

Molar Heights and Molecular Lowlands: Scale and Imagination in Ruskin and John Tyndall

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John Tyndall (1820–93) was an Irish-born physicist, a mountaineer and an empirical scientist who made significant contributions to climate science, glaciology, public health, and epidemiology that still resonate today. With Ruskin, Tyndall shared commitment to the close observation of the natural world and the articulation of those observations in writing. Using an ecocritical approach, this chapter explores the resonances and dissonances between Ruskin's and Tyndall's writings on mountains and considers the cultural perspectives that informed their understanding of the other-than-human mountainscape. Ecocriticism has developed out of nature writing and deals with the web of relations between texts, cultural artefacts, nature, and environment. In this chapter, by an ecocriticism of scale I mean to distil this ecological methodology to concentrate on the functions of scale in the writing and thinking of Ruskin and Tyndall.¹

The terms 'molar' and 'molecular' had specific senses in the nineteenth century. Molar referred to a body of matter rather than its particulate pieces. The earliest recorded use of the word molecule was in 1811 by the Italian physicist Amedeo Avogadro, but there was not yet an understanding of a difference between atom and molecule.² This distinction emerged throughout the nineteenth century. In 1873, James Clerk Maxwell described the distinction thus:

An atom is a body which cannot be cut in two. A molecule is the smallest possible portion of a particular substance. No one has ever seen or handled a single molecule. Molecular science, therefore, is one of those branches of study which deal with things invisible and imperceptible by our senses, and which cannot be subjected to direct experiment.³

Since molecules and atoms could not be visibly detected in the nineteenth century, for the purposes of experimentation volumes of a substance would be upscaled to a size at which they could be effectively handled, while maintaining the proportions of their molecular formula. Since the mid-nineteenth century, the mole has been used in chemistry as a way of measuring quantities of a substance using the Avogadro constant ($6.02214076 \times 10^{23}$). Avogadro's constant refers to the units—be that atoms, molecules, or ions, according to the substance—in one mole of any substance's molecular weight in grams.⁴

To reiterate, in nineteenth-century physics the use of molar was not so specific a measurement and described a complete body of matter, distinct from its molecular or atomic constituents. It is in this sense that this chapter uses the term 'molar'. These molar and molecular scales are woven through Ruskin's and Tyndall's writings on mountains and their associated arguments about sensation and imagination. Through the lens of contemporary ecologies of scale, I extend Ruskin's and Tyndall's modes of thinking and advocate for a posthuman ecological approach combining new materialism with a humanistic rhetoric to make our ecological reality accessible. Ecocritical approaches can show how the language of description facilitates or interrupts the understanding of ecology. This is important because determining the human projections upon the other-than-human world is crucial to our capacity to recognise and then to act upon our ecological predicament.

Ecological modes of thinking

The term 'ecology' has a complex history. While this history is outlined in the introduction to this book it is important to understand some applications of the term as they specifically pertain to scale, before commencing with my readings of Ruskin and

Tyndall. The term ecology was first coined by Ernst Haeckel in 1866. In the twentieth century, the work of people such as Eugene Odum established the holistic approach, and ecosystems as a global set of interrelated systems.⁵ Ecology, in this sense, is the study of complex systems that operate on multiple scales. In 'The Problem of Pattern and Scale in Ecology' (1992), Simon Levin points out that:

Applied challenges, such as the prediction of the ecological causes and consequences of global climate change, require the interfacing of phenomena that occur on very different scales of space, time, and ecological organization.⁶

In their introduction to *Ecological Scale: Theory and Application* (1998), David L. Peterson and V. Thomas Parker argue:

the very notion of complexity ... at least implies relationships across scales. It is when coarse, overarching events appear to be closely related to fine-grained considerations that the system requires treatment as a complex system.⁷

A complex system comprises multiple factors, making it difficult to model or predict. It behaves in a non-linear way and the whole cannot be easily inferred from its parts. Complex systems are also often open systems, that is, systems that are open to interaction with the outside world. This is clearly the case with ecological systems interacting with their environment.

In *Theoretische Biologie* (*Theoretical Biology*, 1920), Jakob von Uexküll developed his concept of *Umwelt* or environment to explain how a mind interprets the world, first put forward in *Umwelt und Innenwelt der Tiere* (*The Environment and Inner World of Animals*, 1909).⁸ Gregory Bateson developed this idea further in his book *Steps to an Ecology of Mind* (1972) in line with a more transactional subjectivity.⁹ These philosopher-biologists provided the wherewithal for meditations between biology, linguistics, and philosophy. This synthesis of semiotics and ecology led to the formation of the new fields of biosemiotics and ecosemiotics. This was eloquently expressed in Dušan Gálik's essay on the subject published in 2013:

Semiosis is not a process containing a narrow range of phenomena such as human communication, human language. It is a universal principle underlying the basic processes of life.¹⁰

Ecology is the study of relationships. It does not concern itself with what might be figured as the discrete objects of the individual organism but of organisms and their environment, the living and non-living, and the dynamics of these relations. What happens, then, when those relationships are interrupted by an observer and turned into writing?

The discipline of ecology confronts what Levin has called the observer's imposition of 'a perceptual bias, a filter through which the system is viewed'.¹¹ And this includes the scalar aspect. Partly this is a problem of language. Within ecology as an empirical science the role of language as mode of description has recently come to the fore, and the word 'scale' has had some particular attention. David Schneider gives an account of the rise of the use of scale in ecology. He begins with the difficulty of attributing a stable meaning to the word, which has a complicated etymology, and he notes the increased prevalence of the term in academic papers on ecology from the 1970s onwards, asserting that 'the concept of scale is evolving from a verbal expression to a

quantitative expression'.¹²

There is still an issue with the loose and inaccurate way in which ecological scale and the organisational level of an ecological system are used interchangeably. Organisational levels are identified as: individual organism, population, community, ecosystem, biome, and biosphere; whereas '[s]cale refers to physical dimensions of observed entities and phenomena. Scale is recorded as a quantity and involves (or at least implies) measurement and measurement units'. Robert V. O'Neill and Anthony W. King expand on this, explaining that 'if you move far enough across scale, the dominant processes change. It is not just that things get bigger or smaller, but the phenomena themselves change'. Arguably the notion of 'scaling up' is better described as translation, they suggest.¹³ As these authors point out, what we require is a wholesale rethinking of categories:

This same heritage also led us to believe that the significance could be named a priori: organism, population, ecosystem, landscape, etc. The levels of explanation must be extracted from data, not pre-imposed. To date, the empirical evidence shows that the levels extracted from the data do not correspond in any simple way to traditional levels of biological organization.¹⁴

It is 'the traditional concept of biological hierarchy' that O'Neill and King wish to undo.

This same distinction between scales and the need to avoid pre-assumed organisational levels is the focus of Timothy F. H. Allen's critique of the biologically hierarchical term 'landscape level'. Most pertinent to our discussion here is the slippage between the term landscape as a measure of ecological scale and as an aesthetic term. Allen notes that '[t]he distinction between types of things and scale of things is fundamental. Scale-dependence and scale-independence are muddled in contemporary ecological parlance'.¹⁵ Here, Allen gives an insight into the usefulness of taking care of the language applied to empirical observations to avoid misrepresenting ecological relations:

Ecologists deal with things. The philosophy used here asserts that things exist in the external world, but not as things. The attribution of 'thingness' comes from the observer. Behind things are models that assign the thing in question to a type. ... A type is a tool that often helps an observer in recognizing things, but it is important to note that the type exists in the mind of the observer even before the observation.¹⁶

This is to say that the identification of thingness is a conceptual construct determined by the mind of the observer and then projected upon external reality. Allen argues that the definition of an organism is a human-made 'type' that does not relate to the material world because 'the concept of organism is still a human device for dealing with experience, not a necessity of nature'.¹⁷ And here, I would say, is a neat dividing line on either side of which we can place Ruskin and Tyndall: Ruskin on the side of cultivating models and types as 'the human device for dealing with experience' and Tyndall on the side of refining perception to reveal 'the necessity of nature'.

