Victorian Literature and Culture (2011), **39**, 367–383.

doi:10.1017/S1060150311000040

"THE CIRCLES OF VITALITY": RUSKIN, SCIENCE, AND DYNAMIC MATERIALITY

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THE DAYS HAVE PASSED IN which John Ruskin's scientific writings were deemed secondary and separate to his art, architecture, or politics, but his science still tends to be viewed predominately via the prism of his later natural history, with its characteristically virulent opposition to Darwin and materialism, and in relation to his application of typological exegesis to landscape study. I would argue that an approach is required that situates Ruskin's response to Darwin against the background of his entire career in scientific writing and that seeks to clarify the relationship between the various influences which informed his engagement with environment. While this article cannot pursue such an analysis in full, it outlines some key reasons for its necessity. Through examination of significant 1843 correspondence and related works, I will call in particular for a re-evaluation of the degree to which Ruskin engaged in modern scientific methods and approaches. In doing so, I will suggest that Ruskin's later anti-materialism did not represent a seamless continuation of a long-established attitude to science and nature, but something of a discontinuity, in which, faced with the implications of evolutionary theory, he attempted to reject not just Darwinism, but many of the elements that had made his own work in science distinctive, convincing, and attuned to modernity, materiality, and process.

The Critical Environment

WHILE JONATHAN SMITH'S *Charles Darwin and Victorian Visual Culture* (2006) continues a welcome resurgence in literary studies of Darwin, it is also an adept analysis of Ruskin's response to evolutionary theory. Building on previous work, Smith adds to current thinking by demonstrating that Ruskin's later natural histories responded directly and in a sophisticated manner to specific aspects of Darwin's writings, rather than representing a general attack on materialist science. Recognising the claims of Frederick Kirchhoff and Dinah Birch that Ruskin's dissent from Darwinism articulated antipathy to materialism in all forms, Smith also identifies "the degree to which Darwin's science challenged the very basis of Ruskin's aesthetics" (27). The theory of sexual selection was unacceptable to Ruskin due to its

sexualisation of organic life, but also because of its suggestion that "human art, human art criticism, and human art critics [were] all enfolded into an evolutionary genealogy" in which "even the human aesthetic sense is shared by and inherited from animals" (Smith 134).

In tracing the specifics of Ruskin's response to Darwinian ideas, Smith naturally concentrates on the period after 1871, rather than trying to analyse the place of Ruskin's later views in the broader context of a career in natural history that can be traced back to 1843, but a sense of periodisation can be discerned in his remarks. Smith contrasts the sections on nature in *Modern Painters* (1843–60, 5 vols.) which "often read more like disquisitions on optics, botany, meteorology, and geology, than on art," and later work which "seems strangely, even deliberately, anti-scientific" (26). I would like to explore the possibility that Ruskin's science has not yet been adequately periodised. Many studies imply that Ruskin's development largely represented continuity rather than discontinuity, and that his notoriously virulent attacks on Darwin were motivated by a shifting scientific climate after 1859; and that in effect Ruskin's position remained stable while the scientific world changed around him. For one of Ruskin's most influential critics, J. D. Rosenberg, Ruskin was a "pseudo-scientist" who failed to understand basic scientific methods, and whose nature texts merely exhibited "Ruskin's delight in his own virtuosities of observation and of prose" (4). Robert Hewison locates Ruskin's natural history simultaneously within the traditions of Romanticism, Natural Theology, and Evangelicalism, without considering the tensions that existed between their divergent conceptualisations of nature. Hewison's analysis of "the scientific practice current during Ruskin's early years," a practice that fostered "walking, drawing, collecting, [and] listing" describes an essentially eighteenth-century, natural theological mode of engagement designed to reveal a designed creation (20). Ruskin's "increasing intellectual isolation" (Rosenberg 181) was revealed as "science advanced beyond the descriptive and classificatory phase, and began to reveal a very different picture, in which blind forces struggled ruthlessly for domination in a world without God" (Hewison 20). James Clark Sherburne suggests that Ruskin forged a Romantic organicism characterised by "failure to emphasize the aspect of organic growth" and "divested of its dynamic implications and restricted to the surface of things" (10). Reinforcing the notion that Ruskin was always a relict of eighteenth-century thought, Sherburne insists that "his interest is not in origins, internal structure, or processes of growth but in the present appearance of nature" (11–12). While the work of these influential critics is far from new, their approach continues to echo in recent studies. In a 2007 article, Roger Cardinal describes the early Ruskin as "a species of late Romantic prone to slide from quasi-scientific observation to poetic conjecture and aesthetic appraisal" (165), while in the same year Howard Hull describes Ruskin's late work as "a deliberate re-affirmation of a romantic ideal in the face of an increasingly material culture" (216). As I hope to show, examination of Ruskin's early scientific practice confounds claims that Ruskin's science was merely an outgrowth of unscientific Romanticism, or a purely descriptive endeavour concerned only with surface forms, and inattentive to process. While it would be absurd to classify Ruskin as a materialist, if the term is taken to indicate a commitment to the prime authority of material explanations of phenomena, critical thought needs to acknowledge Ruskin's understanding of what I would describe as the dynamic materialities of environment, and his engagement with modern trends in science that would ultimately lead to the twin sciences of evolutionary theory and ecology.

In what follows, I will insist on the need to reexamine Ruskin's early natural history in order to recognise those aspects that were attuned to contemporary developments in science;

and to highlight areas in which Ruskin's early work conflicts both internally and with the more straightforwardly anti-materialist stance of the 1870s and 80s. Despite a welcome critical re-evaluation during past decades of Ruskin's science, very few critics – Patrick Conner, Jeffrey Spear, Raymond Fitch, and Sheila Emerson are the most prominent – have argued for Ruskin's place in modern science. The valuable work of Francis O'Gorman and Dinah Birch has done much to situate Ruskin's later science in a range of cultural, educational, and biographical contexts, and suggests that Ruskin's anti-materialism need not necessarily classify him as a writer who was entirely alientated from modernity, but critical efforts have not in general been directed towards comparison of earlier and later science writings, and recent studies reinforce the suggestion that Ruskin was always a scientific conservative.

