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The Sublime in Popular Science

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Abstract

There are two ironies in the popular science genre. First, it seeks to simplify even as it confounds. Authors in this genre have simultaneously to evoke awe-inspiring, sublime imagery, while also rendering the content easily accessible to a non-expert audience. Second, in doing so they undermine the naive realism of empiricist science and the liberal humanist subject that is their implied reader. The first irony occurs because of the use of the *epistemological sublime*, which is a rough cognate with *awe*, or *wonder* and which is the sublime of the eighteenth century, including that of Kant. The second irony is disclosed because of what I call the *ontological sublime*, characteristic of late twentieth-century theories of the sublime.

The ontological sublime is more radical than the epistemological sublime and is especially prominent in the writings of Zizek. Rather than being triggered by the limits of knowledge or imagination — as happens with awe and wonder — it calls into question ontological categories, including the integrity of reality, or indeed the coherence of the subject having the sublime experience. And rather than being self-affirming, it is an ambivalent effect and can be seen as self-abnegating or, more frequently, disruptive of the notion of selfhood entirely.

I perform a textual analysis and trace the paradoxes, aporias and undecidables that modern science discloses even in texts that aim to simplify and vulgarise. In each chapter I examine representative texts from a subgenre of popular science. Chapter 1 looks at cosmology where scientific confidence is at its greatest and so an essentially Kantian sublime is evident. In Chapter 2 I examine quantum physics, where most popular texts merely refer to the "weirdness" of the quantum realm without explicitly mentioning the extremely unintuitive phenomena of quantum experiments and their implications. This includes the literal existence of multitudes of parallel universes containing innumerable doppelgangers of the reader. Thus a vacuum sits at the heart of almost all texts purporting to explain the quantum.

Chapter 3 defines a new subgenre of texts about microbiology (and molecular biology, biochemistry and overlapping disciplines). Here, the subject is dissolved into trillions of cells and subsumed into a planetary cycle of elements. A strong ecological message pervades this subgenre and the notion of a subject *entangled* with nature is

offered. I turn to evolutionary biology in Chapter 4, where an attempt is made to reaffirm the liberal humanist subject. Although evolution places *Homo sapiens* on a continuum with other species, authors use a kind of metalepsis to implicate the reader in the narrative they are telling. By narrating an "evolutionary epic" — which starts at the origin of life and culminates in a species capable of understanding this very epic — evolutionary biologists frame the human as protagonist, reader and writer.

In Chapter 5, I find that popular neuroscience texts contain a direct assault on the liberal humanist subject, calling into question the nature of consciousness and subjectivity itself. At the same time these texts offer a perspective on reading and on centuries old debates over the sublime.

Overall, I find that the popular science genre does reiterate scientific hero myths and rhetorical defences of Big Science, as previous commentators on the genre have noted. But it also obliquely offers a strange and radical worldview, entirely in keeping with contemporary theory, including poststructuralism and the "ontological turn".

Declaration by author

This thesis *is composed of my original work, and contains* no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others to jointly-authored works that I have included in my thesis.

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INTRODUCTION

The popular science genre is deeply ironic. It claims to demystify esoteric science for a non-expert audience. And yet at the same time there are commercial and rhetorical incentives to make science look impressive. This is achieved with awe-inspiring, sublime imagery that dwarfs the reader or exceeds their comprehension. Therefore the genre aims simultaneously to simplify and confound. But there is a stranger irony in the imagery of popular science. The aesthetic of the sublime in poetry and painting from the last 300 years — with its cloud-capped mountains, starry skies and mathematical infinities — certainly *seems* to be echoed in this popular non-fiction genre. Yet the real sublime evinced by these texts is much more extreme and concerns paradoxes, voids in the heart of reality and the estrangement of the reader from themselves. Previous commentators on the genre have noted the appeal to wonder as an aid to selling books and promoting the cultural importance of science. But they have overlooked the sweeping metaphysical implications of ideas and imagery that go well beyond vast phenomena and incomprehensible scales. What appears at the margins of these texts is nothing like the naive empiricism or straightjacketed materialism that is the public philosophy of most well-known scientists. Rather, *the sublime in popular science is ontologically radical.*

Much of what is written about the sublime still assumes an eighteenth-century version of the experience: an encounter with purely epistemological limits experienced by a rational, Enlightenment-era subject. But this experience is closer to what we now call *awe* or *wonder*. The sublime is still a valuable concept but should refer now to an experience of ontological limits or voids. And the subject involved is a post-Kantian, postmodern subject whose status is further questioned or undermined in the experience of the ontological sublime. The five subgenres of popular science that I examine foreground the ontological implications of modern science to different degrees. But in all of the subgenres, attempts at awe-inspiring imagery and wonder-inducing scientific factoids disclose more troubling ontological abysses.

Because other scholars have paid close attention to the rhetoric of popular science, I focus on the sublime and the implicit philosophical themes raised by the texts. I read the genre as I would read modernist or postmodernist fiction, because I think it has similarly challenging ideas about subjectivity, reading and modernity. Each chapter examines a subgenre, for example, cosmology in Chapter 1, or

evolutionary biology in Chapter 4. I introduce the relevant theoretical ideas regarding the sublime, ontology and subjectivity as they arise. In this introduction I offer some brief remarks on the difficult nature of the concept of the sublime, the general significance of the popular science genre, my approach to reading that genre and a brief chapter summary.

The tradition of the sublime

It is standard to remark that the sublime is difficult or impossible to define. The commonest working definition is probably Edmund Burke's formulation of the sublime as a feeling of "delightful horror" (67, 123) prompted by objects so vast, obscure, powerful, or exotic that they temporarily overwhelm the mind in an ultimately pleasurable experience. Otherwise theorists turn to Immanuel Kant's claim in *The Critique of Judgement* that, "*Sublime* is the name given to what is *absolutely great*" (94; pt. 1, sec. 25; italics in original), which means anything that surpasses the limits of imagination or understanding, but which in doing so awakens us to a superior "supersensible" faculty of reason (106; pt. 1, sec. 27). Friedrich Schiller adapted Kant's ideas but was a pithier writer; in the experience of the sublime, "Our sensuous nature feels its limits but our rational nature feels its superiority, its freedom from limits" (22) allowing us momentarily "to think more than we know" (23). For Burke and Kant this could be instigated by impressive features of the landscape such as mountains, tempests and the starry sky: the prototypical sources of admiration for Romantic poets and painters. But critics ever since have been divided as to whether the sublime properly refers only to these sources or includes their representations in art. And if the sublime quality does not inhere in the object itself, can any object then become a trigger of the sublime, provided the subject is in the right relation to that object, or if the rhetorical or expressive power of the artist is great enough? And if the sublime *is* in the eye of the beholder, then perhaps it is merely a cognitive effect, theoretically caused by *any* stimulus that provokes a delightful horror or exceeds imagination.