Allen, in assessing some of the mistakes that some ecologists make, wonders:

So why, one must ask, are ecologists so insistent on using 'the landscape level' to indicate a certain scale of investigation? Perhaps they mean something that corresponds roughly to a Constable landscape painting, an area less than a

country, but more than a small field.¹⁸

This commitment to the aesthetically recognisable encounter figured as art appreciation returns us to Ruskin and *Modern Painters* (1843–60), although not to John Constable, of course, but to J. M. W. Turner.

I propose that there is a two-fold application of the awareness of this bias, to avoid it, then to exploit it: first, to counter it and thus avoid its interference in the methods of ecological observations that misconstrue the realities of ecological relations, but secondly to apply its appeal to the rhetoric of ecological arguments. This dynamic back-and-forth can be seen to play out in particularly sharp relief in the works of Ruskin and Tyndall when they are taken and read side by side.

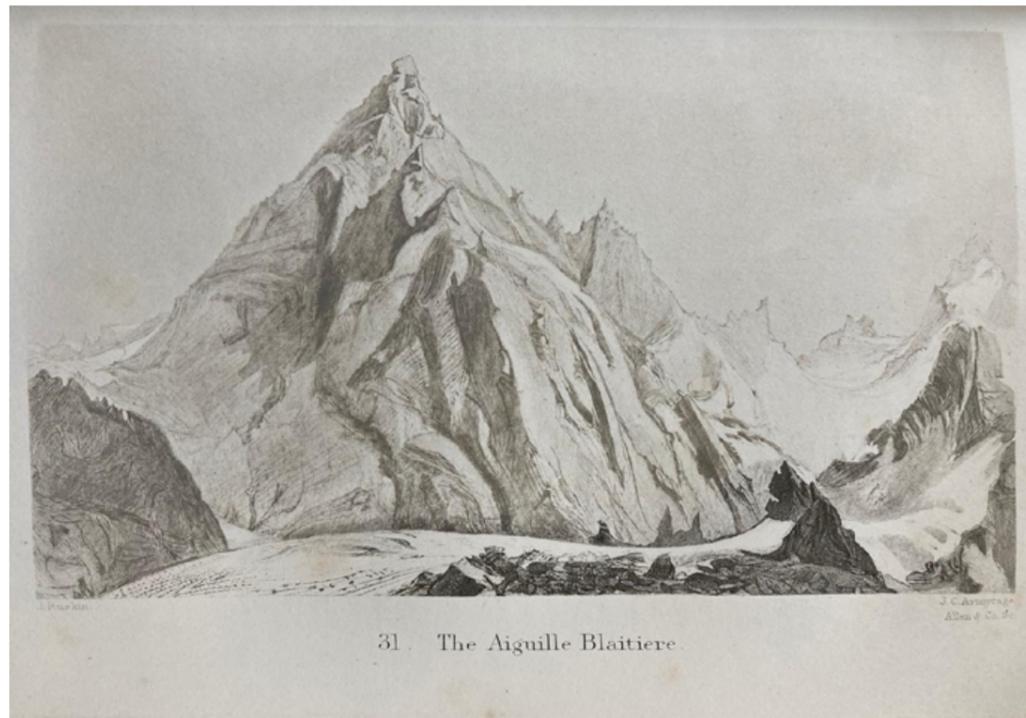
Common ground: meditations on mountains

The potential common ground between the experiences of Ruskin and Tyndall has rarely been seriously explored. In fact, they are not so much antithetical—as has usually been presumed—as asymmetrical in their structures of thinking.¹⁹ It is true that they clashed on the topic of the Alps. In response to Tyndall's criticism of the theories of alpine glacier formation proposed by Ruskin's friend James Forbes (1809–68), Ruskin counter-attacked in Letter Thirty-Four of *Fors Clavigera: Letters to the Labourers and Workmen of Great Britain* (1873).²⁰ Paul L. Sawyer, a scholar of nineteenth-century literature, describes Ruskin's verbal assault as 'ironic' since it was in fact the product of an 'antagonism of resemblances' rather than differences, ones which 'illuminate a crucial intersection in Victorian culture: the intersection of Romantic tradition with the triumph of scientific naturalism'.²¹ Since Sawyer's work, many scholars have further nuanced our historical understanding of the construction of modern scientific epistemology, preeminently the work of Lorraine Daston and Peter Galison in *Objectivity* (2007).²² Peter Dear also takes up this issue in Tyndall, tracing Tyndall's indebtedness to *Naturphilosophie*, a school of thought prevalent from 1790 to 1830, and identifying shared aesthetic and moral elements with the work of Alexander von Humboldt and Johann Wolfgang von Goethe.²³

Ruskin and Tyndall both engaged with an empirical encounter with nature through observation, but what I explore here is the question of the scale of these encounters and the language in which these encounters are communicated. In these regards, the Alpine environment played a major role in the life and work of both men. The battle lines were drawn between romantic sensibility and mechanistic utilitarianism, through the significance of the subjective scale of human aesthetic sensation next to the scales of realms that might only be encountered with the aid of instruments, abstractions, and the imagination. In the opening words of *The Queen of the Air* (1869), Ruskin attacked Tyndall along these lines, by rebuking Tyndall's public lecture on the colour of the sky.²⁴ In the same vein, I will now focus on Ruskin's and Tyndall's works on mountain and rock. From early on, Ruskin's identity as a geologist found equal footing with his identity as an artist, the two endeavours forming a disciplinary symbiosis. Ruskin had a close association with the Alps near Chamonix and undertook multiple visits there. His initial astonishment on seeing Mont Blanc for the first time, as a fourteen-year-old in 1833, provoked an epiphany that he recounted in his diary of the time, and later recalled in *Praeterita* (1885–9):

Not wanting to be anything but the boy I was ... and with so much of science

Fig. 10.1
J. C. Armytage after
John Ruskin, *The
Aiguille Blaitière*.
Engraving,
reproduced in
Modern Painters
4 (1856). Library
Edition, Plate
Thirty-One, facing
6.230.



mixed with feelings as to make the sight of the Alps not only the revelation of the beauty of the earth, but the opening of the first page of its volume,—I went down that evening from the garden-terrace of Schaffhausen with my destiny fixed in all of it that was to be sacred and useful.²⁵

The following year he published an article titled ‘Facts and Considerations on the Strata of Mont Blanc, and on some Instances of Twisted Strata observable in Switzerland’ in the *Magazine of Natural History*.²⁶ This symbiotic artistic-geological practice continued throughout Ruskin’s lifetime. During the course of the nineteenth century, the Alps had become a thriving tourist destination and playground of alpinism, initiated in part by the writing of Horace Bénédict de Saussure (1740–99) and the publication of his popular *Voyages dans les Alpes (Journeys in the Alps, 1779–96)*. For his fifteenth birthday present, Ruskin requested a copy of this highly influential book and he had the greatest confidence in the accuracy and truth of what de Saussure described therein. Ruskin remained a life-long devotee. De Saussure was a geologist, a physicist, mountaineer, and an inventor of instrumentation, a man who in many ways prefigured the combination of attributes that Tyndall embodied. He was also the great grandfather of the founder of structural linguistics Ferdinand de Saussure (1857–1913), a curious yet pertinent fact that I will return to later. Ruskin’s experience of the Alps contributed to his understanding of aesthetics and he began writing his *Modern Painters* in 1842 in Chamonix, within view of Mont Blanc. Ruskin made many drawings and watercolours of the region and its mountains and used a good number of them to illustrate his aesthetic treatise, as with the watercolour of the Aiguille de Blaitière, that was transferred into an engraving to illustrate his section on mountains in the fourth volume (Fig. 10.1).

