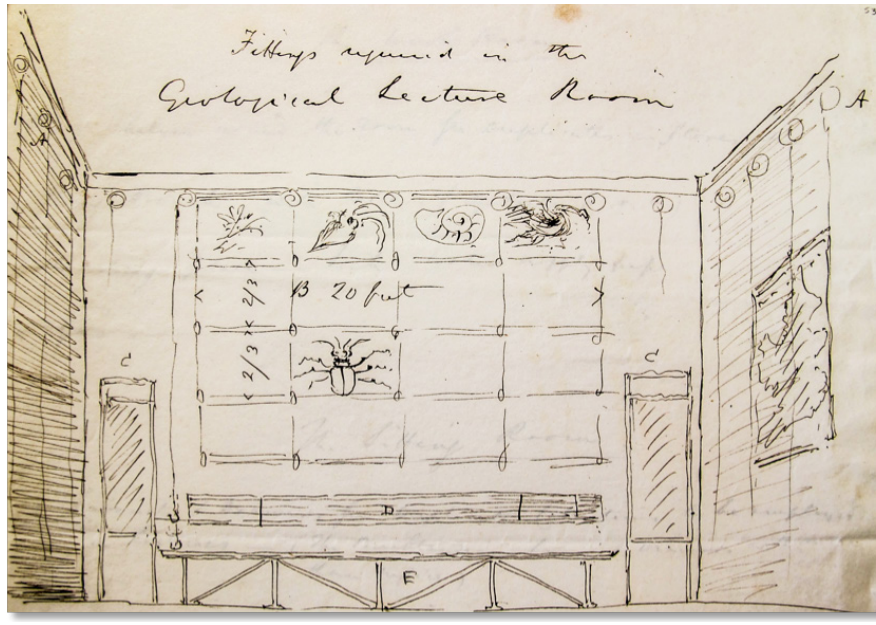

Figure 11 John Phillips, *Sketch of the fittings required in the Geological Lecture Room*, c.1858–1860. Ink on paper. © Oxford University Museum of Natural History (HBM02-049).

skeletons, unifying these elements into what could be perceived as an organic whole.[58]

Phillips's designs were, as contemporaries noted, 'adopted almost unchanged' and completed in a most 'workmanlike manner [. . .] to the entire satisfaction of the architect'.[59] He ordered bespoke wainscot paneling for the display cabinets. Wainscot paneling was specially designed to attach to an existing wall or frame, creating a wooden encasement.[60] It is quite possible that this frame was constructed of iron, a supposition I base on a letter written by Phillips in which he refers to it as the 'skeleton frame'.[61] In today's architectural language, the term 'skeleton frame' is defined as a 'structural frame of concrete, metal, or timber supporting the floors, roof, and exterior treatment; the spaces are filled with a lighter material or the entire structure is protected by an external cladding or curtain-wall, fixed inside or outside the frame'.[62] The term is also used to denote buildings of a substantial height, synonymous with the internal architecture of a skyscraper.

Figure 12 John Phillips, *Sketch for combining the new gallery display cases with the existing cases*, c.1858–1860. Ink on paper. © Oxford University Museum of Natural History (HBM02-048).

I cannot find reference to this term in joinery or architectural discourse at the time of Phillips's writing (circa 1860), but it does become a secularized term with the development of skeleton-frame construction towards the end of the nineteenth century. It would probably have been more appropriate for Phillips to have titled the cases 'ossatures', a combination of the two words in a single nineteenth-century French term, from the Latin *os*, meaning 'bone', and –ature, defined as the 'skeleton of a building, such as a frame or the ribs of a vault', which is still used in contemporary architectural discourse.[63] Yet I

Figure 13 John Phillips, *Sketch of a museum aisle, detailing the architectural columns, display cases and zoological specimens*, c. 1858–1860. Ink on paper. © Oxford University Museum of Natural History (HBM02-150).

believe that Phillips utilized the skeleton as a structural metaphor, possessing a rigid frame onto which materials such as fabric, cladding, paneling or glazing were added. The skeleton was made literal in the physical object of the wainscoted case. One particular drawing by Phillips, drawn in rust-coloured ink, illustrates the affiliation between the skeleton and frame (figure 13). There is no shading or crosshatching, only lines of varying pressure, heavy in the foreground and lighter in the background. The lines of the drawing create the sense of an architectural frame, with the roof arches arresting the eye and preventing it from escaping upwards out of the frame. Phillips's 'skeleton frames' are adroitly associated with the architecture in this drawing, as the shelves echo the horizontal architectural struts and the vertical elements reiterate the pillars. There is even a capped roof to one of the display cases, further enhancing the mimetic approach to an architectural building whilst maintaining a visual link to the Christian reliquaries of the past. In the central recess panel of the image, beneath the location of perspectival convergence, appear two people, their dress identifying them as a man and woman, in

front of a doubled-trefoil arch or window.[64] Three zoological skeletons are depicted above the cabinets lining the left-hand side – a winged, an antlered and a tusked mammal – their skeletons rendered by the closer concentration of architectural lines. Animal skeletons on architectural skeletons, within the museum skeleton. In this way, when osteological specimens are viewed within the cases, a mise en abyme effect is created, an awareness of which is indicated in Phillips's sketches. Thus, the sketch itself takes the form of what it represents – a framed skeleton of his ideas, onto which the fleshed-out details can be added later.[65]