In a 2008 article, Van Akin Burd argues that from 1837 Ruskin was a disciple of renowned Natural Theologian and Catastrophist, the Reverend William Buckland (299). Seeking to analyse Buckland's impact on Ruskin's geology, he contends that Ruskin endorsed Buckland's view that geology demonstrated divine design, and that a non-literal reading of Genesis could conform to the investigations of science. Echoing Hewison (23), Michael Wheeler (182), and Michael W. Brook (13), Burd claims that Ruskin accepted Buckland's argument that the "days" of the Mosaic account of creation could be interpreted as undefined extensive periods. He also deems it significant that before 1843 Ruskin was not exposed to the dissenting Uniformitarism of Charles Lyell. Lyell argued that the present condition of the Earth was not, as Catastrophists insisted, due to the Biblical flood, but instead the result of the steady continuation of geological processes of deposition and erosion over countless millennia (304, 299–300). But as this article will show, Ruskin used Lyell's theories in order to critique the Mosaic account in a manner that suggested disquiet with Buckland's approach, and which is symptomatic of a consistent pattern of engagement with modern science.

Another important layer of critical response to Ruskin's science has come in the form of readings which have rightly located Ruskin firmly in the tradition of Evangelical exegesis. Building upon and responding to the work of George P. Landow, C. Stephen Finley and Wheeler write against a critical tradition that characterises Ruskin's Evangelicalism as "a pronounced anachronism" (Finley 90), and that offers apologia for his early sectarianism. Instead, Finley and Wheeler spurn a secular, post-Victorian reading, "take to heart the task of making the argument from the Evangelical side," and trace the manner in which Ruskin applied typological exegesis to all endeavours, including his nature studies (Finley 11, 7). The importance of Finley's work to a clearer understanding of the impact of Evangelical methods on Ruskin's natural history cannot be understated. Even so, there are potential pitfalls in his approach. Finley accepts "the creative and certainly ambitious character" of Ruskin's appeal "to the common ground between the generally denominated 'sense of something far more deeply interfused,' which is the Wordsworthian basis for both a humane faith and a human psychology, and the distinctively Christian thought, the Calvinist deposit, of his Evangelical religion." However, Finley also suggests that Ruskin successfully "reads the book of nature anew, in the light of Calvin and Wesley" in a manner that involves "a truth claim for the correspondence to be found between romantic nature and the specific typological maneuvers of Reformed and Evangelical hermeneutics" (28). There is indeed a shared anthropocentric basis in both Evangelical and Romantic approaches to environment, and a shared commitment to reading nature for cultural and moral signifiers, but Finley's approach neglects potential tensions between an Evangelical tendency to view post-Edenic nature as a site of moral corruption, and an almost pantheistic celebration in Romantic poetry of a nature that seems

at times to be conflated with or to stand in the place of God as a source of meaning. To argue that Ruskin's attempt to conjoin these two powerful mediating mechanisms was achievable without serious consequences becomes less tenable still when one adds to the list of Ruskin's influences his engagement with modern science. This article will explore Ruskin's attempts to create a stable synthesis of this highly volatile admixture of influences, and will be much more sceptical than previous critics about the consequences of aspiring to do so.

A further point must be made in relation to the kind of exegetical criticism pursued by Finley and Wheeler. Despite the need to locate Ruskin's responses to landscape in an inherited typological tradition, the tendency of the exegetical school to privilege the Evangelical basis of Ruskin's engagements with environment may be problematical in a further sense. To see Ruskin primarily as a writer who sought to decode the cultural, moral, and religious typologies of landscape is to underplay his application of modern scientific techniques to that endeavour; to support characterisations of Ruskin as essentially unscientific; and to reinforce the impression that his response to nature rested on stable foundations. While I will argue that this was certainly not the case, the answer is not to overplay in response the significance of Ruskin's immersion in modern science. Rather, Ruskin's works may reveal more once their internal contradictions are acknowledged, and once they are defined as a site of extreme instability. If an attempted synthesis of Romanticism, Evangelicalism, and science is recognised as unworkable in the long term, there is no possibility of closing the Ruskin text, of limiting its meanings, or tidying up its contradictions. Instead, one must study the manner in which these contradictions generated and multiplied inherent tensions, leading ultimately to a situation in which the pressures of a post-Darwinian environment revealed Ruskin's synthesis to be unsustainable.

In an example of one of Ruskin's responses to a specific passage in Darwin, Smith (167–68) calls attention to Darwin's claim in *Orchids* (1877) that "the final end of the whole flower . . . is the production of seed" (27: 194). In responding to this materialisation and functionalisation of floral forms, Ruskin countered in his own botanical primer, *Proserpina* (1875–86, 2 vols.), that "the flower exists for its own sake, – not for the fruit's sake," and that while "the production of the fruit is an added honour to it," the fundamental truth was that "the flower is the end of the seed, – not the seed of the flower" (25: 249–50).[1] "You are fond of cherries, perhaps," he told readers, "and think that the use of cherry blossom is to produce cherries." Instead, he insisted, "the use of cherries is to produce cherry blossoms." In an emphatically anti-materialist response, Ruskin rejected the reproductive, functional basis of Darwinian botany – the reification of "the mere continuance of the creature" – in favour of an aesthetic, moral, and anthropocentric reading in which flowers represented "the purity, the serenity, the radiance" of divine nature (250). There are countless examples in *Proserpina* of such responses to what Ruskin described as the "vulgar mysteries of the so-called science of botany," whose very nomenclatural system was likely "to defile the reader's mind" with "unclean or debasing [associations]" (25: 200–01). It is easy to assume from the consistently anti-Darwinian tone of *Proserpina* and its attacks on the "unclean stupidities" of "all these materialisms" that this reflected long-held convictions (25: 263). But if we are to argue that Ruskin had always rejected functionalist materialism, one must account for statements in his 1843 correspondence where he defined a flower as "part of the plant which has in it organs of fructification," and insisted that "you can have no other meaning but this; for flowers have no common form, nor appearance, nor anything essential but this" (1: 475). Facing up to this conundrum raises a number of more broadly significant questions. Why in 1843