These difficulties are exactly what Burke himself was weary of in the introduction to his *A Philosophical Enquiry into the Origin of our Ideas of the Sublime and the Beautiful*, cautioning that any subject examined closely enough may "branch out into infinity" (26). This is the impression one may get by ignoring the

history of the sublime and casting around at recent studies of this or that cultural phenomenon with the word *sublime* appended to an adjective or even a noun. A random sample: the digital sublime, the libertine sublime, the Dickinson sublime, the indigent sublime, the chemical sublime. Some commentators go as far as to say that the sublime is best reserved as a label for what cannot be defined: "It is not a category in itself so much as a term that describes what cannot be categorised" (Tabbi xi). It may seem, therefore, like the sublime is a moribund signifier and indeed the literature on the sublime, nowadays, is a morass. Even apart from the studies that simply deploy the word to indicate some notion of excess or extremity, the scholars who try and produce a theory *of* the sublime are almost as diffuse. There are non-overlapping scholarly traditions in art history, religious studies, continental philosophy, aesthetics and now cognitive science as well. There are closely allied concepts with their own lineages too. There is an excellent recent corpus on the history of *wonder*; a nascent neuroscience of *awe*; theological writings on *transcendence*; and the aesthetics of the *marvellous*, the *astounding*, the *ineffable* and the *uncanny*.[1]

In short, writers in this field are often using several words to refer to the same thing, or refer to several different things with the same word. At times, purely lexical resonances have also impeded scholarship. The fashion for the sublime in eighteenth-century British letters came about arguably via a mistranslation. The first treatise on the sublime is said to be Longinus's *Peri Hypsous* (Περὶ Ὕψους) dating from around 50CE, although the attribution of authorship is questionable and the crucial modern translation in 1674 — *Traité du Sublime* by Nicolas Boileau Despréaux — arguably mistranslated the Greek *hypsous* (high or lofty) as *sublimitas* in Latin and thence *sublime* in French (Costelloe 3). For Nietzsche and for quite a few writers in the late twentieth century, the shared Latin root with *sublimate* (German: *Sublimisierung*) led to questionable psychoanalytic borrowings of the term, so that for some the sublime referred to the opposite of the lofty: that which is hidden, repressed, or underneath (Clewis 12). This despite the fact that what Longinus and later writers had in common — the legitimate link between *hypsous* and *sublime* — was clearly more like Freud's uncanny (*das Unheimliche*) or perhaps

[1] See for instance Daston and Park for wonder, Keltner and Haidt for the neuroscience of awe, Milbank on transcendence, Greenblatt on the marvellous, Gunning on astonishment and the uncanny and Jankélévitch on the ineffable.

the oceanic feeling (*ozeanischen Gefühl*), than to anything else in psychoanalysis.[2] And only recently has study of the sublime and its various cognates in antiquity expanded the scope beyond Longinus, especially with reference to Longinus's apparently major debt to Lucretius and various pre-Socratic philosophers.[3]

The reliance on the Greek–Latin–French–English progression of the term has also blinded most scholars to non-Western traditions that potentially describe similar experiences to whatever we mean by *sublime*. Happily, even over the course of my research project, a new willingness to engage with other traditions has emerged. A recent anthology, *The Sublime Reader* edited by Robert Clewis (a philosopher of aesthetics, specialising in Kant), includes an excerpt from the ancient Sanskrit treatise *Nāṭyaśāstra*; a brief writing by the Chinese painter and art theorist Guo Xi (c.1050CE); and an excerpt from an essay by the fifteenth-century Japanese playwright Zeami Motokiyo, a leading exponent of the *nō* theatrical tradition. From personal study I can attest that the *Tao te Ching* and writings from Advaita Vedanta, particularly the *Upanishads*, contain ideas with a strong affinity to the sublime as it will be explored in this thesis.

Crucially, this broadening in time and space of the textual sources of the sublime has actually focused its conceptual nature. But this is not a work of intellectual history. So instead of conducting a thorough excavation of the concept, I will briefly attend to the most germane contemporary writings on the sublime, using the long history of its cognates simply as a useful reference point to aid in a triangulation of a workable theory.

[2]Note also that Freud himself never felt the oceanic feeling, although others reported it to him and he wondered if it might be the origin of all religious impulse (Freud 9).

[3] See Porter's *The Sublime in Antiquity*. Notably, Lucretius has been identified as not only the originator of the sublime by recent critics such as Janowitz and Porter but also of popular science. Carl Sagan called him "the first popularizer of science" (*Blue Dot* 13). And the mythologist Gregory Schrempp notes in his study of popular science that Lucretius's emphasis on natural explanation, his antagonism towards mysticism and religion and even some of the specific questions he asks are identical to contemporary authors (Schremmp 235n13).

"Is a theory of the sublime possible?"[4]

This is the title of Jane Forsey's 2007 article, around which has circled the most recent scholarship in the analytic, Kantian, aesthetic tradition.[5] Forsey answers in the negative after working through potential routes to a cogent theory. First she notes that one tradition has the *object* of the sublime experience as in some way transcendent (383). But this leads to either an epistemological contradiction — one cannot have access to an object beyond epistemological access — or a "troubling ontological" (387) problem where an object is posited that cannot be known and might as well be "a mere fantasy or hallucination" (383). Forsey credits Kant for shifting the sublime away from the object to the subject's experience. Hence the "generally accepted notion of the sublime as a moment of being overwhelmed by a sense of things as incomprehensible, or more powerful than we are" (382). In other words this makes the sublime a pleasing experience of "cognitive failure" (386). But if a theory is agnostic regarding the nature of the triggering object, then, as Forsey points out, her failure to complete the *New York Times* crossword puzzle (386) might be considered as sublime as crossing the Alps, contemplating infinity, or gazing at a painting by Lee Krasner.

After concluding that "traditional theorizing about the sublime has been mistaken all along" (387), Forsey returns to the phenomenology of the apparently philosophically incoherent sublime experience. In an attempt to salvage a theory, she suggests that the experience of the sublime "is not conceptual" but "perhaps emotional, a kind of feeling" and has "nothing to do with cognition at all" (387). But even then, we face a new paradox. Feelings are either intentional or non-intentional. If they are intentional they are feelings *towards* or *of* certain objects and so resolve

[4]The widest survey of scholarship on the sublime is Holmqvist and Płuciennik. See Lap-Chuen for a valiant attempt at a rigorous theory of the sublime. Clewis, Costelloe, Morley and Trifonova have all edited useful anthologies. For an incisive summary of recent psychological and neuroscientific work on awe, see Oldfather in Trfionova. But all these stick to the epistemological sublime. For a more daring single volume work on the topic, Shaw's recently updated work is catholic in its inclusion of different conceptions of the sublime. Another collection, *Beyond the Finite: The Sublime in Art and Science* (edited by Hoffman and Whyte) includes more interesting — ontological — approaches to the contemporary sublime; see especially the chapter by Stafford. For the sublime in antiquity, see all of Porter's original and wide-ranging work, and Williams whose focus is narrower but illuminating, especially on Lucretius, Seneca and other Latin writers. Cheney's *English Authorship and the Early Modern Sublime* fills another important gap. For cross-cultural perspectives, the literature is thin, but Mishra and Hopkins each make a start.

[5] Forsey herself was responding to an important article by Guy Sircello, "How is a Theory of the Sublime Possible?". The articles of Sircello, Forsey and several others all appeared in *The Journal of Aesthetics and Art Criticism*. Further, a collection entitled *The Possibility of the Sublime* was published in 2017, with Forsey's as a target article and six respondents.

into the same problem of arbitrariness as do cognitive theories of the sublime, as with the crossword puzzle example. And if feelings are non-intentional:

> we are left with some thing that cannot readily be theorized at all: How do we provide a theory of this sort of thing beyond some kind of literary capturing of the feelings as they occur? They take no object and have naught to do with cognition. (387)

Forsey's article seems to offer up a range of problems against which any theory of the sublime would run aground: subjective versus objective, epistemological access, troubling ontologies, cognition versus emotion.