The Museum's Iron Skeleton

From its conception, the OUMNH was a space in which metaphors became material, and skeletons of bones and skeletons of iron came together. The skeleton metaphor acted as a point of convergence between what would have been considered two diametrically opposed materials – bone and iron – both in terms of the skeletal specimen and the architectural skeleton of the museum.[66] The input of the various designers and architects could have created a building of disparate elements and fractured parts, yet the OUMNH was, and remains, a space of cohesions. In *The Poetry of Architecture* (1873), Ruskin wrote that his aim when appraising architecture was to draw attention to 'unity of feeling, the basis of all grace, the essence of all beauty'.[67] In the OUMNH, this unity was achieved through an organic articulation of its parts. For Ruskin, articulation was a part of organic growth, of establishing connections as a mode of achieving a unified perception of a living thing.[68] As growth is a condition of life, and the articulations are instruments of growth, then the points of articulation are temporal and spatial nodes full of the potential energy for further growth; and as articulated connections are made, the structure becomes physically and conceptually altered. A similar phenomenon occurs in skeletal articulation: when a bone is articulated with another bone, the two bones are conceptually altered from fragments into something larger, and with the potential to grow further.

The OUMNH was designed to embody the spirit of nature, for which the skeleton was the guiding concept. Ideally, the divisions between different surfaces and materials should be like that of living bone, a division showing organic metamorphosis. They would show an architectonic unity in the transformation of the mesenchyme into cartilage, into bone and into ligament,

at imperceptible faults of differentiation. Bone does not grow from its center, but from its ends – the epiphysis, from the Greek επίφυση, meaning to grow towards or upon – and it is at the epiphysis that bone transforms, grows and becomes articulated. Yet the lack of organic growing tissue in building construction makes such bio-architectonics unfeasible. Artificial articulations become essential. In the museum, the material chosen for this articulation was iron, due to its dual organic and inorganic resonance. As the points of iron articulation carried the potential to embrace an organic nature, they existed as faults of possibility between the materials of bone and iron. It is at these sites of articulation that skeletons were formed and choices made possible, choices for either an artificial or an organic architectonic interpretation, applicable in both the osteological specimen and in the building.

As metaphors work to bridge gaps in language, so too does iron articulate the gaps in the OUMNH's many skeleton forms, and the success of this articulation depends on the perception of a potential for life whilst retaining tectonic unity. The gaps in language, in architecture and in skeletons are the fertile ground from which potential interpretations can spring forth, as words, material and bones are articulated in such a way that they are perceived as natural and organic. The architects of the OUMNH wanted the organic to be the mode of their articulation. They began with skeletons, the essential parts, and attempted to find ways to organically unite them in the museum's design, architecture and displays. Phillips used a skeleton to unify and 'frame' his displays and specimens. He articulated his ideas through sketches of the museum space, which were made all the more profound by their multifarious and recursive nature, like a Russian nesting doll of skeletons (the specimens) within skeletons (the wainscoted cases) within skeletons (the museum's architecture). Ruskin proposed an organic 'nature' to articulate the Gothic, as evidenced by the structural and carved stone ornamentation, and this organic nature was enhanced by an organic appreciation of iron. The potential for iron to change, to oxidize, allows for a metaphorical growth of both the material and of the museum's visitors, who experience a shift in the way they perceive and interpret it.

Notes

I would like to thank the faculty of the History of Art Department at University College London, especially my PhD supervisor, Mechthild

Fend, for her invaluable support and guidance. My thanks to the Ruskin Research Centre for the *Stones of Venice* research grant and for allowing me to reproduce images from their collection. Particular thanks go to Stephen Wildman for his enlightening conversations and insights. I am grateful to Jen Shepherd and the curators at The Ruskin Library, Diane Tyler and Rebecca Patterson, for facilitating my research there. Thanks also to the OUMNH for granting permission to reproduce images from their archives. Funding for this project was generously provided by the University College London Provost's Research Studentship in the Humanities.

1 Donald MacAlister, 'How Bone is Built', *The English Illustrated Magazine*, vol. 1, 1883, pp. 640–649. MacAlister sketched loading vectors in a simple three-cornered rafter and applied the geometry to various materials, including steel, iron and bone. He also found a correlation between these loading vectors and the internal cancellous structure of the calcaneus.