did Ruskin articulate a position on flora which anticipated precisely the starkly functionalist reading he attacked in *Proserpina*? What might this mean in terms of characterising Ruskin's early natural history and the degree of its engagement with modern scientific method and understanding of what I would describe as the dynamic materiality of environment? Why might this suggest the need for a more complete re-evaluation of Ruskin's natural history? To address these questions, I will turn first to the 1843 correspondence, before briefly sketching out relevant issues in "The Work of Iron" (1858) and *The Elements of Drawing* (1857) in order to suggest that the type of modern scientific engagement witnessed in the 1843 letters was, in ways which exemplify his attempts to synthesise religious and scientific approaches to nature, reflected in his published work. Having done so, it will be possible to reflect again on the relationship between Ruskin's early and late science.

The Trees of Eden

> [Eve] engages herself in many foolish things – among others, to study why the animals called lions and tigers live on grass and flowers, when, as she says, the sort of teeth they wear would indicate that they were intended to eat each other. That is foolish, because to do that would be to kill each other, and that would introduce what, as I understand it, is called "death." (Twain 8)

MARK TWAIN'S 1893 COMIC account of the early days of Eden foregrounds the difficulties of reconciling the literal readings of the Bible promoted by Evangelicalism, and an increasingly confident investigative science. In the decades before Darwin's *Origin of Species* (1859), scientists and theologians argued over the implications of geology for Scripture, and in his early years Ruskin engaged with and pursued scientific critiques of Genesis with a frankness that is both surprising, given his later position, and, perhaps even more surprisingly, largely unremarked upon by critics. That he did so by considering exactly the same kinds of logical problems that troubled Twain's Eve (particularly in terms of comparative anatomy) queries attempts to locate him straightforwardly within either orthodox Evangelicalism or Natural Theology. Close analysis of 1843 correspondence with the Reverend Edward Clayton, a former fellow student of Christ Church, in which Ruskin addressed the subject of the Garden of Eden, demonstrates his departure from literalist Evangelical exegesis, and reveals that he deployed materialist methodologies from a range of sciences in order to argue that there was death in Eden prior to the Fall.

Before turning to these letters, it is wise to address their status. There are a number of reasons to reject the possible objection that correspondence should not be accorded the same literary weight as published texts, or that one should not found a major component of an argument about Ruskin's science on the basis of letters. Firstly, the correspondence was not a brief epistle, but two letters and an accompanying essay, together amounting to more than five thousand words, written over a period of four weeks, articulating a consistent, coherent, and well-evidenced scientific analysis, grounded in sustained immersion in contemporary research. Secondly, the fact that Ruskin approved the publication of these letters as *Letters to a College Friend* (1891) considerably complicates their status as private texts. Thirdly, I would point to the fact that Ruskin often voiced anxieties and controversial opinions more frankly to correspondents than to a general readership.[2] When one considers the contrast between Ruskin's confident denunciations of Darwin in print, and the harrowing tone of much of his correspondence on the subject of religion and science, the argument for taking

his letters seriously gains additional weight.[3] Fourthly, other critics have argued for the importance of these letters. Cook and Wedderburn comment that "the note of aggressive Protestantism" in earlier correspondence had disappeared from these letters, and that "the freer interpretation of Scripture towards which he inclines in the Essay on the Fall" evinced "his gradual emancipation from some of the bonds of his early creed" (Ruskin 1: liii). In such a reading, Ruskin's eventual "unconversion" from Evangelicalism in 1858 is anticipated here. Ruskin's editors argue convincingly that Ruskin was a pioneer of the anti-literalist "higher criticism" that would emerge in the 1860s, a period in which Ruskin leant support to one of its principal figures, Bishop Colenso.[4] In frustratingly brief analyses, Conner regards these letters as a "significant" departure for "the doubt-racked Ruskin" who "came down against the literal Biblical version . . . in favour of the heretical viewpoint based on geological evidence" (19), while Spear argues that they reveal Ruskin's conviction that the Bible should be "constantly reinterpreted in the light of scientific discoveries" (45).

In *Letters to a College Friend*, letters 16 and 17 (January 1843), and the accompanying essay, "Was There Death Before Adam Fell, In Other Parts Of Creation," Ruskin used remorseless logic to interrogate Genesis. The initial impetus seems to have been a sermon of Clayton's, sent to Ruskin, but not included with the published correspondence, which apparently introduced the theme of the Fall. However, Burd suggests that Ruskin was introduced to this issue as a result of attending a sermon by Buckland at Christ Church cathedral in January 1839 (306). Later published as *An Inquiry whether the Sentence of Death Pronounced at the Fall of Man included the Whole Animal Creation or Was Restricted to the Human Race*, the sermon aimed to help future clerics wrestle with the exegetical problem of reconciling Romans 5.12 ("As by one man sin came into the world, and death by sin") with fossil evidence of extinct species in existence before *Homo sapiens*. Burd argues that Ruskin shared Buckland's view that Scripture never suggests that "brute creation" experienced death only after the Fall (306). While Ruskin did reach somewhat similar conclusions to Buckland, *Letters to a College Friend* suggest that Buckland's sermon had in fact troubled Ruskin and led to an extended period of contemplation, the culmination of which were the letters to Clayton which place Ruskin much closer than Buckland to modern movements in science. In a manoeuvre reminiscent of Buckland, Ruskin concluded that "man in Eden was a growing and perfectible animal; that when perfected he was to have been translated or changed, and to leave the earth to his successors without pain." The Fall meant that humanity "received what before was the lot of lower animals – corruption of the body – and, far worse, death of the soul" (1: 478). However, Ruskin's uneasy reconciliation of science and Scripture – achieved by erecting a Bucklandite division between humans and "lower animals" – occurs only after a series of scientific arguments which acted as an uncomfortable counterweight to the revisionist conclusion.