The claim of this thesis is that a cursory perusal of ideas in modern science as represented in popular science texts, utterly undermines all these objections. The "problematic ontological commitments" that Forsey (388) worries a theory of the sublime binds us to are nothing compared to the ontological commitments suggested by the unintuitive, unassimilable ideas of quantum physics, or the unobservable parallel universes entailed by now mainstream physics. Meanwhile Forsey's concern about epistemological access assumes that one can either know something in a direct and coherent way — as does a rational Kantian subject — or not. But how do we characterise the knowledge we can have of something like dark energy, which does not interact with light and is detectable only by inference, indeed only by its absence in accounting for the missing mass of the universe? And who is the Kantian or Cartesian subject who is presumed to have this determinate "access" in a clear-cut manner? According to modern neuroscience, such an unproblematic self is merely a useful model, a fiction used by the brain to manage itself (Blackmore, *Meme* 226–30; Dehaene 91–99; Dennett, *Consciousness* 414ff). It has also been scientific orthodoxy for decades that cognition cannot be separated from emotion and that in fact emotion is vital for reasoning (see Barrett, Damasio, Panksepp), to say nothing of a supposedly bright line between intentional and non-intentional cognition. And multiple branches of science utterly discredit any simplistic or outmoded Kantian idea of a neat delineation between a rational subject and the phenomenal world of objects.

Recent theories of the sublime that follow the Kantian or pre-Kantian traditions are curiously insulated from broader theoretical movements.[6] There is a parallel with the popular science genre. Both assume a kind of coherent, individual subject somehow distanced from the phenomena they observe. And yet the *content* in both discourses gainsay this type of subjectivity. In the discourse of the sublime, experiences of the subject being overwhelmed by vast or paradoxical phenomena hint at a porous, limited, or entangled subject, one that cannot effortlessly incorporate such challenges. And in popular science the scientific method practised by a rational and impartial agent is foregrounded while the results of the science frequently speak against the possibility of such detachment. Regardless of what the authors of popular science books might say, the ideas they discuss are much more in keeping with post-structuralist formulations of both the subject and the sublime. Meanwhile Forsey fears the "troubling ontology" implied by theories of the sublime that include difficult-to-categorise objects. But such theorising does not lead to outré transcendence or mysticism, but builds with rigour on ideas and objects commonplace in almost any trade book about modern science.

In a parallel discourse on the sublime, there is a large body of scholarship by literary scholars and writers from the continental tradition. Kenneth Holmqvist and Jarosław Płuciennik compile a wide survey of theories of the sublime from dozens of contemporary scholars. Consolidating, they first offer three formulae for sublime experience which in turn collapse into one:

> presenting the unpresentable, speaking the unspeakable, expressing the inexpressible. We try to persuade our readers in this book that all these formulas can be properly substituted by a formula of re-presenting the unimaginable, which means a mimetic presentation of the unimaginable. (10)

This formula certainly agrees with Jean Francois Lyotard's extremely influential (Rayman 172) description of the sublime in *The Postmodern Condition*. Starting from a reading of Kant as saying that any idea of a sublime object is *unpresentable* either in media or our own imagination (77–8), Lyotard claims that "modern aesthetics is an aesthetics of the sublime" (81). Such aesthetics — for Lyotard the

[6] There are dozens of examples, but four that have been well received are those of Clewis, Forsey, Shapsay and Sircello.

modern includes postmodernism as a subset — "present the fact that the unpresentable exists" and "make visible that there is something which can be conceived and which can neither be seen nor made visible" (78). The sublime in modern art or literature will "allude to something which does not allow itself to be made present" (80) while the postmodern variant "puts forward the unpresentable in presentation itself; that which denies itself the solace of good forms" (81).

By this standard, virtually all popular science texts, especially in popular cosmology (Chapter 1) are *modern*. Just like Malevich's blank squares — Lyotard's example in painting (78) — texts about dark matter, black holes and extra dimensions clearly present the fact that the unpresentable exists. By Lyotard's lights, however, they may not be *post*modern. He illustrates the difference by comparing Proust and Joyce. Proust is modern and "calls forth the unpresentable" by eluding the "identity of consciousness" with absences and evasions throughout his text (80). Joyce, however, is postmodern and it is "the identity of writing" itself that is eluded: by breaking down linguistic and stylistic forms Joyce allows "the unpresentable to become perceptible in the writing itself" (80). Popular science books, although diverse in content, are extremely conventional in form and do nothing approaching the invention of Joyce. Occasionally, in popular neuroscience texts discussing how the brain reads or interprets language, a certain reflexivity enters the prose (see Chapter 5). But otherwise, the focus on explication and the mass-market audience mandate a style that favours declarative sentences, homespun humour, accessible analogies, standard vocabulary (apart from jargon words, always defined, often in a glossary), little interiority or authorial intrusion, little variation of register and earnest entreaties to the reader to find the material fascinating.[7] The reader is undermined or destabilised, however, by the ontological sublime found in other subgenres (Chapters 2 to 5), where the nature of subjectivity is implicitly or explicitly

[7] Exceptions are rare. The poet Diane Ackerman has branched out into popular science in her books *A Natural History of the Senses*, *An Alchemy of Mind* and *The Human Age*. Her books are more stylistically varied and much more lyrical than typical popular science books. Janna Levin's *How the Universe Got its Spots* is in epistolary form and was considered extremely unusual on its release: the popular physics author Jeremiah Ostriker said, "I've never read a book like it" (Levin back cover). Douglas Hofstadter's *Gödel, Escher, Bach* and *I am a Strange Loop* are inspired by Lewis Carroll and contain puzzles, wordplay and self-reference. Authors occasionally include sections of memoir relating to scientific discovery, but little personal feeling enters the text. Venki Ramakrishnan's *The Gene Machine* is unusually candid about the tension, greed and animosity that characterises elite science; likewise with Levin's *Black Hole Blues*. But in general it is only in popular neuroscience that subjectivity becomes a topic explicitly dealt with and so authors feel comfortable sharing more of themselves and destabalise the liberal humanist subject who is the implied reader.

questioned, just like modernist fiction. The content of popular science is radical, modern and sublime, while the style is conventional.

Therefore, I look to Lyotard for a more relevant starting point for theorising the sublime of popular science. Lyotard does not share Forsey's reservations about invoking something beyond epistemological access. He is happy to acknowledge gestures made towards what cannot be directly presented or understood. I follow Lyotard in identifying that feature of modern art and modern literature[8] — and modern science. But in *The Postmodern Condition* Lyotard keeps to the notion that the sublime is ultimately about the subject encountering some presentation of the limits of what they can know. But even more thoroughgoing challenges are possible in the form of an ontological sublime that undermines the seeming reality in which the presentation occurs, or the existence of the subject who encounters the presentation.

The ontological sublime

Unlike writers on aesthetics, the authors of popular science are not reluctant to make bold ontological claims. Cosmologists writing for a popular audience present whole new ontologies and adjudicate their statuses, with these claims going largely unchallenged by writers from other disciplines. In other scientific disciplines, the ontological claims encroach on territory traditionally in the domain of the humanities and social sciences, typically without heed of these latter approaches. Recently, some scientific studies have even tried to name and describe something like the experience of the sublime itself, under the guise of the neuroscience of awe. More importantly, I think a renewed interest in ontology — the so-called ontological turn[9] — in the humanities is welcome, because of the rapacious ontological colonisation undertaken by modern science (which I discuss below).