2 Douglas Harper, 'Online Etymology Dictionary', 2001, http://www.etymonline.com/index.php?allowed_in_frame=0&search=skeleton (accessed 3 January 2016). The first recorded use of the word skeleton to denote the 'bare outline' dates from c. 1600. The skeleton, as the architectural frame for building, entered general architectural discourse in the late-nineteenth century. Its applied use beforehand would have been figurative, and it is generally believed that the term gained validation with the development of steel and concrete architecture, particularly in reference to skyscrapers.

3 Recent conservation at the museum, completed between 2013 and 2014, has seen the suspended whale specimens (relatively untouched for over 150 years) cleaned and repaired, with much of the iron and copper wiring used in the bone articulation replaced with stainless steel wires. Conservation was completed in early 2014. The whale specimens were redisplayed in early 2014, although not in the same order. See Gemma Aboe and Nicola Crompton, 'Whale Conservation Chapter Completed', *Once in a Whale*, Oxford: Museum of Natural History, 2013, https://onceinawhale.com (accessed 4 February 2016).

4 Neil McWilliam, 'A Microcosm of the Universe: The Building of the University Museum', *Oxford Art Journal*, vol. 1, no. 1, 1978, p. 23. Trevor Garnham remarks that 'standing beside one of the gigantic dinosaur skeletons, the visitor might alternatively have the sense of being inside the body of some great creature, the iron structure itself a kind of skeleton, the glass roof the scales', and draws a metaphorical comparison with the story of Jonah inside the whale. See Garnham, *Oxford Museum: Deane and Woodward*, London, 1992, p. 17.

5 Elizabeth Hallam, 'Articulating bones: an epilogue', *Journal of Material Culture*, vol. 15, no. 4, 2010, pp. 465–492, p. 467.

6 Aboe and Crompton, op. cit., https://onceinawhale.com (accessed 4 February 2016).

7 Acland's mission was to present the 'Art of the great Artificer'. See Henry W. Acland and John Ruskin, *The Oxford Museum*, London, 1859, p. 18.

8 See Frederick O'Dwyer, *The Architecture of Deane and Woodward*, Cork, 1997,

pp. 153–155. The prepared memorial states: 'We, the undersigned being officially connected with various Institutions for the advancement of Natural Knowledge in this University, are of the opinion that the several collections contained in the Geological museum in the Clarendon, The Ashmolean Museum, and the Anatomical Museum in Christ Church, are deposited in rooms of inadequate dimensions, and inconvenient arrangement, and that their present efficiency and future progress are by these means retarded' (for full letter, see p. 154). Quote taken from OUMNH archival document, 'Meeting of Convocation', 1 May 1849, MS. Acland, *Papers of OUNHM*, History of the Museum, box 2. Acland submitted a letter for Convocation, signed by his fellow science professors, outlining their aspirations for the study of science at Oxford. William Buckland's signature is conspicuously absent. See OUMNH archival document, 'Letter for Convocation by Acland', 1 May 1849, MS. Acland, *Papers of OUNHM*, History of the Museum, box 2.

9 Popularity in the study of Natural Philosophy and Theology had been steadily increasing since the beginning of the nineteenth century. Historian Horace Vernon considered the increased curiosity in nature to have been stimulated by the publication of William Paley's *Natural Theology: or, Evidences of the Existence and Attributes of the Deity*, London, 1809. As popularity increased, so did the university's collections. See Horace M. Vernon and K. Dorothea Vernon, *A history of the Oxford Museum*, London, 1909, p. 36, p. 40, p. 43.

10 John Ruskin, *On the Nature of Gothic Architecture: And Herein of the True Functions of the Workman in Art*, London, 1853, taken from E.T. Cook and A. Wedderburn, *The Complete Works of John Ruskin*, Library Edition, (39 vols.), vol. X, London, 1903–1912, Chapter 6, pp. 180–269.

11 Stephen Kite, 'Building Texts + Reading: Metaphor, Memory, and Material in John Ruskin's *Stones of Venice*', *Library Trends*, vol. 61, no. 2, 2012, pp. 418–439, pp. 422–426.

12 Ruskin and the Pre-Raphaelite Brotherhood advocated realism in art and Gothic architecture, which may have tempered the romantic feelings invoked by medieval Gothic ruination. This thirst for realism is also discernable in the changing genres of literature and the public's growing taste for 'realistic fiction' at this time. See M. Gamer, *Romanticism and the Gothic: Genre, Reception and Canon Formation*, Cambridge, 2006. See also J. P. Stern, *On Realism*, London, 1973.

13 Ruskin, *On the Nature of Gothic Architecture: And Herein of the True Functions of the Workman in Art*, London, 1853, op. cit.