Ruskin's critique of Clayton's letter centred upon an investigation of Eden's flora and fauna which, according to literal readings, were immortal and at peace prior to the Fall. Ruskin's response to this thorny issue demonstrated that his debt to the work of Lyell, whom Ruskin had met during meetings of the Geological Society in the early 1840s, was considerable. Referring to arguments in volume 1, chapter 14 of Lyell's *Principles of Geology* (1830–33, 2 vols.), Ruskin challenged Clayton with "geological evidence of death extending for an infinite series of ages before man." Ruskin spoke of Lyell's discovery of "the bones of the mastodon, the most recent of all fossils, in a bed *cut through* by the ancient course of the Niagara, three hundred feet above its present bed, and three miles and

a half below the falls," a finding which meant that "the river by the very lowest calculation must have been occupied 15,000 years" (1: 478). Ruskin's acceptance of this dating, and Lyell's Uniformitarian methodology, was irreconcilable to literalist exegesis.

Botany joined geology in providing crucial evidence. Arguing from first principles, Ruskin suggested that the tree of Genesis could not have been immortal if it was like a modern tree. Beginning by asking "what is your notion of a *tree*?" and answering that it is "a thing with leaves on it, and bringing forth flowers in its season," Ruskin's methodology prioritises logical attention to materiality. Defining leaves and flowers, he terms the former "an instrument for depriving carbonic acid of its oxygen, and giving carbon to the plant" and the second "a part of the plant which has in it organs of fructification" (1: 475). In seeking key properties, Ruskin dismissed the "colours, and forms, and appearances" of leaves as irrelevant to their photosynthetic function, which he described as "the essence of a leaf," while the varied and beautiful appearance of flowers (exactly those features he would later reify in *Proserpina*) are deemed peripheral to their "essential" reproductive properties (1: 475). This methodology dismissed aesthetics in favour of morphological division and function.

A defining feature in the development of nineteenth-century science was growing emphasis on dynamic process, something highlighted in the following paragraph, where Ruskin argued that leaves and flowers functioned to produce new life and implied "growth – change of state – and preparation for a succeeding existence." A tree is "a growing, changing, and preparing thing" which produces flowers and fruit designed to prepare for the growth of another tree, which in turn would replace the parent, so that "every bud and blossom of the parent tree implies and necessitates its destruction" (1: 476). Ruskin's science, in such passages, emphatically rejected a purely descriptive methodology and surface focus. Crucial in discerning the relationship here between Ruskin, materialist methodologies, and understanding of dynamic materalities – and in distancing him from his later anti-Darwinism – are the links made between reproduction and death. Because, "when you say a preparing thing, a fructifying thing, you mean a dying thing," it followed logically that "whenever you speak of a tree, you speak of death." The inescapable conclusion was that "that which has not in it the beginning and germ of death, is not a tree." Recognition of the essential place of death in natural systems produced an unpalatable choice:

> If there were trees in the Garden of Eden there was death; or, if there was not death, they could not have had leaves, nor flowers, nor any of those organs of growth or germination which now constitute the essence of a tree. People will look very grave at you, indeed, if you hint that there were no flowers in the Garden, and yet the very meaning of the word flower is – something to supply death. (1: 476)

While in *Proserpina* cherries existed to produce flowers, which are conceived as the highest purity of a plant, here flowers were purely reproductive organs whose ultimate end was their own demise and the proliferation of the species. The opposition between his positions in 1843 and the 1870s is so striking as to undermine any notion that Ruskin's later anti-materialism can somehow be transposed onto his entire career.

In 1843, Ruskin's commitment to rigorous scientific enquiry interrogated Scripture, and, in Spear's perceptive phrase, conceded "the logical priority of science to revelation" (45). Ruskin argued that if one were to interpret an Edenic tree as "something which had neither leaves nor flowers, nor any organs of a tree, you may give up your trust in [Genesis] at once"

because "you can never tell, if there be such latitude of interpretation, what anything means throughout the book." The function of leaves and flowers implied mortality, which meant that "either Scripture is wholly to be distrusted, as meaning one thing when it says another – or there was death in Eden" (1: 476).

The Animals of Eden

THE EXTENT TO WHICH Ruskin's analysis engaged with contemporary scientific trends is further evident when one recognises the range of sciences upon which he drew. In the next section of his first letter, in which Ruskin turned to the question of the supposedly peaceable animals of Eden, Ruskin's debt to Baron Cuvier's anatomical researches becomes clear. While Cuvier, whose opposition to Lamarckianism was consistent, positioned himself firmly within the tradition of natural theology, or as John Hedley Brooke has more rightly termed it, natural theologies, he was also an important figure in the transformation of science from an eighteenth-century Linnaean mode to a nineteenth-century mode of investigation that stressed the dynamic functionality and materiality of nature. Ruskin's deployment of Cuvier becomes apparent during a rhetorical interrogation of Clayton with regard to the ontological and physiological status of fauna. Like Twain's Eve, Ruskin began with the tricky issue of carnivores. Despite the implications, Ruskin pursued the same functionalist methodology that had characterised his discussion of trees, asking "what do you understand by the term 'lion'?" and answering that it must surely be "an animal with claws and sharp teeth?" Rejecting the idea that "God gave it claws and teeth for nothing," he insisted that "if it have not claws and teeth it is not a lion" but "some other animal." Anatomy and function defined the ontological status of lions: "The gift of an instrument supposes the appointment to a function. The claw is to catch with, the teeth are to tear with, and there is a particular juice in the stomach to digest meat with." To imagine "that these were given without intention of being used" is akin to supposing "that your tongue was given to you without your being intended to talk or taste with it" (1: 476). The inescapable conclusion was that lions at peace with other animals could not have existed. Ruskin's recognition of the anatomical mutuality of claws, teeth, and stomach, suggests familiarity with Cuvier's major work, *The Animal Kingdom Arranged After its Organisation* (1802). He owned an 1840 edition of that work, although it is not clear when he obtained it, and also borrowed a copy of Agassiz's palaeontological anatomy, *Poissons Fossiles*, in 1843.[5] In *Discourse On The Revolutionary Upheavals On The Surface Of The Globe And On The Changes Which They Have Produced In The Animal Kingdom*, Cuvier made clear that internal connections between organs were crucial to understanding animal organisation:

> The form of a tooth leads to the form of the condyle, that of the scapula to that of the nails. . . . Similarly, the nails, the scapula, the condyle, the femur, each separately reveal the tooth or each other; and by beginning from each of them the thoughtful professor of the laws of organic economy can reconstruct the entire animal. (98–99)

Cuvier argued that each anatomical feature of an animal reflected its needs: in recognising the functional mutuality of a lion's claws, teeth, and stomach, Ruskin had applied Cuvierian methods to his dissection of Genesis.