[8] Lyotard is canny enough to see that these periodisations are not rigid. There are historical precursors to this aesthetic that are seen in retrospect to have been modern or postmodern. Hence he says "work and text. . .always come too late for their author". To wit, he identifies Schlegel's *Athenaeum Fragments* as modern and Montaigne's *Essays* as postmodern (81).

[9] See Van der Tuin for a discussion of this phrase, which comes originally from anthropology. Regardless of how common the phrase itself is, movements in several disciplines seem to bear out a recent focus on ontology or metaphysics. I have in mind not only object oriented ontology, speculative realism and new materialism but also movements in the analytic tradition such as rainforest realism, ontic structural realism and modal realism.

With ontology in mind, consider the problems faced by theorists grappling with the sublime, using as an example, the epitome of sublime imagery, a vast mountain range. A long-running debate concerns whether it is the object, a mountain range, that is sublime or the experience of the object.[10] A sub-question seeks to clarify whether a painting of mountains is sublime, or only the experience of viewing the painting, or neither and the encounter has to be direct. If artistic representations are legitimate, does that include poetry or oratory that conjures sublime imagery in the receiver, like Wordsworth's description of the Alps in *The Prelude*? Or are only more representational media able to do so? Mountains are natural objects, but critics differ on whether unnatural objects can also count as sublime or even abstract objects like the mathematical concept of infinity. Regardless of what causes the experience, there is just as much disagreement over whether it is affectively positive, ambivalent, or even negative. Those who claim the latter — such as Christopher Hitt (614) or Alan Richardson (35) — tend to say that the experience is self-abnegating as opposed to the orthodox claim that the sublime engenders self-affirmation. Perhaps the sublime changes over time. It might be a perennial feature of normal human experience, or it might be historically and geographically situated, changing according to a culture's conceptions of what mountains are.[11] The sublime has traditionally been a highly gendered concept as well: in Burke and Kant the beautiful is figured as feminine, the sublime as masculine and even more recent formulations frequently assume a kind of individualism and autonomy reserved for a male subject who is not the Other (Battersby 86–7, 190ff). This immediately suggests a class difference might also be entailed in responses to potentially sublime situations. The claim that the sublime is above all an *aesthetic* experience seems to presuppose a certain disposition or background knowledge on the part of the subject, for instance a cultural inheritance of Romantic imagery of the Alps, or geological knowledge of mountains. And nowadays, we might also try and determine whether the experience is an evolved response to certain kinds of stimulus, whether nonhuman animals

[10] See for instance Clewis (1), Forsey (386), McBride (23).

[11] Marjorie Hope Nicolson's somewhat forgotten work *Mountain Gloom, Mountain Glory* is a study of the changing aesthetics of mountains in Europe in the seventeenth and eighteenth centuries. She provides a compelling case that at least in British culture, in that time, mountains were generally seen as blots, blemishes, or warts on god's landscape, until the publication of Thomas Burnet's *Sacred Theory of the Earth* in 1681. By the end of the next century, grand tours to the Alps were common and the fashion for the sublime was at its peak. Nicolson attributes the shift to the nascent geological discourse inaugurated by Burnet and the subsequent framing of mountains as evidence of god's grandeur (143).

experience the same emotions given the same stimulus, and whether it must be accompanied by a certain galvanic skin response and raised heart rate to count as truly sublime (see Oldfather).

The crux of these problems is a set of binary oppositions. They include subject versus object, nature versus culture, rational versus emotional, mind versus body, inside versus outside, logos versus pathos, human versus animal and self versus other. Much like post-structuralist thought, but in a less overt manner, contemporary science unsettles these rigid dyads. That might not be the stated aim of the authors and much positivistic science still proceeds with the tacit assumption of these binaries being in place. But as we will see in each subgenre of popular science writing, the vision of the world that creeps into these texts is far more subversive than previous commentators on the genre have recognised.

In light of this, I offer one relatively straightforward intervention into the ongoing struggle for a theory of the sublime: a distinction between the *epistemological sublime* and the *ontological sublime*. This distinction will become clear in successive chapters, but figuratively speaking it is the difference between limits and voids respectively — along with near-synonyms such as boundaries, frontiers, or edges; and abysses, vacua, or gaps. The epistemological sublime is triggered by some indication of the *limitations* of human knowledge, understanding, representation, imagination. It overlaps significantly with current articulations of wonder and awe and is better associated with the eighteenth-century writings on the sublime, especially the pre-Kantian discourse. The ontological sublime is more radical and is evoked, often indirectly or by inference, by some intimation of the baselessness or lack of coherence of reality or the subject. Consequently, whereas the epistemological sublime is accompanied at least belatedly by a positively valenced affective state (such as delight), the ontological sublime is genuinely ambivalent, even challenging the coherence of the subject who would experience that affect. At a minimum, it undermines the rational subject assumed by Kantian and pre-Kantian versions of the sublime, as well as the liberal humanist subject assumed by popular science authors in both their framing of scientific heroes and their implied reader. At times it challenges even fragmented and decentred postmodern conceptions of subjectivity as well.

I offer these terms — epistemological sublime and ontological sublime — not as another binary opposition. It may well be that the distinctions of previous

theorists allow us to discern fine-grained differences between some of the cognate terms that overlap with the sublime, such as awe, astonishment and uplift. The ontological sublime, however, is meant to carve out a set of experiences that trouble the terms in those aforementioned binaries, especially the subject versus object binary which still pervades a lot of writing on the sublime and the public facing ideology of much science communication. Most popular science proceeds on the tacit or overt presumption that a scientific subject uses appropriate methods to *objectively* investigate the object world. But such investigations, as related in these same popular science books, open up gaps that cannot be contained by the binary. Plainly put, the ontological sublime is *any experience that leads to a questioning or undermining of the ontological status of the world or of the experiencing subject*. Because this is usually quite a shocking disclosure, it may well be felt as a negative affect, but that is not necessary.

The historically constructed nature of the ontological sublime is taken as given. But this is just to say that the conditions required for it are any stimuli — in any medium natural or unnatural — that lead to the erosion of ontological certainty or security. Such conditions are *probably* more widespread now, in a scientifically advanced culture, among people who engage with counterintuitive ideas about the nature of reality.[12] Because these unintuitive ideas tend to unspool even the differences between subject and object, or even what counts as an *experience*, the ontological sublime should be seen as a structural effect prompted by the appearance of these conditions. The epistemological sublime can be a relatively remote or passive experience — albeit with a profound intellectual engagement, but without critical *self*-reflection — triggered by some disruption to habitual thought. The ontological sublime, on the other hand, implicates the experiencing subject in the disruption. Precisely how this plays out is a matter of the subject's pre-existing beliefs about ontology. If the subject believes in the divine the ontological sublime may well be a moment of transport to some experience of the godhead (Milbank 221–5); if the subject is a rationalist the experience is a window into the substrate of pure reason (Kant 215; pt. 2, sec. 57); if the subject believes only matter exists, then the experience may be of the vitality of matter itself and the material basis of the self

[12] There are certainly precedents in the early modern period such as in the writings of Giordano Bruno, Johannes Kepler and Mary Cavendish. See Mary-Baine Campbell's *Wonder and Science: Imagining Worlds in Early Modern Europe* and Mary-Jane Rubenstein's *Worlds Without End: The Many Lives of the Multiverse*.