14 Art historian and archeologist Charles Waldstein (1856–1927) wrote a book dedicated to Ruskin's influence on the British public. In Waldstein's opinion, Ruskin contributed immensely to 'the general advance in the intellectual and social life of England' and was 'an active factor in producing a change in the more special sphere of art [. . .] bringing about a diffusion of the taste for art among the classes'. See C. Waldstein, *The Work of John Ruskin: Its influence upon modern thought and life*, London, 1894, p. 14.

15 Augustus W. N. Pugin, *Contrasts; and the true principles of pointed or Christian architecture (1836)*, London, 2003; Nikolaus Pevsner, *Some Architectural Writers of the Nineteenth Century*, Oxford, 1972, pp. 103–122.

16 For a general overview of the history of neo-Gothic architecture in Europe, see Barry

Bergdoll, *European Architecture 1750–1890*, Oxford, 2000, pp. 142–170. Bergdoll highlights William Wilkins's proficiency in both Classical and Gothic design, in ibid., pp. 55–56. Nikolaus Pevsner presents some of the most influential architectural theorists of the nineteenth century, including Rickman and Ruskin. See Pevsner, op. cit., pp. 28–35, pp. 139–156. Also see Thomas Rickman, *English Architecture: An attempt to discriminate the styles of English Architecture from the Conquest to the Reformation*, London, 1835, pp. 37–120.

17 Eve Blau, *Ruskinian Gothic: The Architecture of Deane and Woodward 1845 – 1861*, Princeton, 1982, p. 51. O'Dwyer notes that there was no building style stipulated or any architectural style imposed, 'but architects should bear in mind that elegance of interior arrangement will be judged more essential than exterior decoration'. See O'Dwyer, op. cit., p. 166.

18 The opinions of the various competition judges on the submitted architectural designs are outlined by O'Dwyer in ibid., pp. 166–173. There may have been possible 'back-stage' manoeuvering by Acland to have Deane and Woodward's design selected (see pp. 173–176). Vernon and Blau assert that the museum was designed in the Rhenish-Gothic style, although Carla Yanni and Barry Bergdoll describe it as Venetian Gothic, and O'Dwyer identifies it as Veronese. See H. Vernon and K. Dorothea Vernon, op. cit., pp. 55–58; Blau, op. cit., p. 52; C. Yanni, *Nature's Museums: Victorian Science and the Architecture of Display*, New Jersey, 2005, p. 71; Bergdoll, op. cit., p. 215; and O'Dwyer, op. cit., p. 180. The design's Latin title translates as 'Unless the Lord built the house', extracted from the book of Psalms, Chapter 126, meaning that nothing can be done without God's blessing: 'Unless the Lord build the house, they labour in vain that build it. Unless the Lord keep the city, he watcheth in vain that keepeth it'.

19 Eve Blau discusses Ruskin's direct and indirect influence upon the architectural team of Deane and Woodward. By comparing architectural sketches by Woodward with Ruskin's drawings from *The Stones of Venice*, which look remarkably similar, Blau argues that the Gothic buildings designed by the architectural duo (including the OUMNH and Trinity College Museum, Dublin) are examples of a new 'Ruskinian Gothic'. See Blau, op. cit., pp. 27–81.

20 Ruskin and Virginia Sutees (ed.), *Reflections of Friendship: John Ruskin's Letters to Pauline Trevelyan 1848–1866*, Virginia Surtees (ed.), London, 1979, pp. 94–95. The letter is dated Thursday (probably 13 or 14 December 1854), the day after the results of the museum's design competition were announced.

21 Ruskin first published his Gothic tenets in *On the Nature of Gothic Architecture: And Herein of the True Functions of the Workman in Art*, London, 1853, op. cit. Also see Acland and Ruskin, op. cit., pp. 50–51: 'We desire (A) to make art large and publically beneficial, instead of small and privately engrossed or secluded; (B) to make art fixed instead of portable, associating it with local character and historical memory; (C) to make art expressive instead of curious, valuable for its suggestions and teachings, more than for the mode of its manufacture'. For Acland, the term 'nature' includes 'every known and observed form of matter by which our world and its inhabitants were either made or are maintained, and whatever laws of their construction or for their maintenance have by reason been inferred' (p. 18).

22 Garnham, op. cit., p. 5. Warwickshire stones were also used in the interior court. See O'Dwyer, op. cit., p. 180, p. 196.

23 Ruskin, *The Stones of Venice*, vol. 1 & 2, taken from Cook and Wedderburn, *The Complete Works of John Ruskin*, op. cit., vol. IX, p. 81, p. 323, p. 397; vol. X, p. 57. Also see Blau, op. cit., p. 59. O'Dwyer notes that the museum's stone polychromy was a later modification of the original Gothic design, proposed by Woodward in 1856. The contrasting bands of colour are not strictly in keeping with Veronese polychromy, which was comprised of contrasting stone and brickwork, and not colour. O'Dwyer, op. cit., pp. 180–181, pp. 194–195.