It is puzzling that the influence on Ruskin of Cuvier's emphasis on temporality, function, form, and mutuality has received little attention since 1912, when Cook and Wedderburn, in habitually encyclopaedic fashion, catalogued his many references to Cuvier.[6] Why this places Ruskin within modern trends in science can be appreciated by offering a specific analysis of Cuvier's anatomy; and of how such anatomy was a significant departure from the type of eighteenth-century natural philosophy with which Ruskin is routinely bracketed.

Defining Nature: Linnaeus and Cuvier

LINNAEUS REVOLUTIONISED eighteenth-century life sciences by using anatomy and sexuality to erect a nomenclatural system through which organisms could be scientifically classified. His "unusually intense passion for the delights of arrangement" seemed to promise that "all living nature could be organised into neat rows of shelves and boxes" (Worster 32). Looking for strict relations of difference and identity, he pursued a quantitative evaluation in which, as Gary Gutting notes, "the primary instrument of knowledge becomes the analysis of resemblances, not their mere recognition": Linnaean method "no longer [aimed] to draw things together on the basis of their resemblances but [sought] to separate them on the basis of their differences" (147). By limiting valid evidence to the structural characteristics of an organism, Linnaeus, like Ruskin in the 1843 letters, ignored other sensory data, and rendered natural phenomena manageable, analysing similarity and difference in order to base taxonomic units on structural analysis. The relations between structures were mapped by Linnaeus in a mathematical and hierarchical system that privileged reproductive anatomy as a distinguishing marker, but unlike Cuvier or Ruskin, the emphasis on outward form, rather than growth or function, viewed organisms in stasis. A Linnaean description of dead zoological or herbarium specimens presumed that daily changes and environment were irrelevant to their unchanging structural features.

For Linnaeus, Foucault contended, "time is always extrinsic to the essential reality of a living thing and has no role in determining its nature," whilst "a genuinely evolutionary view of nature conceives time as a principle of development for living beings in their internal organization" (159). During the nineteenth century, Linnaeus's "sexual system" in botanical taxonomy was replaced by the "natural system" of Cuvier, Candolle, and Jussieu, which represented "a move away from primary concern with floral physiognomy towards depiction of the whole plant" (Smith 148). In anatomy, Cuvier demanded recognition of the role of temporality and interaction in natural systems, principal markers of a paradigmatic shift from previous approaches. Cuvier's *The Animal Kingdom* argued that Linnaean structural categories were unsustainable, and that only contextual analysis of functional organisation could furnish the means to understand organic life. In a work first available to an English readership in 1816, Cuvier argued that "Natural History" differed from physics (which "examines, abstractedly, each of the properties of those moveable and extended beings which we call bodies") and from chemistry ("a science almost wholly experimental"), disciplines which together consisted "in isolating bodies, reducing them to their utmost simplicity" in order to quantify, observe, and experiment with them "for the purpose of establishing a body of doctrine, and, if possible, of referring the whole to one single law" (1). This also offers a fair description of Linnaeus's attempted regularisation of the life sciences into an observational, classificatory "hard science." Natural History, as conceived by Cuvier, was, conversely, "confined to objects which do not allow of rigorous calculation, or of precise

measurement" because it was seldom the case that its subjects were "so little complex as to permit of it" (1–2). Because plants and animals could not be studied in the same way as atoms, Cuvier studied the "entire" organism in situ, rather than merely detailing its separate parts, and reflected upon the relationship between an organism's anatomical form and physical existence, making it imperative that in anatomical investigations, "the component parts of each must be so arranged as to render possible the whole living being, not only with regard to itself, but to its surrounding relations" (2, 2–3). Where Linnaeus pursued the separation of species, and of their organs, Cuvier sought to place species within a wider environmental context, and to understand the organs of bodies as part of a functioning whole.

Cuvier's definition of living matter reflected its dynamic materiality: life was "a vortex, more or less rapid, more or less complicated, the direction of which is constant," and because "life . . . presupposes organisation" it followed that "life proper to each presupposes the organisation peculiar to that being." Animal and plant anatomy reflected conditions of existence, and resulted from "the mutual action and reaction of . . . parts" as they were organized to fulfil functions of sensory perception, movement, nutrition, and reproduction (6). What became significant was how a plant or animal *functioned* within its environment, and how its internal anatomy was organised to respond to environmental exigencies. While Cuvier supported the notion of design and rejected Lamarck's ontogenical evolutionism, his emphasis on functionality was one of a range of factors that helped create the theoretical landscape in which the development of ecology and Darwin's phylogenetic evolutionism became possible.