(Porter, *Sublime* 393, 410). In my view the ontological sublime is therefore frequently a litmus for one's broader metaphysical views. But what makes popular science especially germane to study of the sublime in general, is that it is a genre that confidently suggests — or supplants — the reader's ontological views. Modern science makes bold and unintuitive claims about the interconnectedness and inseparability of all things. In a word, *entangled* — in the sense used by Karen Barad, whose ideas will be prominent in Chapters 2 to 5 — gives a feel for the kinds of ontology and subjectivity that loom in popular science and which provoke a particular form of the ontological sublime.

This also implies that much of what has been written about the sublime is nowadays better filed under one of the cognate terms. I employ *epistemological sublime* as a way of marking off the work that is largely indistinguishable from the subjectivity of *awe*, *wonder* and others. The sublime is still a live, useful concept but it is best applied to the more radical, ambivalent effects precipitated by the extreme ontological implications of modern physics, biology and cognitive science. A new subjectivity and an ontology with a new *mise en scène* calls for a new sublime.

The popular science genre

Scholars in the humanities generally rely on popular science books for their information about science; it is rare to see them, other than the more intrepid scholars in science studies, go beyond these exoteric texts to consult journal articles or textbooks. The version of science that gets imported into discourse in the humanities is therefore fashioned largely by this mass-market genre. But little scholarly attention has been paid to the genre itself.

The few existing studies come mainly from scholars of rhetoric. I hope to offer a different perspective, one that is more focused on the worldviews and aesthetics (mainly the sublime) presented in the genre. This includes the overarching political goals of the authors where they are apparent and I take it as given that the texts are suffused with rhetorical ploys, aimed chiefly at the validation of ongoing funding to science, the mythologising of scientific heroes, the commercial success of the books and the claim to cultural prestige of various scientific disciplines. But my literary approach hopefully uncovers some of the ironic, subtextual and ideological (in the broadest sense) features of popular science.

I take an interdisciplinary approach, by which I do not mean incorporating the methods of two or more disciplines. My methods are only those of a scholar of literature. Rather, I think scholars in the humanities are warranted in applying their perspectives to *any* cultural productions, including science and science popularisation. More than that I want to avoid a *conflict* approach. It is too easy to see other disciplines as in conflict with one's own, which helps to reify the disciplinary boundaries. Doubtless, in a purely economic sense, the conflict is real; the funding pool is finite and humanities scholars are less favoured by funding bodies than our counterparts in the natural sciences. But if *that* motivates a study of a field within the ambit of another discipline, it becomes very easy to lapse into obvious rhetoric of one's own, that tries merely to intellectually trump the "rival" discipline. Moreover, the grab for cultural influence betrayed by popular science authors — that science can solve our problems and so deserves more funding — conceals the more profound involvement in the realm of the humanities. Namely, that the ontological sublime found in modern science represents a similar — and interlinked — disruption of philosophical and ideological presuppositions to that of modernism and postmodernism in the arts. I aim to demonstrate potential affinities between the latent worldview of modern science and that of contemporary theory. I turn now to the most comprehensive study to date of popular science in order to introduce some terms and elucidate the problems and virtues of rhetorical approaches.

In *Communicating Popular Science: From Deficit to Democracy* (2013) Sarah Perrault defines science popularisation as: "science-related communication directed at nonspecialist audiences" (xiii). She includes all written formats in her study, whereas I use the term *popular science* to refer only to full-length standalone books. The crucial part of the definition, which I follow Perrault in using, is that the *intended* audience is non-specialist, which is not to say non-scientist: "Even scientists in one area read as amateurs in other areas of science" (Perrault xii). Additionally, even specialists read popular science books in their area of specialty, but unlike scientific papers and textbooks, popular science is aimed at including non-specialists too. Perrault covers the history of the genre, the narrative forms standardly employed by writers, the writers' professed goals for the genre and the different paradigms driving science communication efforts. The book is particularly

strong on rhetorical analysis and incorporates the insights of other scholars of rhetoric who have previously critiqued the genre.[13]

Critique is the operative word. Perrault points out a robust divide between "science boosters" and "science critics" (4–6). Although there are a few scientists among the critics, most popular science authors are boosters. Perrault defines boosters as: "advocates who see science communication as public relations, with success measured in terms of how well the public's priorities and concerns align with those of scientists" (3). Science critics — which includes some historians of science, sociologists of science, and communications scholars focusing on science — urge popularisers to pursue more democratic ideals because "people in a technoscientific society are asked constantly to make decisions affecting their day-to-day lives, and to make informed judgments and weigh in on decisions about technoscientific issues more broadly" (5). Clearly this is the rationale motivating Perrault's own work.

But this democratic ideal sounds a lot like the ideals voiced by some prominent science boosters whom Perrault quotes in a later chapter. One well-known science writer, James Gleick, writes that "modern life demands a certain amount of sophistication about science, if we are to function properly as individuals and as members of the polity" because "our technocratic age requires urgent messages from the sometimes baffling, sometimes tumultuous frontiers of knowledge — the place we call science" (Gleick in Perrault 54). Richard Dawkins is quoted as justifying science outreach partly so that people in professions such as lawyers, judges, and "politicians up to the highest level" can improve their scientific understanding so that it may help them in their roles (Dawkins in Perrault 52). And here is Perrault discussing the view of Brian Greene (whose work is the focus in Chapter 1 of this thesis):

> Greene also wants us to think like scientists so we can be good citizens because "science and technology play an increasingly pervasive role in everyday life. . . full participation in the global conversation requires a familiarity with the major advances in science and technology as well as an understanding of the scientific way of thought". Apparently, these benefits

[13] This includes several scholars important to my work, such as the pioneering work of Jeanne Fahnestock in *Accommodating Science: The Rhetorical Life of Scientific Facts* (1986), Peter Broks' *Understanding Popular Science* (2006), as well as the contributions of Davida Charney and others to a special issue of *Written Communication* in 2004.

> extend even beyond science: "Even on issues that seemingly bear no direct relation to science, a scientific mindset can have a radical impact". His example, that statistically minded Americans would have understood the futility of re-counting votes in the 2000 presidential election, is eyebrow-raising (54)

These examples sound indistinguishable from the critics' goal of engaging citizens to make informed decisions in a technoscientific world. Gleick is interested in the empowerment of the polity, Dawkins in politicians' ability to legislate and Greene in understanding elections: the very stuff of democratic engagement.

I have been selective in taking these particular quotations from Perrault's longer discussion of science boosters. In the context of that broader survey, these views are offered as evidence that boosters adopt the *deficit model* of science communication, whereby the public lacks understanding and can only redress this lack by becoming more like the scientists themselves. The deficit model is undoubtedly simplistic and probably counter-productive. But the way the above quotations have been shoehorned into a general critique of science boosters, demonstrates why rhetorical approaches are limited. Although I applaud the skill and perceptiveness of Perrault and others like her, they can fall into conflict-based approaches that — ironically — represent positions of rhetorical weakness. That is, they drive everything towards their own rhetorical point. In this case, to show that most science popularisers evince the deficit model rather than the democracy of Perrault's subtitle, even when they say the opposite. Tellingly, Perrault subscribes to I.A. Richards' view of rhetoric as "the study of miscommunication and its remedies" (Richards in Perrault xiii), which could be paraphrased as the deficit model of rhetoric. Dawkins, Gleick and Greene are certainly all boosters. But the ideologies that populate their texts are complicated and inconsistent, and can often align with the democratic ethos of the critics.[14]