Tyndall spent every summer since 1856 in the Alps, and after his marriage to Louisa Charlotte Hamilton in 1876 he made it their habit to spend the summer every year in the Swiss Alps. His initial residence was at the Belalp Hotel before he and Louisa built a house some one hundred metres higher up from the hotel known as the

Tyndall Villa, overlooking the Aletsch Glacier and in view of the Matterhorn. Tyndall was a pioneering mountain climber and published popular books on the topic. In the introductory notes to *Hours of Exercise in the Alps* (1871), Tyndall makes the claim for the relation and association between his engagement with the mountain landscape as a climber and his practice of scientific inquiry:

A short time ago I published a book of ‘Fragments,’ which might have been called ‘Hours of Exercise in the Attic and the Laboratory’: while this one bears the title of ‘Hours of Exercise in the Alps.’ The two volumes supplement each other, and, taken together, illustrate the mode in which a lover of natural knowledge and of natural scenery chooses to spend his life.²⁷

The high mountains furnished the scientist with the actual possibility of a view from above. Tyndall spent many hours in the mountain watching the skies and changing weather patterns, and looking at the geological formations from many aspects. From his perches on some of the highest peaks, Tyndall found himself liberated from the confines of the laboratory, yet he still brought the insight and mentality of a systematic, empirical analyst to the mountain scenery. He applied this mentality to examples of natural phenomena at the two extremes of temporal pace: the quick formation of clouds and the visible weather patterns over minutes and hours, on the one hand, and the inscrutably slow evidence of geological structural development over millennia, on the other. In his introduction to *Essays on the Use and Limit of the Imagination in Science* (1870), Tyndall wrote that he had ‘carried with [him] to the Alps this year the heavy burden of this evening’s work’.²⁸ This could be interpreted as both a figurative and physical burden; his collection of books and equipment but also the ‘burden’ of the intellectual task of thinking and writing on the topic of imagination.

Scale: imagination and sensation

In these *Essays on the Use and Limit of the Imagination in Science* Tyndall claimed the imagination as the province of science. In the essay ‘Alpine Sculpture’ in his book *Hours of Exercise in the Alps*, an inquiry into the contested theories of the formation of the Alps, Tyndall claimed imagination for science, writing the following:

Imagination is necessary to the man of science and we could not reason on our present subject without the power of representing mentally a picture of the earth’s crust cracked and fissured by the forces which produced its upheaval. Imagination however, must be strictly checked by reason and by observation.²⁹

Tyndall made the following request during his explication of light waves, their movement through layers of atmosphere and air, and what this progression through the air might look like: ‘And now I would ask your imagination to picture this act of reflection’. Tyndall further explained that, ‘[b]y the force of imagination and reason combined we may penetrate this mystery also’, following this with an alpine example.³⁰ Technological enhancements to sensation such as the microscope facilitated science’s access to the molecular, although this remained limited. It was the imagination that Tyndall appealed to in order to bridge the gap. Tyndall described an experiment to reveal how sky matter becomes cloud, explaining how these invisible particles amassed considerably yet remained indiscernible under the microscope:

What notion can you form of the magnitude of such particles? The distances of stellar space give us simply a bewildering sense of vastness, without leaving any distinct impression upon the mind; and the magnitudes with which we have here to do bewilder us equally with infinitesimals, compared with which the test objects of the microscope are literally immense.³¹

There are bewildering magnitudes in either direction, from the microscopic to the interstellar. In this regard, a mountain assumes a comparatively familiar scale.

The vast, other-than-human scales that we discover in Tyndall's writings on the imagination contrast with Ruskin's frequent insistence upon the bodily scales of sense perception from which the imaginative faculty was derived. In his lecture *The Storm-Cloud of the Nineteenth Century* (1884), Ruskin, after picking Tyndall to pieces for fudging his distinction between vibration and undulation, asserted:

This only I desire to mark with attention,—that both light and sound are sensations of the animal frame, which remain, and must remain, wholly inexplicable, whatever manner of force, pulse, or palpitation may be instrumental in producing them: nor does any such force become light or sound except in its rencontre with an animal.³²

Here Ruskin emphatically refused Tyndall's invitation to imaginative speculation in order to upscale and downscale beyond the realm of bodily perception, beyond the anthropocentric scale (although Ruskin's intriguing phrase 'animal frame' is not explicitly anthropocentric, it is clear from the context that Ruskin's primary reference is to himself and therefore to human scale). Edward Alexander argues that Ruskin found value in science insofar as it supported 'fidelity to natural fact' whilst insisting that 'artistic perception must be preserved from the analytic and dissecting habit of modern science'.³³ It is this argument that Ruskin made in his introduction to *The Queen of the Air*. Modern science was, Ruskin proclaimed, a poor substitute for mythology, which provided human insight. This was plain from what Ruskin called 'the evidence of an instinctive truth in ancient symbolism'.³⁴ In this passage, Tyndall's blue-sky experiments bear the brunt of Ruskin's sarcastic disapproval:

So that the bright blue eyes of Athena, and the deep blue of her aegis, prove to be accurate mythic expression of natural phenomena which it is the uttermost triumph of science to have revealed.³⁵

We can trace further the threads of this argument by turning now to a consideration of the two writers' comments on mountains. Tyndall, of course, was not insensitive to the problem posed to our sense and sensations by the unfathomably minuscule and the inconceivably large. In 'Old Alpine Jottings', published in *New Fragments* (1892), he tackled problems posed by extremes in scale of space and time and their challenge to human understanding:

Think of the ages which must have been consumed in the execution of this colossal Alpine sculpture! The question may, of course be pushed to further limits: Think of the ages it may be asked, which the molten earth required for its consolidation! But these vaster epochs lack sublimity through our inability to grasp them. They bewilder us, but they fail to make a solemn impression ... When the intellect has to intervene, and calculation is necessary to the building

up of the conception, the expansion of the feelings ceases to be proportional to the magnitude of the phenomena.³⁶

For Ruskin, the encounter with the mountain and inquiry into geology also generated thoughts on scale, not just of territorial expanses and three-dimensional scale but temporal scales of vast durations. In one of his earliest essays, 'On the Forms of the Stratified Alps of Savoy', published in *Geologist* in 1863, Ruskin writes on geological time:

Immeasurable periods of time would be required to wear these [Alps] away; and to all appearances, during the process of their destruction, others were rising to take their place, and forms of perhaps far more nobly organised mountain would witness the collateral progress of humanity.³⁷

This beguiling quotation shows Ruskin initially acknowledging the deep time of geology only to foreground the human timescale in the sarcastic phrase 'collateral progress of humanity'. Ella Mershon, commenting upon Ruskin's rejection of Charles Lyell's deep time of geological formation, describes Ruskin 'confining himself to what is perceptible to the naked eye during the course of a human life'.³⁸ In the case of this quotation, Ruskin looked past a single human life but he still regarded the sublime forces of nature in relation to human processes.