Ruskin, Cuvier, and Animal Anatomy in Eden

RUSKIN'S PARTICIPATION IN a wider movement towards a dynamic concept of environment suggests that he had moved at least some way along a road whose ultimate destination was the kind of scientific naturalism exemplified by Darwin. The fact that he was also open to Uniformitarianism allowed him to extend his participation in the formation of a dynamic, holistic vision of the natural world that was not merely a reflection of his Romantic leanings. It also implied a wide-ranging sympathy with the conceptualisations of nature that were emerging with growing confidence in Victorian science after 1840. Sherburne's claim that "the 'biological revolution' never touched the organicist Ruskin" (7), and Hewison's argument that Ruskin's adherence to "the principle of direct observation and resistance to speculation leads to an attitude to nature that rests upon externals," and to a methodology in which "all you need to know can be discovered by simply using your own eyes" (21) cannot be confirmed by the actualities of Ruskin's practice, not just in his Eden letters, but throughout his work. When one observes Ruskin's methods, both in the correspondence and in the natural history sections of *Modern Painters* (1843–60, 5 vols.), it is clear that he habitually looked beneath the surface of organisms. Indeed, he famously claimed in *Modern Painters* (vol. 1, 1843) that "the chief narrowness of Wordsworth's mind" was that "he could not understand that to break a rock with a hammer in search of crystal may sometimes be an act not disgraceful to human nature" or that "to dissect a flower may sometimes be as proper as to dream over it" (5: 359). Even in later, anti-materialist works like *Proserpina*, Ruskin included four chapters on plant anatomy (25: 320–37, 483–512). What set the early Ruskin apart from Linnaean natural philosophy, and broadly within the same camp that began at the time of Cuvier and extended through to Lyell, Darwin, and Ernst Haeckel (who coined the

term "ecology" in the 1860s) was his commitment to function, inter-relation, and temporality. This commitment, though, was never uncontested in his work, as a counter-current, in the form of a vision of a hierarchical, designed environment, vied with a more modern approach. Ruskin's attempts to conjoin these counter-conceptualisations of environment would over time be subject to increasing tensions and instabilities.

Ruskin's application of Cuvier problematised the Genesis account of fauna: "a lion at peace with other animals," he tells Clayton, is a "contradiction in terms," akin to claiming that "God has adapted every muscle to a function which it was never intended to discharge" (1: 477). Either "these animals were at peace in Eden" and "created with especial view to their *after* functions, and maintained for a short time at peace by especial miracle" or "they were different animals – not lions nor tigers, but things of which we have no conception, having different muscles, no claws, no digestive organs for meat" (1: 477). Ruskin argued that the naming of animals by Adam "gives the lie direct" to the first claim, because Adam could not "know their nature, when every one of their functions was miraculously suspended." The second claim would presuppose "a *new creation* at the fall of Adam," which Ruskin felt would "have been at least indicated in some way or other in scripture" (1: 477). Distinguishing himself from Evangelical orthodoxy, Ruskin concluded that Genesis must be read "as something very like an Eastern allegory" (1: 482).

Responding to protests from Clayton and his sister, Ruskin used his second letter, accompanying essay, and a battery of materialist arguments, to press further. Applying Malthusian logic to suggest that "by the institution of carnivora, one third more *happiness* is brought into existence" by providing "one more step of existence," he then turned to geology to argue that the plants and animals of antiquity must have had "the same organs, the same structure and development, as those growing now" (1: 477, 484). Even the emergent science of palaeontology (through Agassiz), which revealed that "the digestion of the Icthyosaraus is as regular and simple as that of any living aquatic beast of prey, and far more easily traceable," provided counter-evidence to Clayton's speculation that animal anatomy had been different in the past (1: 484). Ruskin deployed agricultural science, chemistry, and biology, to argue that organic life relied on death for the provision of air as well as food: atmospheric ammonia, produced only through animal decay, combines with "the carbonic acid, which is the result of animal *breath*," forming carbonate of ammonia, which, when dissolved in rain water, is "presented in this form to the root of the plant" (1: 483). Analysis of a materially dynamic environment confounded scriptural claims of immortality, because existence was predicated on the death of other organisms, but a recurrent anxiety underlying the letters to Clayton centres upon what should be done with the discoveries of materialist science.

The Breath of Life

For Ruskin, materialism was true within its remit, but could never represent the whole truth. His natural histories represented an attempt to synthesise the work of an unrestrained, investigate science, complete with a range of materialist methodologies, and a moral enquiry into the signficance of nature to human life that drew upon Romanticist tropes and typological exegesis. To achieve this meant a simultaneous invocation of science, spirituality, culture, and aesthetics. The correspondence from *Letters to a College Friend* reveals that Ruskin had understood and endorsed materialist modes of investigation, but in energetically pursuing its findings, he was also concerned with wider implications. The fact that his public work

was more restrained in pursuit of materialist investigation suggests a desire to find a way to integrate, rather than reject, its approaches. During the 1850s, Ruskin's confidence in his synthesis of Romanticism, exegesis, and science, gave rise to important works of natural history.

"The Work of Iron," a lecture given at Tunbridge Wells, offers perhaps the clearest example of the manner in which Ruskin managed for a time to conjoin an explication of dynamic environmental materiality with a broader cultural reading. In a town famed for therapeutic waters, Ruskin took as a framing detail the rusty water basins of the town's wells, and from this localised particularity, moved outwards, proposing to "think a little over the full significance of that saffron stain" in order to outline "the functions of Iron, in Nature, Art, and Policy" (16: 376). More ambitiously still, this movement from microcosm to macrocosm demonstrated that the town's inhabitants were also connected to a monumental organic system symbolised by the rusted wells. Ruskin's desire to trace complex connections of cause and effect within environment, and to overturn complacency by asking his audience to re-evaluate nature and their place within it, began with a challenge to their perception that "rusty iron [must be] spoiled iron." Counter-intuitively, he insisted that "it is not a fault in the iron, but a virtue, to be so fond of getting rusted, for in that condition it fulfils its most important functions in the universe," so that "in a certain sense, and almost a literal one, we may say that iron rusted is Living; but when pure or polished, Dead" (16: 376–77). In his description of oxidisation, iron actively inhales air, revealing itself and oxygen as dynamic substances that participate in physical transformations. By respiring as we do, iron becomes part of a communion of living and nearly living organisms and substances that interact at a foundational level. Iron and other metals reach their "most perfect and useful state" only when they have "breath put into them," a breath of life both physical and spiritual, and from which all else begins (16: 376, 377). Just as organic life is dependent upon carbonate of ammonia resulting from the combination of rain, animal breath, and decayed animal matter, so life itself came into being only because of primæval interactions of iron and air. The dynamic changes which the consummation of oxygen and iron enacts are endless, and, Ruskin insisted, "the main service of this metal . . . is not in making knives, and scissors, and pokers, and pans," but "in making the ground we feed from, and nearly all the substances first needful to our existence": the soils of the earth "are all of them metals which have undergone this . . . vital change . . . by permanent unity with the purest air" (16: 377). Fields were not timeless landscapes fixed in present forms, but the result of an unceasing process of connection and interaction. Ruskin dissolved boundaries between nature and humanity by pointing out that respiration, understood in its widest sense, maintained human life, but also created every resource on which humans relied.