24 O'Dwyer, in ibid., p. 194.

25 See Acland and Ruskin, op. cit., pp. 21–22: 'Without the Geologist on one side, and the Anatomist and Physiologist on the other, Zoology is not worthy of its name. The student of life [. . .] will find in the collections of zoology, combined with the Geological specimens and the dissections of the Anatomist, a boundless field of interest and of inquiry, to which almost every other science lends its aid: from each Science he borrows a special light to guide him through the ranges of extinct and existing animal forms, from the lowest up to the highest type, which, last and most perfect, but pre-shadowed in previous ages, is seen in Man'.

26 J. C. Prichard, 'On the Cosmogony of Moses; with some preliminary Observations on Dr. Gilby's Communication in Number 209', *The Philosophical Magazine and Journal*, vol. 46, no. 212, 1815, pp. 285–290. Also see Charles Lyell, *Principles of Geology: Being an Attempt to Explain the Former Changes of the Earth's Surface, by Reference to Causes Now in Operation*, London, 1830–1833.

27 James Ussher, *The Annals of the Old Testament*, London, 1650, p. 1. The Rev. James Ussher (1581–1656) is generally credited for establishing the day of creation as 'the entrance of the night preceding the 23rd day of October [. . .] the year before Christ 4004'.

28 There is evidence that Acland supported the 'archetype' interpretation of fossils, as indicated by some of his handwritten margin notes that I discovered in his copy of Richard Owen's *On the Nature of Limbs: A Discourse Delivered on Friday, February 9, at an Evening Meeting of the Royal Institution of Great Britain*, London, 1849. Acland's copy is currently housed at the Wellcome Library, Euston Road, London. Ruskin's struggles with (and eventual loss of) his evangelical beliefs are more widely documented. It is believed that this was attributed to the advances in the field of geology and the development of the fossil record.

29 Jacqueline Fearn, *Cast Iron*, Buckinghamshire, 2001, p. 20. It is unsurprising that the first recorded building with an iron-frame structure was Bage's flax mill, built in Shrewsbury in 1796, as mills were highly susceptible to fire damage.

30 Ibid., p. 14.

31 Acland and Ruskin, op. cit., p. 51.

32 In terms of the russet colours and stenciling on the ironworks, Jones and Wickham credit this process to Francis Skidmore: '[H]e almost certainly created the colorful stenciling on the columns at the Oxford University Museum'. See H. Jones and A. Wickham, 'Francis Skidmore: A Coventry Craftsman', *Coventry Arts and Heritage*, 2003, pp. 3–8. O'Dwyer writes that it was Skidmore's idea to paint the metals in the colour of their oxides, which would add credence to my argument for the 'organic' iron skeleton. See O'Dwyer, op. cit., p. 265. Also see H. Vernon and K. Dorothea

Vernon, op. cit., p. 81, who write that the ironwork fell short of expectation, partly due to the 'unpleasant tints with which it has been painted; though, if a suggestion which was made at the time of imitating the natural colouring had been carried out, the results must have been far more tragic'.

33 In 1858, Ruskin gave a lecture on the vitality and vibrancy of iron in Tunbridge Wells. This lecture was later published as an essay. See Ruskin, 'Lecture V – The work of iron, in nature, art and policy', in *The Two Paths*, *essays by John Ruskin*, taken from Cook and Wedderburn, *The Complete Works of John Ruskin*, op. cit., vol. XVI, pp. 375–411, p. 379.

34 Ibid., p. 378.

35 Thomas Carlyle, 'Signs of the Times', *The Edinburgh Review*, vol. 49, 1829, taken from *The Collected Works of Thomas Carlyle*, London, 1858, p. 99. Also see 'Characteristics', *The Edinburgh Review*, vol. 54, 1831, taken from Carlyle, *Characteristics*, Vest-Pocket Series of Standard and Popular Authors, Boston, 1877, p. 44, p. 65.

36 Roden Noel, 'On the use of Metaphor and "Pathetic Fallacy"', in *The Fortnightly Review*, Vol. 5, 1 August 1866, pp. 670–684.