In Ruskin's preferred epistemology of perception, considered in a holistic manner, we may discern an ecological way of thinking. Ruskin, although well informed on geology and keen to ascertain fact up to a point, also feared the loss of holistic perception—the human appreciation of the whole—lest it be overridden by the dissecting imperatives of the scientific perspective. He wrote in the appendix to the section on Rock Cleavage in *Modern Painters 4*:

I was quite sure that if I examined the mountain anatomy scientifically, I should go wrong ... touching the external aspects. Therefore in beginning the inquiries of which the results are given in the preceding pages, I closed all geological books, and set myself, as far as I could, to see the Alps in a simple, thoughtless, and untheorising manner.³⁹

Here Ruskin positioned himself against the atomising tendency of analysis. Ruskin held observation with the naked eye in the highest esteem, and the edict to 'draw what one sees' always led the way.

These issues played out in Ruskin's art criticism just as they did in his reflections on mountains. In his letter to *The Times* praising William Holman Hunt's *The Light of the World* (1851–3), published 5 May 1854, Ruskin summed up true Pre-Raphaelite painting's procedures of perspective and scale in contrast to Pre-Raphaelite pastiche:

The true work represents all objects exactly as they would appear in nature in the position and at the distances which the arrangement of the picture supposes. The false work represents them with all their details, as if seen through a microscope.⁴⁰

Hunt's picture replicates human-scaled perception by blurring outline and variegating colour in small details such as the ivy on the door and the gems on the figure. The effects are convincing from the right distance, beautiful and mysterious up close. By contrast,

the 'spurious imitations of Pre-Raphaelite work represent the most minute leaves and other objects with sharp outlines, but with no variety of colour, and with none of the concealment, none of the infinity of nature'. They are flat, dull, and untrue. Significantly Ruskin signed off his famous letter to *The Times* by praising J. Dearle's 'very lovely' study 'of a calm pool in a mountain brook'.⁴¹ In a much later lecture (1883) collected in *The Art of England*, the microscope again became an issue for Ruskin, while he was condemning woodcuts as being capable of conveying ideas of ugliness and terror yet incapable of beauty of form. Ruskin cautioned: '[n]o microscope can teach the beauty of a statue, nor can any woodcut represent that of a nobly bred human form'. He continued, amusingly conflating his aesthetic argument with a satirical take on scientific illustration: 'but only last term we saw the whole Ashmolean Society held in a trance of rapture by the inexplicable decoration of the posteriors of a flea'.⁴²

In a wonderful passage in his autobiography *Praeterita*, Ruskin tied up a lot of these threads. Not only do artificial enhancements to human sight destroy beauty, Ruskin implied, but honestly perceiving beauty is itself a kind of knowledge making, albeit one that ends, paradoxically, in mystery:

The use of the great mechanical powers may indeed sometimes be compatible with the due exercise of our own: but the uses of instruments for exaggerating the powers of sight necessarily deprives us of the best pleasures of sight. A flower is to be watched as it grows, in its associations with the earth, the air, and the dew; its leaves are to be seen as they expand in the sunshine; its colours, as they embroider the field, to illumine the forest. Dissect or magnify them, and all you discover or learn at last will be that oaks, roses, and daisies are all made of fibres and bubbles; and these again, of charcoal and water; but, for all their peeping and probing, nobody knows how.⁴³

Ecology, nature in all its varied interactions, remains within the realm of the visible: the humanly visible.

That said, Ruskin sometimes conceded the limited value in examining a landscape with a telescope, or under a microscope. Above all, Ruskin was ambivalent in his approach to technology because he was concerned that technological progress and moral regression went hand in hand, writing: 'I do not often invite my readers to use a microscope; but for once and a little while, we will take the tormenting aid of it'.⁴⁴ This concession was prompted by the wish to understand the structures of a bird's feather with the aim of improving one's drawing of it. And, as a word of warning against trying too hard for a perfect finish on the completed artwork, Ruskin advised: 'take a good magnifying-glass to our miracle skill, and the invisible edge is a jagged saw, and the silky thread a rugged cable, and the soft surface a granite desert'.⁴⁵ Significantly, Ruskin concludes this list of the microscopically visible and the molar equivalences with a geological analogy. Isobel Armstrong has described Ruskin's 'hostility to [microscopy's] intense phenomenological disturbance in the visual field'. While Ruskin's hatred of the mediation of the microscope is 'often read as archaic and reactionary', Armstrong recognised it as actually indicating 'an argument about ways of knowing'.⁴⁶

Mountain writing

Tyndall and Ruskin shared a common territory, the Alps, to which they were deeply attached. In their writings they had both common and contrasting approaches. As to



Fig. 10.2
Edward Whymper,
*The Weisshorn
from the Riffel*.
Engraving,
reproduced in John
Tyndall, *Hours
of Exercise in the
Alps* (London:
Longmans & Co.,
1871). Facing p.
91.

their commonalities, I have highlighted their shared reliance upon empirical practices of observation. As to their contrasts, I have focused on Ruskin's and Tyndall's attitudes to scale. One further relevant contrast concerns how Tyndall repeatedly, vividly figured

himself mid-ascent in his writings, while Ruskin's subjectivity has a more ambiguous status. In *Hours of Exercise in the Alps*, Tyndall gave experiential accounts of climbing, utilising dramatic language such as 'disaster on', 'ascent of', 'assault on', 'rescue from', 'adventure on', 'death on', referring to the regional peaks such as the Matterhorn, Weisshorn, Jungfrau, Mont Blanc, Piz Morteratsch, and Aletschhorn. Tyndall's party, comprising himself and two extraordinarily skilled local guides, Johann Joseph Bennen and Ulrich Wenger, were first to achieve the scaling of the Weisshorn.⁴⁷ A pair of competing climbers, who had followed them up to the halfway point, turned back and saw Tyndall's team 'as three flies upon the summit of the mountain'.⁴⁸ In *Hours of Exercise in the Alps*, the Weisshorn is illustrated with an engraving (Fig. 10.2). The right side of the white peak was the path followed by Tyndall's team, and in the foreground at a lower height three miniscule figures can be seen assembled perhaps in brief rest or conversation. Given the story of their scaling the Weisshorn, we can take these figures to represent Tyndall, Bennen, and Wenger. Tyndall's account of this ascent of and return from the Weisshorn includes effusive descriptive passages on the colour effects of the sunset in the mountains, along with accounts of the bodily sensations of cold and exposure. In describing the methods of the climb, such as cutting footholds with the axe and discerning safe passage across snow-filled crevasses and rock faces, Tyndall's accounts describe the guides' tacit knowledge of snow structure—when to trust it to support a body—and the animal wisdom of the chamois (a type of goat-antelope) on its crossing of the mountain side. He shared reflections on the body's necessary contortions—of toe, hand, wrist, and arm—combined with the mental effort required to persist, supported at points by jingoism, or fortified by champagne.

Turning to Ruskin, Peter Garrett argues that Ruskin's work has been misconstrued, with critics 'tending to lodge it in one of two incongruous regimes of thought: either inside a fading era of English romanticism, or instead within an emerging rhetorical counter-paradigm of scientific fact and objectivity'. Ruskin was himself guilty of misconstruing and oversimplifying the position of Tyndall as a reductionist materialist, perhaps knowingly or not. As a corrective, Garrett argues that *Modern Painters* should be seen as a kind of 'epistemological aesthetic', claiming that the five volumes of art criticism and natural history, in shape, texture and argument, can be read as an extended empiricist drama'. What is more, '[e]ven in passages describing mountainous landscapes or the properties of clouds, his persona mediates between reader and any objects it conjures'.⁴⁹ In this way, Ruskin both exhorts the disappearance of the subject in observation while simultaneously foregrounding his own self as narrator. It could be argued that Ruskin makes his assault upon the Matterhorn and other peaks through language: although Ruskin exhorts his readers to look beyond themselves in looking out to nature, paradoxically, Ruskin's subjectivity is foregrounded, not erased, in the process of the writing.