Ruskin's attention to process is everywhere in works published prior to the 1870s. In a work of art instruction, *The Elements of Drawing*, he told students that he had drawn their "attention early to foliage" because "its modes of growth present simple examples of the importance of leading or governing lines." Only by "seizing these leading lines" can the artist achieve "a kind of vital truth to the rendering of every natural form." Such leading lines are markers of growth and "are always expressive of the past history and present action of the thing." In mountains, they reveal forces of formation and erosion, and in trees "they show what kind of fortune it has had to endure from its childhood: how troublesome trees have come in its way, and pushed it aside, and tried to strangle or starve it; where and when kind trees have sheltered it, and grown up lovingly together with it, bending as it bent; what winds torment it most; what boughs of it behave best, and bear most fruit" (15: 91). In an often undervalued

study, Fitch claims that for Ruskin, "the infinite subtleties and complexities of organic form" are to be captured only "by intimate knowledge of plant aspects coupled with imaginative penetration of the being-there of the particular living form." Critical of Sherburne's theory of "static organicism," Fitch shows that for Ruskin, mimetic art can capture the essence of plant life only if it conveys its dynamic relations with environment: "the subtleties of organic form manifest an inherent ordering and unifying that we call life" and, crucially, "its relation to the particular form in a plant is to be understood only by entering the lived world, the *Dasein* as it were, of the plant" (331). The Heideggerian notion of "being" or "being-there" highlights Ruskin's preoccupation with growth as a widely applicable model of creativity. Far from being a disciple of an eighteenth-century scientific mode, Ruskin's purpose – in art, science, and cultural studies – was underpinned by attendance to process and interaction.

In "The Work of Iron," Ruskin's primary concern – to highlight the connectedness of the elements of a dynamic environment – was achieved through conjunction of materialist analysis of oxidisation and cultural analysis of the universal impact of iron oxide on organic life. Its painstaking description of the manner in which life was entirely dependent upon an ecological system based around the rusting of iron, depicted an environment in which humans, animals, flora, and rocks were all inextricably bound within this dynamic system. In an intimate and sensual internalisation of the work of iron, Ruskin embraced the co-dependence of humanity within "the circles of vitality" by invoking the religious symbolism of blood: "is it not strange," he asks, "to find this stern and strong metal mingled so delicately in our human life that we cannot even blush without its help?" (16: 384). To Clayton, Ruskin used this motif of interconnectedness to insist that Genesis cannot satisfactorily account for the emergence of life: "*We,* again, require for our nourishment, not ammonia, but the nitrogenised substances, gluten, albumen, etc., of plants. Hence, each species of existence furnishes in its death food to the other, and the nourishment of one implies the simultaneous dying of the other" (1: 483). The principle feature markedly distinguishing the 1843 correspondence from "The Work of Iron" was its more insistent materialisation of nature, something softened in public accounts, but clear when he tells Clayton that "*We* are machines for turning carbon and oxygen into carbonic acid" while plants are machines "for turning carbonic acid into carbon and oxygen." Each "is the supplement" of the other (1: 483). While Ruskin's use of a mechanical analogy is extremely untypical of his wider practice, comparison of this study of respirational interdependency with that in "The Work of Iron" suggests that the two works both relied upon intimate understanding of the dynamic materiality of environment.

More substantial differences arise when one compares these early letters with one of Ruskin's most Evangelical texts, *Modern Painters* (vol. 2, 1846), where he warned that "when we are told that the leaves of a plant are occupied in decomposing carbonic acid, or preparing oxygen for us, we begin to look upon it with some indifference as upon a gasometer" (4: 153). This warning enables us to glimpse differences between Ruskin's private and published work, reveals tensions in his own approach, and anticipates later concerns. Problems with the promotion of a materialist science that saw animals and plants as mechanisms lay in the realm of morality. Scientific engagement might lead to moral degradation, if not guided by the kind of skilful cultural and moral reading of environment at which Ruskin became adept. In private, Ruskin deployed gas exchange to critique Genesis, but tempered this reading in print by suggesting that it was insufficient. In "The Work of Iron," Ruskin outlined the ineluctable forces of iron ecology, but also strove to persuade his audience of the need to preserve an environmental system on which they depended. Challenging his audience to

imagine a world in which "all your meadows, instead of grass, grew nothing but iron wire," he articulated disquiet at the desire of industrial technology to arrest or harness nature in pursuit of artificial commodities (16: 378). Ruskin provoked listeners further by asking if they would be content "if the whole earth, instead of its green and glowing sphere, rich with forest and flower, showed nothing but the image of the vast furnace of a ghastly engine." The desire of industry for synthetic perfection and command of environment misunderstood its organic complexities, and might turn a world of intricate, dynamic connections into "a globe of black, lifeless, excoriated metal" (16: 378). Ruskin withdrew from the audience the world as it still existed, in which iron rusted, in which change was perpetual, and offered a bleak monochromatic dystopia that would follow the cessation of iron ecology. Restoring the real world to the audience in a moment of epiphany, Ruskin urged acceptance of the work of iron:

> [The earth would be lifeless] were it not that all the substance of which it is made 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. (16: 378)

It was this biblically-tinted ecological binding that Ruskin wished his audience not only to see, but to embrace; and not only to understand, but to protect.