[14] I have a professional background in science communication and an academic background in English literature. My reason for leaving the science communication discipline was because I found the approaches to be theoretically thin and practically impotent: my special interest was communicating climate change, something I and my colleagues clearly failed to do well. In that discourse, scientists really are cast in the role of Cassandra. But otherwise their pleading cultural irrelevance — which Perrault accurately criticises them for (4) — is propaganda. Knowing that, I personally find it unhelpful when humanities scholars perform a similar move and suppose that *their* audiences have an entirely uncritical approach to scientific ideas, even though it has been *de rigueur* for anyone who studied (in at least the last 40 years) the history of science, the philosophy of science,

Perrault is right to point out the liberal, rationalist thrust in the writing of science boosters. The reading subject assumed by authors in this genre is a rational one who simply needs more scientific information to become even more rational. And the ultimate model for such a subject is the scientific hero portrayed in such texts. Perrault also identifies a pattern of emphasising science as a bulwark against pseudoscience, sloppy thinking, or simply confusion. She notes that "for Gleick, science writing is a cure for a kind of irrationality" and that "Dawkins invokes the power of science writing to cure not only ignorance but fear" (53). In the scientifically literate world hoped for by these boosters, the subject is perforce a rational, liberal humanist subject. Such a subject is able to weigh evidence and make informed decisions and is somehow able to prescind from their historical context. This is where a space opens up between the epistemological assumptions of most popular science authors and the ontological disclosures that would undercut those assumptions. The ideal scientist is presented as a liberal humanist subject who can dispassionately reason their way to knowledge. Likewise the presumed *reader* is able to read the text and become more rational, more like a scientist, more capable of participating in a liberal technocratic society. Despite the manifold examples of modern scientific findings that speak against the coherence of a liberal humanist subject — as this thesis will detail — there still seems to be a tendency among science boosters to assume that this subject remains insulated.

Two recent works get closer to the shape of the analysis I aim for. Alan Gross's *The Scientific Sublime: Popular Science Unravels the Mysteries of the Universe* (2018) and Lisa Sideris's *Consecrating Science: Wonder, Knowledge and the Natural World* (2017). Both identify the genre with a particular ideology.[15] Gross's title sounds like it might cover similar ground to this thesis. But his sublime is very much in the Burkean (epistemological) mode (Gross 7) or the wonder offered by Burke's contemporaries (Gross 15–19). And Gross focuses mainly on the materialist, atheist worldview permeating the texts in his selection, including books by Dawkins and Greene and their "effort to substitute science for God" (22). "Popular science writers are motivated not only by miseducation and public ignorance [*i.e.* the deficit

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the sociology of science, science studies, the rhetoric of science, or even science communication, to critique the military ties, the economic rationalism, the naive empiricism and the pretence to objectivity of science. This has blinded many scholars to the radical nature of much of the knowledge produced by natural science.

[15] See also Curtis White's *The Science Delusion*.

model]," writes Gross, "but by their own growing atheism, their increasing sense of the irrelevance of God" (282). Sideris also homes in on the secular version of wonder contained in books by authors who write on the "epic of evolution" (see Chapter 4 for a discussion of this narrative form). Although she is not looking at popular science *per se*, her study includes Dawkins and other authors who have published popular science books. Sideris examines "practices and rhetoric that invest science with sacred meaning and purpose, sometimes to the point of conflating science and religion, or making science *into* a religion" (7, italics in original). Gross and Sideris view the sublime and wonder respectively as forms of rhetoric and both identify a kind of religious zeal or an attempt to supplant religion in the secular proselytising of well-known scientists who write books for the public. I chose not to examine religion in my study. Again, partly because I wanted to avoid a conflict narrative: science versus religion, or science versus the humanities.[16] But also because others, like Sideris, have already looked at the quasi-religious rhetoric of science boosters; above all, I want to emphasise the as yet unexplored ideological strains in the genre.

There certainly are several prominent, public atheists among the top popular science authors: Richard Dawkins, Stephen Hawking, Lawrence Krauss, Carl Sagan. But Gross and Sideris are quite selective in their sampling of the genre. Jerry Coyne and Richard Dawkins are both outspoken atheists and rationalists and both adhere to an Anglo-American liberalism that is prominent in the public sphere but perhaps not representative of the heteroglossia found in popular science texts and the plurality of ideologies espoused by popular science authors. The genre has humanists (Steven Pinker), agnostics (Neil deGrasse Tyson), "poetic naturalists" (Sean Carroll, Janna Levin), deists (Paul Davies), platonists (Roger Penrose, Max Tegmark), Buddhists (Susan Blackmore, Jill Bolte Taylor), Hindus (Venki Ramakrishnan), Taoists (Fritjof Capra), Christians (Francis Collins), or inventors of their own religion (David Eaglemann); there are Marxists (Stephen Jay Gould, Richard Lewontin) and arch capitalists (Matt Ridley); second wave feminists (Lynn Margulis), third wave feminists (Cordelia Fine) and existentialists (Jacques Monod); radical environmentalists (Tim Flannery, David Suzuki) and climate change deniers (Freeman Dyson); Spinozists (Antonio Damasio), Leibnitzians (Lee Smolin),

[16] When scholars of religion, such as Sideris, accuse boosters like the biologist E. O. Wilson of turning science into a religion, I see their point (Sideris 79–81). But this seems a strange rhetorical position to be in. It prompts the question, awkward for a scholar of religion: is it inherently bad to turn something into a religion? I have no equivalent qualms treating science like literature.

Popperians (David Deutsch) and even devotees of Anaximander (Carlo Rovelli); as well as instrumentalists (Lawrence Krauss), constructionists (Lisa Feldman Barrett) and "model dependent realists" (Leonard Mlodinow); and there are former plumbers (Leonard Susskind), former editors of *Rolling Stone* (Timothy Ferris) and former pop stars (Brian Cox). Many of these authors have multiple ideological positions or identities, along different dimensions, which are not mutually exclusive, and certainly do not involve proselytising for atheism or science to become a secular religion, or indeed zealotry of any kind. Science boosterism surely is not necessarily *religious*, for that would seem to arrogate to religious discourses the only warrant to promote ideas. The democratic ideals promoted by science critics, for instance, are surely not cases of proselytising or religious zeal.

In addition to this breadth, the ideological reach of popular science is also greater than rhetorical approaches suggest. The genre is much more popular than philosophy, theory, social science, or any other academic genre. It also speaks for a body of research that is significantly better funded than anything in the social sciences or humanities. And it represents the vanguard of the knowledge that informs new medical, extractive, IT and military technologies. The rhetoric-minded scholars have, I feel, actually missed the larger, potentially more immane effects of science's cultural status. Scientific knowledge certainly impinges on other disciplines — including theology — but more than that it is allied to capitalist, colonialist and military aspirations. There is a unidirectional momentum to scientific discourse that is unlike the cultural memory and ethic of restoration or reappraisal valorised in the humanities. Ongoing scientific production entails a growth economy and generally does not brook traditional ways of knowing. Like the epistemological sublime, Big Science is about ever-expanding frontiers and limits. I advocate understanding the ontological sublime, revealed in popular science texts, as a way to complicate the mentality of rapacity of the science boosters.