By contrast, we have the following passing but revealing description by Tyndall of the effects of scaling the Weisshorn: 'I was astonished on the morrow to find the loose atoms of my body knitted so firmly by so brief a rest'.⁵⁰ It is as though the physical exertion and extremes of scale have brought about a temporary dissolution in his material self, albeit one that is reversed after a good night's sleep. In fact, arguably Tyndall did not just lose material cohesion on the Weisshorn, his very subjectivity was overcome by his intense, immediate bodily sensations. Here Tyndall gives credit to the dependence of his subjectivity upon the temporary cohesiveness of a molecular flow. The mountains are a test of this via extreme physical exertion that threatens the dissolution of the subject, in a way quite contrary to the firm (albeit ambiguous) establishment of Ruskin's voice through his writing. The day after scaling the Weisshorn, Tyndall wrote a

letter to his friend Michael Faraday describing his inability to transcribe the experience of summiting:

I opened my note-book to write a few words concerning the view, but I was absolutely unable to do so. There was something incongruous, if not profane, in allowing descriptive faculty to meddle with that which belonged to the soul alone, so I resigned myself up to the silent contemplation of the scene, completely overpowered and subdued by its unspeakable magnificence.⁵¹

Ruskin generally misconstrued Tyndall, caricaturing his beliefs as reductionist, possibly as a foil to Ruskin's own argument. Whereas the truth was: Tyndall's mode of understanding was a scientific naturalism based upon a holistic vision. Tyndall was deeply affected by the senses in his encounter with mountain landscape (even if he could not always put it into words as well as William Wordsworth, Percy Bysshe Shelley, or indeed Ruskin) and his interpretation of the wonder of the natural world was, as Ruth Barton has also observed, scientific naturalism with a pantheist underpinning rather than simple scientific reductionism and atheism.⁵²

By paying attention to their different attitudes to scale, we can evaluate the different balances struck by Ruskin and Tyndall at different times in their writings between a humanist understanding of nature and what we could call a post-anthropocentric ecology. Ultimately, these two conceptualisations of the other-than-human can never be wholly extricated from each other in either Ruskin's or Tyndall's structures of thought. This ambiguity is rich ground for contemporary ecological thinking, the path to which has been illuminated here by my study of scale.

Landscape and mountainscape

Returning to the concept of landscape level as I laid it out in the introduction, while staying in the Alps writing his address on 'The Scientific Uses of the Imagination' Tyndall made use of a landscape metaphor. This landscape metaphor is employed so as to comment upon the contrasting scales of the molar and the molecular, and to invite imaginative speculation to upscale and downscale beyond the realm of bodily perception, that is to say, beyond the anthropocentrism of the human scale (a stark contrast to Ruskin's emphatic insistence upon the bodily scales of sense perception). Tyndall refers to the doctrine of relativity, that impressions made are dependent on circumstance or previous state:

Two travellers upon the same height; the one having ascended to it from the plain, the other having descended to it from a higher elevation, will be differently affected by the scene around them. To the one nature is expanding, to the other it is contracting, and impressions which have two such different antecedent states are sure to differ. In our scientific judgments the law of relativity may also play an important part. To two men, one educated in the school of the senses, having mainly occupied himself with observation: the other educated in the school of imagination as well, and exercised in the conceptions of atoms and molecules, to which we have so frequently referred, a bit of matter, say 1/50,000th of an inch in diameter, will present itself differently. The one descends from the molar heights, the other climbs from his molecular lowlands. To one it appears small, to the other large.⁵³

Tyndall may be making a reply to Ruskin and Ruskin's supporters here. In a sense this passage tells of the meeting between these two men, both 'travellers upon the same height' as they hiked through the landscape that they both loved, Ruskin descending from the lofty heights and grounding everything in visual perception on the human scale, Tyndall on the ascent from molecular lowlands, skilled in observation *plus* imaginative discovery of the other-than-human scales.

Actual encounters between Ruskin and Tyndall on these crowded mountainsides may not have been inconceivable, but I would propose as a thought exercise that we speculate on a larger gathering on the mountainside. Let us imagine joining this meeting between Ruskin and Tyndall and perhaps bringing some conciliatory interventions into what may have been an otherwise irascible exchange, in the form of the figure of Henry Clifton Sorby (1826–1908). Sorby, a friend of Ruskin, developed the technique of petrography, a lithological identification procedure aiding the study of the way thin slices of rock transmitted—rather than reflected—light. In his address to Sheffield Literary and Philosophical Society at Firth College in 1897, Sorby recounted:

In those early days people laughed at me. They quoted Saussure who has said that it was not a proper thing to examine mountains with microscopes, and ridiculed my action in every way. Most luckily I took no notice of them.⁵⁴

We might imagine, then, Sorby contributing an argument for the application of microscopic investigation into the materiality of the mountain rock upon which they all met, and thus we might construe Sorby as a stepping stone between the molar and molecular of mountain experience. It is not clear that Sorby gives a fair account of Horace Bénédict de Saussure's opinion.⁵⁵ Any of these men—Tyndall, Sorby or Ruskin—might have invoked de Saussure's name to their own purposes: Tyndall, in the service of the molecular, invisible particles of air in the skies of the Alps, and of the mountaineer remarking on the unknitting of the very molecules of his own body by fatigue; Sorby, in the service of his microscopic examination of the geological samples that he collected en route through the mountains; Ruskin in the service of a willingness to engage with the theories of the geologist, yet without losing touch with the holistic and the human, and in the service of seeing the 'true' vision of the landscape at a scale that affirms human sensation, captured and communicated with the scientist's powers of accurate description.

As it happens, Horace Bénédict de Saussure's great grandson was Ferdinand de Saussure (1857–1913), who brought a structuralist approach to the study of language, proposing the theory of the sign, signified, and signifier, and laying the groundwork for semiotics, structuralism, and post-structuralism. Saussurian structuralism made way, in turn, for post-structuralism and the work of Gilles Deleuze and Félix Guattari, who would return once more to Spinozist monism and the very *Naturphilosophie* shared, in fact, by Tyndall and Ruskin, as Dear explains in his article 'Romanticism and Victorian Scientific Naturalism' (2015).⁵⁶

Deleuze and Guattari adopted the terms molar and molecular to describe two ways of seeing or two epistemological tendencies: the molar, signifying the unitary and whole, the stabilised, the being; the molecular, signifying flow, the dynamic, and becoming. In Deleuze and Guattari, molar and molecular are scalar differences but qualitative differences too: the molar operates on a macro level and is rigid, the molecular is open to flows and becoming. The molecular pertains to the animal modes of relating and the line of flight. The molar are those entities that appear as stable coherences to the naked eye, the scale at which Ruskin preferred the encounter; on

the molecular level, molar entities are revealed as dynamic and unstable, in a mode of becoming, constituted by changes and flows.⁵⁷ The scalar distinctions, ambivalences, and interrelations I have been exploring in Tyndall and Ruskin are seen to continue to structure ecological critical thought.