37 Ruskin's comment regarding 'the black skeleton and blinding square' was made during an address to the Members of the Architectural Association on 23 January 1857, and is published in 'Lecture IV: Influence of Imagination in Architecture', in *The Two Paths*, *essays by John Ruskin*, taken from Cook and Wedderburn, *The Complete Works of John Ruskin*, vol. XVI, London, p. 349. For Ruskin's comments regarding Crystal Palace, see the pamphlet *ARTIII: Architecture – The opening of Crystal Palace*, 1854, printed in Cook and Wedderburn, *The Complete Works of John Ruskin*, op. cit., vol. XII, pp. 417–432. Ruskin was perhaps more vehement in his appraisal of the building due to his mounting anger at the treatment of the Turner Bequest, which was languishing, unseen, 'left to decay in a dark room near Cavendish Square'. Ibid., p. 420. See O'Dwyer, op. cit., p. 257. O'Dwyer draws attention to the fact that Ruskin was involved in the OUMNH's construction right up until it opened, refuting the myth that he had previously resigned due to his disapproval of iron. Although Ruskin does criticize the museum's roof, in particular Woodward's agreement to use iron, his criticism was written much later, in 1877. With regards to Ruskin's criticism of the iron roof, Michael Brooks has written that Ruskin projected 'backwards his later dislike of iron'. During the period of the OUMNH's construction, 'his attitude was more ambivalent and interesting'. Michael Brooks notes that Ruskin's remarks were made in a letter to the Revd. Richard St. J. Tyrwhitt in 1877. See Michael Brooks, *John Ruskin and Victorian Architecture*, New Brunswick, 1987, p. 31.

38 Ruskin, 'Lecture V – The work of iron, in nature, art and policy', in *The Two Paths*, *essays by John Ruskin*, taken from Cook and Wedderburn, *The Complete Works of John Ruskin*, op. cit., vol. XVI, p. 384.

39 Ruskin wrote the poem 'Chamouni' in 1833, when he was but 14 years old. See Ruskin, 'On tour on the continent', in *Poems*, London, 1891, taken from Cook and Wedderburn, *The Complete Works of John Ruskin*, op. cit., vol. II, p. 381.

40 Ruskin, 'Poem: A tour through France, Canto 1 stanza 29', in ibid., pp. 396–416. Quote taken from p. 407. This is a poem by Ruskin about the geological forms and mountains of France, which makes reference to the form of the mountain as a skeleton.

41 Ruskin, *Modern Painters*, vol. 4, ch. XIV, taken from Cook and Wedderburn, *The Complete Works of John Ruskin*, op. cit., vol. 6, p. 239.

42 See Mark Frost, 'The Everyday Marvels of Rust and Moss: John Ruskin and the Ecology of the Mundane', *Green Letters*, vol. 14, 2011, pp. 10–22.

43 Ibid., p. 11.

44 Nikolaus Pevsner and Lars Spuybroek are amongst the architectural historians who affirm Ruskin's dislike of iron as a material of construction. See Pevsner, *Ruskin and Viollet-Le-Duc: Englishness and Frenchness in the Appreciation of Gothic Architecture*, Walter Neurath Memorial Lecture, London, 1969, pp. 33–34; and Spuybroek 'Steel and Freedom: In conversation with Arjen Mulder', *The Architecture of Continuity: Essays and Conversations*, Rotterdam, 2008, p. 268.

45 The confirmation of iron as a component of blood in the early-nineteenth century generated significant interest from scientists who wished to fully comprehend the composition and properties of blood. They tested extensively, creating treatments using ores and magnets. The red blood cells were osmotically burst and the iron extracted and tested. It was discovered that the quantity of iron in the blood cell varied between species. See J. T. Edsall, 'Blood and Hemoglobin: The Evolution of Knowledge of Functional Adaptation in a Biochemical System', *Journal of the History of Biology*, vol. 5, no. 2, 1972, pp. 205–257. Since the identification of galvanistic forces in the late-eighteenth century, an arms race in magnetic experimentation occurred. One experiment by Ludwig Achim von Arnim in 1800 utilized iron caps, or *armatures* on the poles of a magnet to deduce if there was a variable iron oxidation rate between the poles. See R. Martins, 'Ørsted, Ritter, and Magnetochemistry' in R. M. Brain, R. S. Cohen and O. Knudsen (eds), *Hans Christian Ørsted And The Romantic Legacy In Science*, Dordrecht, 2007, pp. 339–85. Also see E. Sabine, 'Report on the Variations of the Magnetic Intensity Observed at Different Points of the Earth's Surface', *British Association for the Advancement of Science*, vol. 6, 1837, pp. 1–87; and D. E. Hughes, 'The Cause of Evident Magnetism in Iron, Steel, and Other Magnetic Metals', *Journal of the Society of Telegraph-Engineers and Electricians*, vol. 12, no. 49, 1883, pp. 374–400.