The main theorists I utilise in this thesis are notable for having engaged boldly with the most challenging ideas from modern science, without falling into either side of a simple booster/critic dichotomy: Karen Barad, Katherine Hayles and Slavoj Žižek.[17] Although none of these scholars take an avowedly rhetorical approach,

[17] Notably, Barad is a practising quantum physicist and Hayles once worked as a research chemist. I have been greatly influenced by other scientifically aware theorists, although I do not quote them in this thesis. They include Terrence Deacon, Elizabeth Grosz, Luciana Parisi and Isabelle Stengers.

neither are they naive consumers of scientistic propaganda. I follow their lead in not only recognising the immense and troubling cultural and colonial influence of science, but also in treating the philosophical claims implicit in much science writing as being well within the purview of the humanities.

Method of reading and selection of texts

I assume the author's stated intentions — and their rhetoric — in one part of the text may well contradict their revealed preferences in another part of the text. A ready example. Richard Dawkins closes *The Selfish Gene* with a note that humans "alone on earth" are capable of overriding the imperatives of their genes (260). The entire book up to that point has been about how gene "vehicles" (organisms' bodies) *appear* to be the locus of motivation, but they are really only projections of the strategies by which genes use them to get replicated. Do we take Dawkins at his (final) word about human exceptionalism, or read the ending in the context of the arguments and evidence against that in the preceding 250 pages? Because this thesis is not about the methods of persuasion used by the authors, I do not dwell on finding anything like a determinate reading of which of Dawkins' statements made in the same book we should take as *his* intention — although I do elsewhere (Freestone "Selfish Genre"). I focus instead on ideas and imagery that may not be part of any mindful, or even inadvertent, rhetorical strategy. I assume that there are multiple, often contradictory, voices in the text and that there are also unassimilable elements: some of it akin to junk DNA, some akin to viral strains that enter via the world beyond the text despite the author's attempts at remaining inviolate.

Another revealed rather than stated preference of the authors is that they choose to write books. Most popular science books are written by highly successful scientists. This suggests that it is an attractive option even for mid-career scientists to sacrifice their publishing output and research agendas to write a book. Lisa Randall, for instance, was arguably the most successful theoretical physicist in the world by the mid-2000s, if citations are used as an indicator. But since then she has written three hefty popular books on different branches of physics: no small outlay in time and resources. There is a strong financial incentive, but also a reputational trade-off, as scientists who focus on popularisation lose some prestige among their peers: the so-called "Sagan effect" (coined by Taylor and Wood). It may also be that

popular science is an indirect appeal beyond the scientific research community to maintain funding of it. Its readers are largely non-scientists and may include legislators or at least the people who vote for legislators.

The highest selling popular science book of all time is either Hawking's *A Brief History of Time* (Gross 1) or Bill Bryson's *A Short History of Nearly Everything* (Turney and Bell 23); provided we ignore female authors, which booksellers, critics and compilers of lists seem to do. From what I can tell, the mantle should go to *The Immortal Life of Henrietta Sacks* by Rebecca Skloot. Perhaps tellingly, this text is somewhat more critical of the scientific establishment and dwells on the ethical issues involved in medical and genetic research. It is normally referred to as a work of biography. There is an echo of the dynamic found in other genres where female authors are subtly re-classified: novels are often said to be more memoir than creative fiction and women produce "life writing" rather than serious essays. This double standard was mordantly catalogued in Joanna Russ's *How to Suppress Women's Writing*, originally published in 1983.[18] In popular science this is visible in the absence of books that explain the science of pregnancy and birth; many such books exist and although they include extensive biological and embryological detail, they do not seem to count as popular science. This same sexism is documented in *Hidden Figures* by Margot Lee Shetterly, the account of the unsung African-American female mathematicians who were critical to America's space program. *Hidden Figures* is arguably the *next* top selling book in the genre; admittedly it is not so much focused on scientific explanation as it is on the lives of the protagonists; yet no such pettifogging attends books by the likes of James Gleick, who is widely regarded as one of the finest writers in the popular science genre, although his books *Chaos* and *The Information* are both about scientific communities and key individuals, much like *Hidden Figures*.

In light of this, I attempted to restore female authors to an incipient canon of science writing that is already repeating the pattern of bias in the literary canon. Otherwise I simply read what appear to be the most popular science texts and then focused on particular texts that were thematically exemplary.

[18] See also the annual statistics released by the organisation VIDA. They routinely show no serious improvement in the massive under-representation of women writers in book reviews, including of nonfiction and popular science.

Chapter summary

In Chapter 1 I focus on *The Fabric of the Cosmos* by Brian Greene, in which the reader is dwarfed by incomprehensible scales and presented with unimaginable phenomena such as curved spacetime and dark matter. Popular cosmology is the subgenre of popular science that departs least from the Kantian heritage of the sublime and contemporary notions of awe and wonder. The liberal humanist subject is not directly questioned and the confidence born of cosmology's fiscal and experimental successes is evident. Authors like Greene happily admit ignorance, safe in the assumption that the frontier of knowledge moves ever outward. I show that even exotic cosmological findings, that seem to have little to do with the reader's identity, gesture towards something that is not only impossible to easily represent or envision, but which implies that reality itself is based in a void or vacuum: an absence rather than a presence.

Chapter 2 follows this thread into popular books that purport to explain the science of the texture of reality: quantum physics. I say *purport* because I found that from a sample of 40 books about quantum physics only a handful addressed the actual results of quantum experiments in any detail and only a few dwelt on the philosophical implications or the *interpretation* of the results. The authors avoid the more shocking results and interpretations, merely calling them "weird" or "bizarre" apparently wary of delving into metaphysics. The few texts that are more intrepid — such as my focus, *The Beginning of Infinity* by David Deutsch — exemplify the ontological sublime because they invoke parallel worlds complete with doppelgängers of the reader and they claim that all potentialities are realised in the multiverse. Hence notions of individuality, agency and uniqueness are compromised.

In Chapter 3 I look at texts from a cluster of related disciplines that concern biology at an invisible scale, such as microbiology and molecular biology. Invisible biology presents a view of nature that is utterly alien to the Romantic inheritance of mountains, rivers, forests and fauna visible to the naked eye. The relation of the subject to nature is also nothing like that of the traditional sublime. Instead of an autonomous subject impressed with their own reason, the subject is dissolved in an ontological sublime. First it is disaggregated into trillions of semi-autonomous cells, most of which are foreign organisms and many of which exert influence over behaviour. Then the planetary view of life frames the subject as merely an ephemeral

event in the ongoing global cycling of nitrogen, carbon and other elements. My main texts in this chapter are Ed Yong's *I Contain Multitudes* and *Microcosmos* by Lynn Margulis and Dorian Sagan. Both demonstrate the strong ecological perspective that also accompanies the emphasis on going beyond the human. Unlike other instances of the sublime that I examine, Margulis and others in her subgenre shift the centre of gravity away from the subject who is implied in the usual experience of the sublime, towards the nonhuman in a broader and more diffuse concept of nature.

Chapter 4 focuses on the epic narratives of evolutionary history, especially in Dawkins' books. The long time scales in this subgenre produce an epistemological sublime. But the stranger effect is to implicate the reader in the narrative. By framing evolutionary history as a narrative that culminates in humans *understanding* that narrative, the reader is figured as protagonist. I argue this is a unique kind of metalepsis — a blurring of diegetic levels — and that it is further complicated by the inevitable discussions of the *reading* of the genome and its *rewriting* with genetic manipulation: hence the reader is figured as protagonist *and* author. Along with information about the relatedness of all life on Earth and the ongoing effect of history from millions of years ago, the subject is entangled in time, space and narrative levels. But although this might have been an opportunity to seize on such entanglements, Dawkins instead reverts to a push for human exceptionalism. The ontological sublime of the evolutionary epic aims to reaffirm the scientifically informed subject by placing it in the narrative of evolutionary history, thereby blurring the teller and the told, in an attempt to subsume all ontological domains under the aegis of Darwinian explanation.