Congruence of different worldviews

I suggest that the argument between Ruskin and Tyndall as they meet at the same height on the mountainside, having arrived there respectively from molar descent and molecular ascent, is one to do with the necessity of molecular observation to support the understanding of the multi-scalar inter-relations of ecological phenomena, decentring the human. The new materialist approach in ecocriticism recognises that matter and meaning are co-constitutional. In a new materialist account of ecocriticism, the writing of any nature observation, in its construal of a discrete subjectivity or its performance of the dissolution of the subject, is participating in the ecology it describes.⁵⁸ For an accurate comprehension of ecology one must abandon attachment to the human perspective and the preference for the human scale, so, leave Ruskin behind on the mountainside. On the other hand, I would argue that human concern for ecological care needs to be activated via descriptive rhetoric on a human scale and an appeal to the senses. This is where we engage with Ruskin on the mountain. In reality, these two levels (scales) are always at play and interplaying.

In this chapter, I have argued that a multi-scalar analysis of complex ecological systems should take place in relation to the human scale, where our ecological awareness ultimately resides. From the tiniest elements, beyond the view of the microscope, to the global, the study of ecology has scalar relations at its heart. The scales at which observations are made are known to have consequences for the patterns of relationship that manifest. For example, scalar changes in observation may reveal interpretive shifts from a closed to an open system. Ecologists have discussed the additional problem posed by language in dealing with ecology's multi-scalar complexity, and have, as Allen points out, made the mistake of taking the description of levels of organisation to be actually existing realities in the world. Allen gives the notion of 'landscape level' as an example of this misapprehension of ecological reality contrived to fit with a human preference for a scale humanly recognisable when making their interpretations.

Ruskin picked arguments with Tyndall over the appropriate scales of encounter with the mountains, taking account of Tyndall's advocacy for imagining the molecular and deep geological time while ignoring his admiration for mystery beyond the scope of science, while Ruskin himself spoke up for the scale of human aesthetic sensation. In our current time, the Anthropocene has been proposed as the name for the geological period in which the consequence of human action has become globally present in human-caused deposits, making a mark and becoming legible in the geological record.⁵⁹ The naming of this as the Anthropocene connects human temporality with geological time and is seen by some as hubristic. This notion of the hubristic Anthropocene might be seen as similar to the humanistic anthropocentrism demonstrated by Ruskin as he ruminated on the geological time of mountains that might witness the 'collateral progress of humanity'. For the geologist today, to accept this new category means recognising a boundary, measured by stratigraphic markings: a signal in the rocks, a kind of mountain writing, recorded by an other-than-human agency.

The future of our world rests on a meeting on the mountainside of different worldviews: the points of view that consider nature through a humanist frame and

the post-human ecological *Umwelt*. Tyndall frequently described the experience of encountering the extremes of scale beyond human measure as bewildering. To bewilder, in its archaic meaning, suggests to lead astray or to lure into the wilds. On the descent from the Weisshorn, Tyndall explained that at the point when they had almost lost their way, the guides made use of the previous day's observation of 'a solitary chamois moving along the precipice'. They fixed the place in their memory and in this moment of urgent need 'they sought the traces of the chamois, found them, and were guided by them to the only place where escape in any reasonable time was possible'.⁶⁰

The post-human decentring potential of ecological thinking and new materialism is bewildering. But our understanding of the multi-scalar ecological relationships, including the human, and other-than-human *Umwelts* that participate in meaning-making are all important for our survival. In the end, I offer this anecdote of human reliance on other-than-human *Umwelt* as an allegory for the urgent imperative for us to attend to scale beyond human measure. As with scale within ecology, sometimes it is not a question of merely upscaling or downscaling but one of a qualitative translation between the human and other-than-human worlds. Ruskin's thinking may seem to support a holism that sits well with current ecological understandings of the interconnectedness and dynamic relations of all things, with all things, and may have been a counter to the reductive scientific materialism of his time. However, his thinking fails in as much as its dedication to the scale of the human sensorium risks leading to fallacious conclusions regarding our ecological observations. According to Tyndall, scientific imagination enables a crucial scalar leap, enabling, in turn, the decentring of the human in new materialist thinking. Tyndall claims that scientific imagination allows for the human mind to follow the scalar leap, yet he has recourse to a metaphor on a human scale, the descent and ascent in the landscape. But he also invokes the example of the chamois—the other-than-human guide—and the possibility of following in the footsteps of the mountain goat in translation from a human to other-than-human understanding of ecology. Even as ecological understanding supports the decentring of the human in new materialist thinking, there is still the call to give an aesthetic appeal via the human scale, allowing us to follow these ecological arguments. I argue that this is where the value of Ruskin lies. From this perspective, Ruskin's drawings of animals take on a whole new value. As regards our escape in any reasonable time from our current ecological predicament, like Tyndall's climbing party, we must 'seek the traces of the chamois'.

Coda

Following in the footsteps of the mountain goat, I offer what might seem to be a digression into my parallel practice as an artist, although I propose this as a demonstration of what my chapter advocates: the capacity to move across practices and disciplines, that is, translations. The influence of the thought and work of Ruskin as an artist and writer is discernible in my second solo show at Danielle Arnaud, London, in 2020 titled *Architecture for an Extinct Planet*. In it there are aspects of the exploration of scale and the human as mountain. *Alpine Architecture* is a series of watercolours, although directly referencing the work of Bruno Taut in his c.1917 book of the same name of utopian visions for an Alpine city of glass, it also references the Alpine landscape of the topic of this chapter (Figs. 10.3 and 10.4).⁶¹ It is a watercolour practice of observational studies of iconic mountain peaks, some of which Tyndall may have climbed and all of which Ruskin would have admired. In addition are the transparent and colourful geometric shapes balancing on the apex of each named mountain. I had in



Fig. 10.3
Polly Gould, *Alpine Architecture: Dent du Géant* (2017).
Watercolour on paper, 38 × 58 cm.
Photo: © Polly Gould 2020. All rights reserved.

mind the many modest huts that provide mountain refuges in the harsh environment for those climbers en route to the summit, as well as the often architecturally extraordinary and ecologically inventive contemporary designs for Alpine huts. In a series of watercolours, after Bruno Taut, I propose the geometric architectural confections of

Fig. 10.4
Polly Gould, *Alpine
Architecture: Piz
Roseg* (2017).
Watercolour on
paper, 38 × 58 cm.
Photo: © Polly
Gould 2020. All
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disproportionate scale as fantastic projects of building at the top of the world, extending the highest peaks that nature has to offer with human constructions. Can we inhabit these landscapes? Should we indulge our human hubris in these ambitions? Can these

Fig. 10.5
Polly Gould,
*Paper Architecture:
Matterhorn* (2020).
Inkjet print on
paper and thread,
30 × 42 cm.
Photo: © Polly
Gould 2020. All
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experiments prepare us for survival in inhospitable environments? I have painted these works in watercolour which then provided the source imagery for the subsequent sequence titled *Paper Architecture*, made from inkjet print on paper, folded and stitched with thread into semi-relief pieces (Figs. 10.5 and 10.6). This iteration in a Japanese paper that behaves like fabric was then upscaled into the installation *The Crystal Chain: habit/refuge* as a set of wearable dress versions of the mountainscapes with architectural mask/headdresses and installed on five mannequins (Figs. 10.7, 10.8, and 10.9). The paper tent-like mountain range offers a scaling-up from the watercolour pieces into

Fig. 10.6
Polly Gould, *Paper
Architecture: Mont
Blanc* (2020). Inkjet
print on paper and
thread, 30 × 42
cm. Photo: © Polly
Gould 2020. All
rights reserved.