For Ruskin, the presentation of iron ecology celebrated its ability to sustain life, provide social lessons, and give delight. The power of the lecture lay in its ability to conjoin a modern scientific method, defined by an ability to attend to the fluctuant multiplicity of a complex material environment, to a cultural perspective. The force of "The Work of Iron" arose out of the interplay between materiality and culture, and it is this relationship which defines a range of other works from the period 1843–1860, from the architectural studies of *The Stones of Venice* (1851–53, 3 vols.) through to the nature studies of the final two volumes of *Modern Painters* (1860). Once the bedrock of this relationship – the commitment to a vision of environment that discerned its dynamic materialities and processes – was removed after 1870, Ruskin's late works were denuded of much of their power, and relied on curious moral and religious readings of nature which had little relationship to materiality and resided instead in a curiously static mythopoetic realm in which individual plant species were seen as active participants in a battle of good and evil. Whilst it is true, as Birch ("Science of Proserpina" 153) suggests, that *Proserpina* was written in response to natural sciences that Ruskin felt had become "debased by arrogance, lack of spirituality, envy, egoism and shallowness," his attempted rejection of all manifestations of materialism was also a rejection of much that had been integral to his own previous studies.

Just as connection remained a crucial feature of Ruskin's early celebration of the dynamic energy of environment, the disconnection in his later work between modern science, on the one hand, and aesthetics and morality on the other, is a marker of a diminution of the very energy that Ruskin had earlier celebrated. By acknowledging the ways in which the early Ruskin actively integrated modern science into his work, it becomes possible to gauge the degree to which his later work represents a quite distinct period in his scientific outlook; and the extent to which Darwinism necessitated a fundamental change in Ruskin's approach to environment. Instead of insisting on a Ruskin primarily preoccupied with an untheorised description of externalities, I would argue, with Emerson (152), that "no one, not even

Darwin, has so vividly evoked the labor of attending to nature's fluctuant multiplicity." The enormous and inescapable influences of Christianity, Natural Theology, and Romanticism were conjoined to a commitment to modern science, but as the 1850s drew to a close it became increasingly apparent that this had become a particularly unstable mixture. Tensions within his natural history increased in time until the point in the early 1870s at which Darwin's evolutionary assault on sexuality and aesthetics forced Ruskin to make a fundamental choice, and to attempt to dismantle the unstable and vital synthesis that had sustained his work for so long. In choosing to privilege hierarchy, morality, and aesthetics over dynamic materiality and cultural ecology, Ruskin's later work became disconnected from the very "circles of vitality" that had underscored his earlier approach. By attending in greater detail to this fundamental change in Ruskin's scientific vision, and to the tensions that drove these changes, a credible account of both his science and his epistemology may yet emerge.

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NOTES

1. All subsequent citations of Ruskin's texts will refer to Cook, E. T. and Alexander Wedderburn, eds. *The Library Edition of John Ruskin's Works*, 39 vols. London: George Allen, 1903–12. These will be given in the form of volume number and page number(s).
2. Speaking of debates about science and religion in the 1840s, Conner asks whether these weakened Ruskin's Evangelical faith, and argues that whilst "one would not believe it if one judged merely from the confidently orthodox tone of his published writings in the 1840s . . . his private correspondence tells a very different story" (19). J. D. Hunt argues convincingly that Ruskin consciously suppressed some of his more controversial opinions in print (280–82).
3. In his late ornithological work, *Love's Meinie* (1875–83), Ruskin dismissed Darwinism as "the work of human bats; men of semi-faculty or semi-education, who are more or less incapable of so much as seeing, much less thinking about colour; among whom, for one-sided intensity, even Mr Darwin must be often ranked" (25: 263). In the *Pall Mall Gazette* in 1886, he claimed that "Darwin has a mortal fascination for all vainly curious and idly speculative persons, and has collected, in the train of him, every impudent imbecility in Europe, like a dim comet wagging its useless tail of phosphorescent nothing across the steadfast stars" (25: 586). In private correspondence to Elizabeth Barrett Browning, Thomas Carlyle, Charles Eliot Norton, and Susie Beever, however, doubts and anxieties about science and faith are readily apparent. On this, see Ruskin, 36: 363–64, 596–7 and 37: 165, 590; as wells as Kaplan (442) and Cate (92–93).
4. During the 1860s, Ruskin endorsed the Anglican Bishop Colenso of Natal, who attempted to re-shape doctrine in the light of science. Colenso controversially claimed that "the Pentateuch, as a whole, cannot personally have been written by Moses, or by anyone acquainted personally with the facts which it professes to describe," and that while the Mosaic narrative might be read for revelatory purposes, it "cannot be regarded as *historically true*" (8). Ruskin supported Colenso publicly in *The Crown of Wild Olive* in 1866 (18: 416–17) and *in Fors Clavigera* (1871–83, 5 vols) (28: 364), but voiced his opinion first in private in an 1862 letter in which he told Sir John Naesmyth that he had been "quite unable to tell anyone" that "for the last four years I've been working in the same direction." "One must take one's side," he told Naesmyth, "and I stand with the Bishop and am at ease" (36: 424–25).
5. Ruskin had consulted this work by the time he cited it in *The Stones of Venice* (vol. 1, 1851) (9: 276). It is likely, but unverifiable, that Ruskin owned the volume in 1843. On Agassiz, see Ruskin 1: 457.

6. Ruskin listed "plates from Cuvier's *Animal Kingdom*" in his "Rudimentary Series" of art education drawings (21: xxxix); included many Cuvier prints in the Ruskin Art Collection and educational material (21: 92, 163, 228, 320; and 22: 12); invoked the "wise natural history of Cuvier's" in his geology (26: 296, 310); and, in 1878, wrote to Henry Acland requesting "all sixteen volumes of Cuvier in translation" to aid his botany (see 25: xxvii–xxviii, 53, 175). Ruskin's later fulminations against vivisection might suggest that Cuvier would become a figure of vilification, but his approval of Cuvier never wavered.

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