46 A. Guenyveau, 'Report on the Use of the Hot Air Blast in Iron Furnaces and Foundries', *Journal of the Franklin Institute*, vol. 17, no. 5, 1836, pp. 354–62; W. Fairbairn, 'On the Strength and Other Properties of Cast Iron Obtained from the Hot and Cold Blast', *British Association for the Advancement of Science*, vol. 6, 1837, pp. 377–417; W. Wood, 'Progress of Practical and Theoretical Mechanics and Chemistry: Hot Air Blast', *London Mining Journal*, vol. 19, 1837, pp. 348–51; J. M. Heath, 'Improvements in the Manufacture of Steel', *Journal of the Franklin Institute*, vol. 50, no. 5, 1850, pp. 338–40; and C. M. Du Puy, 'On the Direct Process of Making Wrought Iron and Steel', *Journal of the Franklin Institute*, vol. 104, no. 6, 1877, pp. 377–388.

47 Ruskin, 'Lecture V – The work of iron, in nature, art and policy', taken from Cook and Wedderburn, *The Complete Works of John Ruskin*, op. cit., vol. XVI, p. 394.

48 Ruskin, *The Seven Lamps of Architecture*, 1849. Architecture surpasses mere building through the use of ornamentation, those 'certain characters venerable or beautiful, but otherwise unnecessary'. Taken from Cook and Wedderburn, *The Complete Works of John Ruskin*, op. cit., vol. XIII, pp. 28–29. For the ornament to be considered 'high art', it must be founded on knowledge of nature. Ibid., p. 11.

49 James Hutton, *Theory of the Earth, with Proofs and Illustrations*, vols I & II, Edinburgh, 1795. Garnham also perceived the relationship between the fossil specimens and the stones of the building: 'Skeletons resonate with structure, fossils emerge delicately from solid stone as the past encapsulated and living plants were frozen in stone'. However, this is the limit of his observations. See Garnham, op. cit., p. 18.

50 Acland and Ruskin, op. cit., p. 17, p. 37. Twice Acland paraphrases Sir Thomas Browne's famous quote 'nature is the art of God' from *Religio Medici*, 1643.

51 Caroline van Eck, *Organicism in Nineteenth-century Architecture: An inquiry into its theoretical and philosophical background*, Amsterdam, 1994, pp. 126–130.

52 Philip Steadman, *The Evolution of Designs: Biological Analogy in Architecture and the Applied Arts*, Cambridge, 1979, pp. 31–33. In terms of the correlation of parts, Georges Cuvier believed that he could conceive an entire skeleton from a single bone. The Rational Gothic architects interpret a structure in the same manner – from one cross-section you can conceive the architectural members, then the whole monument. The work of Georges Cuvier in the field of Comparative Anatomy profoundly influenced the work and writings of architect Viollet-le-Duc (1814–1879) in France during the mid- to late-nineteenth century. See Eugène Emmanuel, 'Viollet-le-Duc', *Dictionnaire raisonné de l'architecture française du XIe au XVIe siècle*, Caen, 1869.

53 Although Steadman dedicates an entire chapter of his book to the animal skeleton in architectural theory, his level of engagement is primarily methodological. Steadman examines Cuvier's theory of 'the correlation of parts', and the influence of Cuvier's comparative method on nineteenth-century architects such as Viollet-le-Duc and Gottfried Semper. He flatly refuses to engage with the skeleton on a metaphorical level, stating that the skeleton metaphor is simply a 'naïve expression' of the obvious structural resemblance between the animal's internal support structure and the architectural framework. Steadman, op. cit., 'The anatomical analogy – Engineering structure and the animal skeleton', ch. 4, pp. 31–51, p. 39.

54 Acland and Ruskin, op. cit., p. 18. The quote is a direct reference to the biblical phrase from 1 Corinthians 13:12 (King James Version): 'For now we see through a glass, darkly; but then face to face: now I know in part; but then shall I know even as also I am known'. Acland repeats this sentiment again on p. 43: '[A]nd in many succeeding generations, when we are long forgotten, may young minds be here freshly learning and warmly loving the things which they may be allowed to perceive as in a mirror, dimly'.

55 O'Dwyer, op. cit., p. 200. For a detailed discussion of Phillips's contributions to the field of geology, see J. Morrell, *John Phillips and the Business of Victorian Science*, Hants, 2005.

56 Acland and Ruskin, op. cit., pp. 93–102.

57 See H. Vernon and K. Dorothea Vernon, op. cit., p. 77, p. 79, pp. 82–83. Davies and Hull, op. cit. The new collection was an amalgamation of various College collections, such as Lee's, as well as others from the anatomy school at Christ Church, which took upwards of six years to relocate. Once the museum was up and running, donations poured in from various sources, in large part due to the museum's facilities and space for specimen display. Authors such as the architectural historian Carla Yanni praise Phillips's contribution to the 'polished statement of national pride' found in the column

shafts of British and Irish stone, drawing attention to the didactic dimension of the stone columns' chronological and type-based arrangement, which cunningly enabled the geological specimen to be 'built into the fabric of the museum'. At Oxford, she adds, 'while the carved stone capitals represented natural specimens, the stone column shafts actually *were* natural specimens'. Yanni, op. cit., pp. 82–83. Also see O'Dwyer, op. cit., pp. 223–230, who mentions Phillips's contributions in the carved capitals, cobles, masonry piers and polished stone shafts.