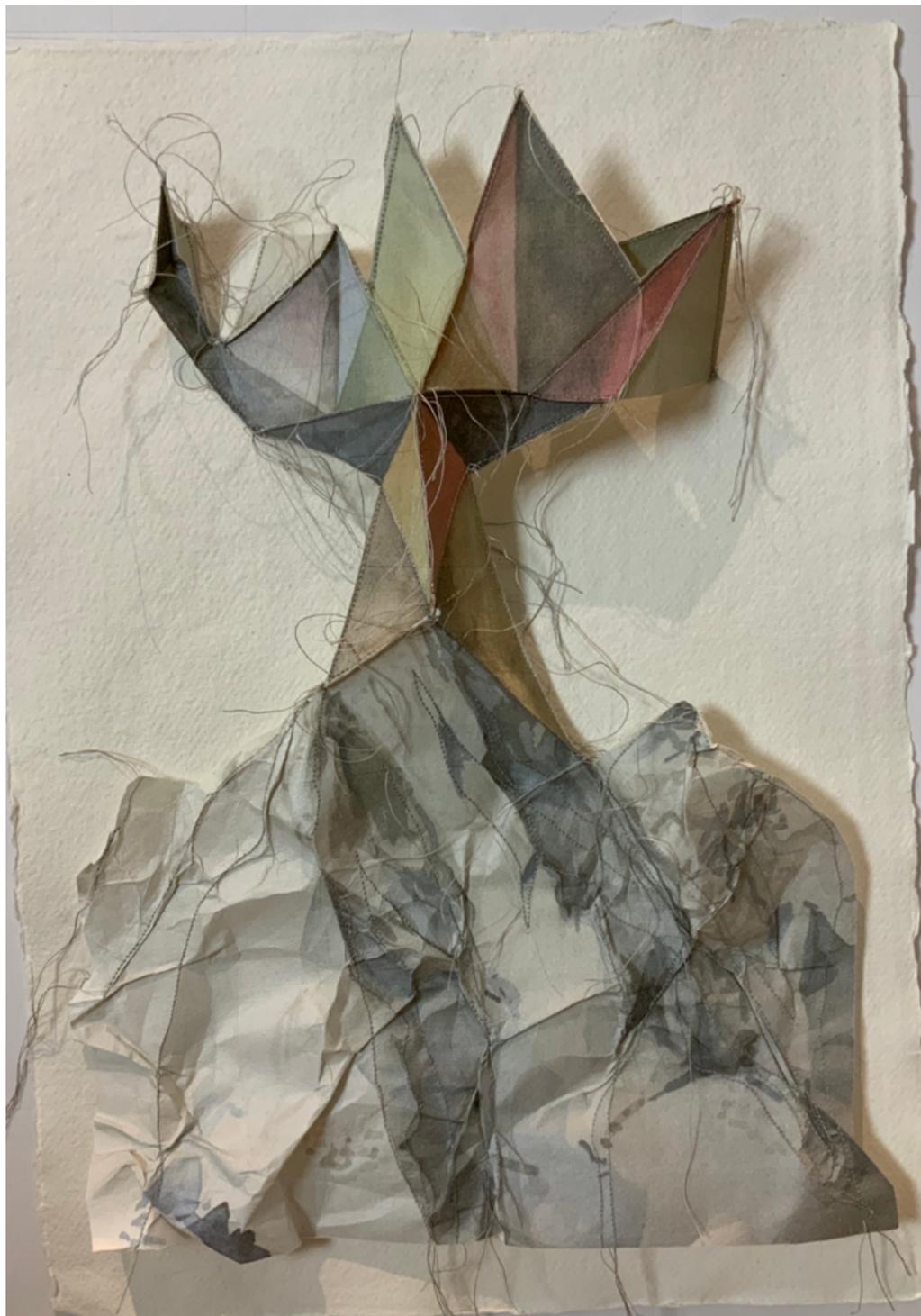


Fig. 10.7
Polly Gould, *The
Crystal Chain:
habit/refuge* (2020).
Paper, inkjet print,
watercolour, thread,
and mannequins,
dimensions
variable.
Photo: © Polly
Gould 2020. All
rights reserved.



Fig. 10.8
Detail of figure
10.9.



Fig. 10.9
Polly Gould, *The
Crystal Chain:
habit/refuge* (2020).
Paper, inkjet print,
watercolour, thread,
and mannequins,
dimensions
variable.
Photo: Oskar
Proctor. © Polly
Gould 2020. All
rights reserved.



a human-sized wearable range of outfits that anthropomorphises the mountain while simultaneously miniaturising it. The paper mountain and the headdresses suggest a carnivalesque pageant or some secretive cultish practice celebrating becoming mountain, or a fashion show, or a multifunctional dress as habitat, a personal protective costume/tent. These pieces attend to the scale beyond the human, and gesture towards the other-than-human agencies of mountain landscape while appealing to the narrative of a human size and the dimensions of human encounter.

1. Ecocriticism was coined by William Rueckert in his 1978 essay entitled 'Literature and Ecology: An Experiment in Ecocriticism'. As Cheryll Glotfelty puts it, 'ecocriticism is the study of the relationship between literature and the physical environment', Cheryll Glotfelty and Harold Fromm, *The Ecocriticism Reader: Landmarks in Literary Ecology* (Athens GA and London: The University of Georgia Press, 1996), p. xvii.
2. See Amedeo Avogadro's 1811 'Essay on a Manner of Determining the Relative Masses of the Elementary Molecules of Bodies, and Proportions in Which They Enter into These Compounds', translated in John Dalton, Joseph Louis Gay-Lussac, and Amedeo Avogadro, *Foundations of Molecular Theory, Comprising Papers and Extracts*, (ed. and trans.) J. Walker (Edinburgh: W. F. Clay, 1893), pp. 28–51. This essay is available online at the Wellcome Collection, London, accessed 10 November 2020, <https://wellcomecollection.org/works/yqn5s2wd/items?canvas=55&langCode=eng&sierraId=b2168764x>.
3. James Clerk Maxwell, 'Molecules', *Nature* (September 1873): pp. 437–47.
4. See the definition in Encyclopaedia Britannica, accessed 10 November 2020, <https://www.britannica.com/science/Avogadros-number>.
5. Eugene P. Odum, *Ecology* (New York: Holt, Rinehart, and Winston, 1963).
6. Simon A. Levin, 'The Problem of Pattern and Scale in Ecology', *Ecology*, 73:6 (1992): p. 1943.
7. David L. Peterson, and V. Thomas Parker (eds.), *Ecological Scale: Theory and Applications* (New York: Columbia University Press, 1998), p. xi.
8. Jakob von Uexküll, *Theoretische Biologie* (Berlin: Verlag von Gebrüder Paetel, 1920), and Jakob von Uexküll, *Umwelt und Innenwelt der Tiere* (Berlin: J. Springer, 1909).
9. Gregory Bateson, *Steps to an Ecology of Mind* (San Francisco: Chandler Publishing, 1972).
10. Dušan Gálik, 'Biosemiotics: A New Science of Biology?', *Filozofia* 68:10 (2013): p. 860.
11. Levin, 'The Problem of Pattern and Scale in Ecology', p. 1943.
12. David C. Schneider, 'The Rise of the Concept of Scale in Ecology', *BioScience* 51:7 (2001): p. 545.
13. Robert V. O'Neill and Anthony W. King, 'Homage to St. Michael; or, why are there so many books on Scale?', in Peterson and Parker (eds.), *Ecological Scale*, pp. 5–7.
14. O'Neill and King, 'Homage to St. Michael', p. 11.
15. T. F. H. Allen, 'The Landscape "Level" is Dead', in Peterson and Parker (eds.), *Ecological Scale*, p. 37.
16. Allen, 'The Landscape "Level" is Dead', p. 37.
17. Allen, 'The Landscape "Level" is Dead', p. 38.
18. Allen, 'The Landscape "Level" is Dead', p. 42.
19. Roland Jackson has recently brought attention to this fact in his blog entry, 'John Tyndall and John Ruskin', 12 September 2018, accessed 10 November 2020, <https://www.rolandjackson.co.uk/post/2018/09/12/john-tyndall-and-john-ruskin>. See Roland Jackson, *The Ascent of John Tyndall: Victorian Scientist, Mountaineer, and Public Intellectual* (Oxford: Oxford University Press, 2018). See also: Francis O'Gorman, 'Ruskin's "Fors Clavigera" of October 1873: an unpublished letter from Carlyle to Tyndall', *Notes and Queries*, 43:4 (1996): p. 430; Silvana Cardoso, Julyan Cartwright, and Herbert Huppert, 'Stokes, Tyndall, Ruskin and the Nineteenth-Century Beginnings of Climate Science', *Philosophical Transactions of the Royal Society* 378:2174 (2020), accessed 10 November 2020, doi: 10.1098/rsta.2020.0064.
20. Ruskin, 27.625–47 (Letter 34 of *Fors Clavigera: Letters to the Labourers and Workmen of Great Britain*, October 1873).
21. Paul L. Sawyer, 'Ruskin and Tyndall: The Poetry of Matter and the Poetry of Spirit', *Annals of the New York Academy of Sciences* 360, *Victorian Science and Victorian Values: Literary Perspectives* (1981): p. 217, accessed 10 November 2020, doi: 10.1111/j.1749-6632.1981.tb20707.x
22. Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2007).
23. Peter Dear, 'Romanticism and Victorian Scientific Naturalism', *European Romantic Review*, 26:3 (2015): pp. 329–40. There are further parallels with the Spinozist monism in post-structuralism and new materialism in the works of Gilles Deleuze and Félix Guattari, Rosi Braidotti, Karen Barad, Manuel De Landa, and Bruno Latour.
24. Ruskin, 19.292 (*The Queen of the Air*, 1869). See also my essay, Polly Gould, 'Ruskin's Storm-Cloud and Tyndall's Blue Sky: New Materialist Diffractions of Nineteenth-Century Atmospheres', in Maura Coughlin and Emily Gephart (eds.), *Ecocriticism and the Anthropocene in Nineteenth-Century Art and Visual Culture* (London: Routledge, 2020), pp. 115–32.
25. Ruskin, 35.116 (*Praeterita*, 1885–9).
26. Ruskin, 'Facts and Considerations on the Strata of Mont Blanc, and on some Instances of Twisted Strata observable in Switzerland', *Magazine of Natural History* 7 (March 1834): pp. 644–5.
27. John Tyndall, *Hours of Exercise in the Alps* (London: Longmans Green, and Co., 1871), p. vii.
28. John Tyndall, *Essays on the Use and Limit of the Imagination in Science* (London: Longmans Green, and Co., 1870), p. 13.
29. Tyndall, *Hours of Exercise in the Alps*, pp. 232–3.
30. Tyndall, *Essays on the Use and Limit of the Imagination in Science*, pp. 25, 27.
31. Tyndall, *Essays on the Use and Limit of the Imagination in Science*, p. 35.
32. Ruskin, 34.27 (*The Storm-Cloud of the Nineteenth Century*, 1884).
33. Edward Alexander, 'Ruskin and Science', *The Modern Language Review* 64:3 (1969): pp. 508–21.
34. Ruskin, 19.292 (*The Queen of the Air*, 1869).
35. Ruskin, 19.202.
36. John Tyndall, 'Old Alpine Jottings', in *New Fragments* [1892] (New York and London: D. Appleton and Company, 1915), p. 451.
37. Ruskin, 26.3 ('On the Forms of the Stratified Alps of

- Savoy', 1863), quoted in Ella Mershon, 'Ruskin's Dust', *Victorian Studies* 58:3 (2016): p. 479.
38. Mershon, 'Ruskin's Dust', p. 480.
 39. Ruskin, 7.475 (*Modern Painters* 5, 1860).
 40. Ruskin, 12.331 (Letter to *The Times*, 5 May, 'The Light of the World', 1854).
 41. Ruskin, 12.331–2. This discussion of Ruskin, Pre-Raphaelite painting, and enhanced vision parallels John Holmes in *The Pre-Raphaelites and Science* (New Haven and London: Yale University Press, 2018).
 42. Ruskin, 33.353–4 (*The Art of England*, 1883).
 43. Ruskin, 35.430 (*Praeterita*, 1885–9).
 44. Ruskin, 15.405 (*The Laws of Fésole*, 1877–8). This is quoted by Alan Davis, 'Technology', in Francis O'Gorman (ed.), *The Cambridge Companion to John Ruskin* (Cambridge: Cambridge University Press), p. 173.
 45. Ruskin, 5.154 (*Modern Painters* 3, 1856).
 46. Isobel Armstrong, 'The Microscope: Mediations of the sub-Visible World', in Roger Lockhurst and Josephine McDonagh (eds.), *Transactions and Encounters: Science and Culture in the Nineteenth Century* (Manchester: Manchester University Press, 2002), pp. 31, 43.
 47. Tyndall climbed the Weisshorn in August 1861 with the guides Bennen and Wenger. Bennen died in a mountaineering accident in 1864. See Tyndall, *Hours of Exercise in the Alps*, pp. 91–113, and 'Death of Bennen on the Haut de Cry, by Philip C. Gossett', pp. 194–207.
 48. Tyndall, *Hours of Exercise in the Alps*, p. 105.
 49. Peter Garrett, 'Ruskin's *Modern Painters* and the Visual Language of Reality', *Journal of Victorian Culture* 14:1 (2009): pp. 54, 55, 60.
 50. Tyndall, *Hours of Exercise in the Alps*, p. 113.
 51. Tyndall cited in Jackson, *The Ascent of John Tyndall*, p. 227. Also see John Tyndall, *Mountaineering in 1861: A Vacation Tour* (London: Longman, Green, Longman, and Roberts, 1862), p. 58.
 52. Ruth Barton, 'John Tyndall, Pantheist: A Rereading of the Belfast Address', *Osiris* 3 (1987): pp. 111–34.
 53. Tyndall, *Essays on the Use and Limit of the Imagination in Science*, p. 38–9.
 54. Henry Clifton Sorby, address to the Sheffield Literary and Philosophical Society at Firth College in 1897, quoted in Klaus Hentschel, *Visual Cultures in Science and Technology: A Comparative History* (Oxford: Oxford University Press, 2014), p. 106.
 55. The point being that de Saussure had died in 1799, so prior to any moment when he may have been able to comment on Sorby's practice, in which case this was the opinion of others speaking for de Saussure, but in a way that seems to contradict de Saussure's own ethos and openness to microscopy.
 56. Dear, 'Romanticism and Victorian Scientific Naturalism'.
 57. See Gilles Deleuze and Félix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia* [1980], (trans.) Brian Massumi (Minneapolis: University of Minnesota Press, 1987).
 58. Serenella Iovino and Serpil Oppermann (eds.), *Material Ecocriticism* (Bloomington and Indianapolis: Indiana University Press, 2014). See especially pp. 1–17.
 59. 'Anthropocene' was coined as a term by Paul Crutzen and Eugene Stoemer to indicate the increasing influence of humans on the Earth. Paul J. Crutzen, 'Geology of Mankind', *Nature* 415:23 (2002).
 60. Tyndall, *Hours of Exercise in the Alps*, p. 112.
 61. Bruno Taut, *Alpine Architecture* [c.1917], (trans.) Matthias Schirren (New York and London: Prestel, 2004).

Seeing Stars of Light: Plate Three of *The Seven Lamps of Architecture*

COURTNEY SKIPTON LONG