58 OUMNH archival document, Booklet titled 'Statement of the requirements of the Oxford University Museum, and Plan of the Site (1854); Prepared for the use of Architects by the Delegates who were appointed in Convocation held on 8 April 1854, for the purposes of obtaining Designs and Estimates from Architects, of examining and selecting from them, and of reporting thereon for the approval of the House', *Papers of the OUMNH*, History of the Museum, box 5. Also see Morrell, op. cit., p. 310. Phillips's supposedly amenable personality has led Morrell to consider Phillips as a unifying figure in the successful construction of the museum, by preventing 'the personal and departmental friction and jealously which could have so easily marred its early years'. Ibid., p. 307.

59 Ibid., p. 316. Morrell observes that Phillips's designs were 'adopted almost unchanged'. Also see OUMNH archival document, 'Quote from Jackson and Graham Interior decorators, 31 January 1862, Specification letter for the Wainscot cases', *Papers from the OUMNH*, History of the Museum, box 2. This letter details that the work was carried out 'in a workmanlike manner [. . .] to the entire satisfaction of the architect'.

60 C. Soanes and S. Hawker, *The Compact Oxford Dictionary of Current English*, New York, 2005, p. 1168. Wainscot is a type of wall paneling applied to the lower portion of a room's wall, typically made with historical imported oak. The term can either be indicative of the paneled area (singular) or the wood used in paneling (mass noun, which dates from the early-nineteenth century).

61 OUMNH archival document, 'Letter to cabinetmakers in which skeleton frame is mentioned several times', M.S. Phillips, *Papers of the OUMNH*, History of the Museum, box 7.

62 For the definition of 'skeleton frame', see J. S. Curl, *A Dictionary of Architecture and Landscape Architecture*, Oxford, 2006, p. 718.

63 For the nineteenth-century French definition of 'ossature', see J. C. Laveaux, *Nouveau Dictionnaire de la Langue Française*, vol. 2, Paris, 1820, p. 291: 'L'ensemble des os. Il se dit aussi, en terme d'architecture, des parties qui lient un édifice'. Also see E. Littré, *Dictionnaire de la langue française*, vol. 3, Paris, [n.d], c.1880, p. 870: 'Terme didactique. L'ensemble des os, la charpente d'un homme ou d'un animal. Ce qui lie entre elles les différentes parties d'un ensemble comparé au corps d'un animal. De l'amoncellement des carapaces calcaires des infusoires se composent les plus vastes assises de l'ossature terrestre. L'ossature de notre langue.'

64 The abstract 'skeleton' structure of the two figures emphasizes the architectural elements of Victorian fashion, particularly corsetry. The majority of Victorian corsets were comprised of a metal and whalebone framework encased in cloth, with busks and stays drawing the torso inward and the breasts upwards. Hoops were added to the underskirt to create volume and accentuate the waist. Leigh Summers discusses the role

of the corset in 'articulating an appropriate Victorian femininity', in *Bound to Please: A History of the Victorian Corset*, Oxford, 2001, p. 5.

65 Steadman detects comparable characteristics between objects (including buildings) and the way they are designed, their modes of individual and cultural production, which 'lend themselves particularly well to description and communication via biological metaphor'. Steadman, op. cit., p. 4.

66 Bone is plastic, continuously being destroyed and remade within the living body in a process known as remodeling, allowing for adaptability. See D'Arcy W. Thompson, *On Growth and Form*, Cambridge, 1917. The compact bone of the long bone is notably thicker at the midpoint of the diaphysis, where the 'danger-point' of bending would reside, but this 'has been avoided, and the thickness of the walls becomes nothing less than a diagram, or "graph", of the bending-moments from one point to another along the length of bone'. Ibid., p. 227.

67 Ruskin, *The Poetry of Architecture: or, The architecture of the nations of Europe considered in its association with natural scenery and national character* (1873), taken from Cook and Wedderburn, *The Complete Works of John Ruskin*, op. cit., vol. I, p. 4.

68 Ruskin described the two types of organic articulation in *Proserpina* (1875–1886). They are the leaf-stem articulations seen in flora and the joints in the endo- and exoskeletons of various fauna. In plants such as canes, the articulations between the parts provide strength. The joints become stiff, allowing for the cane to grow taller, to support its weight and withstand external environmental forces. On the other hand, the articulating parts in the animal, its joint, are points of flexibility and allow for muscle movement. See Cook and Wedderburn, *The Complete Works of John Ruskin*, op. cit., vol. XXV, pp. 324–325.