In the final chapter I detail how popular neuroscience texts mount a frontal assault on the coherence of the reading subject. This is evident in *How Emotions are Made* by Lisa Feldman Barrett and Nick Chater's *The Mind is Flat*. These and other popular texts from the last decade have not only discredited certain preconceptions about the integrity of this or that aspect of mental life — think of demonstrations of the imperfections of visual perception with optical illusions — but have further called into question: the idea of a self, the possibility of introspection, the nature of memory, the source of emotions and the existence of consciousness itself. Taken together, such challenges totally undermine the subject that would experience the Kantian sublime or other epistemological sublimes. A stranger kind of sublime experience is suggested, one that is adequate to a fragmented subject recognisable

from modernist or postmodernist fiction. Following other scholars in the humanities — especially Hayles and Žižek — who have written of the radical implications of cognitive science, I suggest a sublime of *lucidity* that incorporates the distributed, unconscious, entangled nature of cognition and a stranger kind of subjectivity.

CHAPTER 1: The epistemological sublime in cosmology

> Of all the sciences cultivated by mankind, Astronomy is acknowledged to be, and undoubtedly is, the most sublime, the most interesting, and the most useful. For, by knowledge derived from this science, not only the bulk of the Earth is discovered…; but our very faculties are enlarged with the grandeur of the ideas it conveys, our minds exalted above [their] low contracted prejudices. (Adam Ferguson qtd. in deGrasse Tyson, *Astrophysics* 193)

In the subgenre of popular cosmology, it is almost exclusively the epistemological sublime that is on show. Longinus (sec. 17), Burke (62, 71) and Kant (122; pt. 1, sec. 29) all mention the starry sky as a source of the sublime and so modern cosmology or astronomy would seem an obvious place to look for a scientific sublime in the epistemological mode.[19] I focus here on Brian Greene's *The Fabric of the Cosmos*. Not only is it a popular and critically acclaimed example from the genre but its coverage is wide. It details cosmological phenomena considered sublime in the traditional pre-Kantian or Kantian sense, as well as some ideas that evade or exceed that classification. It therefore provides a bridge from the epistemological sublime to the ontological sublime that will be more of a focus in subsequent chapters. In fact, the sublime of cosmology — based on incomprehensible physical scales and phenomena that resist depiction or imagination — can be found in all the other

[19] A lineage of a scientifically produced sublime could be established. Ashfield and de Bolla's *The Sublime: A Reader in British Eighteenth-Century Aesthetic Theory* contains many references to an astronomically or broadly scientifically produced feeling of sublime or wonder. The contemporary literature on the sublime is vast, but in terms of analysis focused on science and the sublime there is relatively little. Science writer Jon Turney is one of only a handful of scholars who specifically look at popular science as a genre whose dominant aesthetic mode is the sublime and only in one article ("Abstract"). Erin K. Johns Speese article on the feminine scientific sublime in the writing of Mary Sommerville was an early inspiration for this thesis. Gross, already mentioned in the Introduction, also does so but offers a fairly shallow version of the sublime. The other is Ian Greig, who looks at the sublime in physics, focusing on the interpretation of quantum mechanics offered by David Bohm. Two educational researchers, E. David Wong and Shane Cavanaugh independently come close to this, and recognise the sublime tendency in modern science and in the instruction of science, taking for granted that the connection is easily drawn. Two other scholars, Cian Duffy (a Romanticist) writing about de Quincey's foray into popular science and Paul Duro (an art historian) examining Joseph Wright's paintings of scientific apparatus, also touch on the notion of a scientific sublime; they too assume that the content of science or science popularisation is inherently amenable to analysis with respect to the sublime. Porter's work on the sublime in Lucretius also takes this view as does Ann Janowitz (another Romanticist) who echoes the work on Lucretius and identifies what she calls the "cosmic sublime" in some eighteenth-century writers. But no one has developed a dedicated analysis of the sublime in modern science, let alone modern popular science texts.

subgenres as well. But it would be redundant to detail them in those subgenres. This chapter is therefore an introduction into an epistemological sublime that runs through all popular science as an attempt to strike the reader with awe and to emphasise the reach and dominion of scientific inquiry. It should be taken as given that in subsequent chapters I am omitting examples of vast or tiny scales or unrepresentable phenomena that are nonetheless commonplace in the respective subgenres.

The central conceit of Greene's book is to uncover the fabric of spacetime, recognising that it is hidden from ordinary view. In doing so Greene addresses major topics in twentieth century physics from Einstein's general theory of relativity (1916) up to the holographic universe proposal of Leonard Susskind and Gerard t'Hooft (1995). In between are explanations of the very small (like string theory and next chapter's focus, quantum phenomena) and the very large (galaxy clusters, the overall geometry of the universe) as well as phenomena that remain almost completely inscrutable (black holes and dark matter). Because of this range and the nature of these topics, Greene's text is ideal as a site to investigate the sublime in modern cosmology, dealing as it does with objects vast, obscure, perplexing and inaccessible. I consulted many other texts in this subgenre, that I will occasionally refer to, but Greene's text handily demonstrates all the stylistic and thematic concerns of this chapter. [20]

[20] All of the popular cosmology books I read made obvious attempts to conjure one or more sources of the sublime, sometimes explicitly. Stephen Hawking's *A Brief History of Time* (the best selling popular science text of all) used extreme brevity to achieve a somewhat gnomic approach to the then frontier of cosmology. Lisa Randall's *Knocking on Heaven's Door* actually has a small section devoted to the sublime (40–3), which she relates mainly to the issue of scale: the central theme of her book. Leonard Susskind's *The Black Hole War* was also useful, as it deals primarily with black holes and the holographic universe theory, both of which are key topics in examples from Greene that I will discuss. The other texts that were used to define a field were: Sean Carroll's *The Big Picture,* Paul Davies' *The Mind of God,* Neil deGrasse Tyson's *Death by Black Hole* and *Astrophysics for People in a Hurry*, Timothy Ferris's *The Whole Shebang,* Greene's *The Hidden Reality*, Hawking's *The Grand Design*, Krauss's *A Universe From Nothing* and *The Greatest Story Ever Told…So Far*, Janna Levin's *How the Universe Got its Spots,* Roger Penrose's *The Emperor's New Mind,* Randall's *Dark Matter and the Dinosaurs* and *Warped Passages*, Martin Rees' *Just Six Numbers,* Carlo Rovelli's *Reality is Not What it Seems*, Simon Singh's *Big Bang*, Lee Smolin's *Time Reborn*, Max Tegmark's *Our Mathematical Universe*, Kip Thorne's *The Science of Interstellar* and Steven Weinberg's *Dreams of a Final Theory*. I also consulted some top selling works of general popular science that contain substantial sections devoted to cosmology: *A Short History of Nearly Everything* by Bill Bryson, Carl Sagan's *Cosmos* and Natalie Angier's *The Canon*. And I used some popular physics texts of a more didactic kind to increase my general background knowledge in this area: Richard Feynman's *The Character of Physical Law* and *QED: The Strange Theory of Light and Matter*, Walter Lewin's *For the Love of Physics*, Penrose's *The Road to Reality* and Rovelli's *Seven Brief Lessons on Physics.*

In this chapter, although I am keeping within what I call the epistemological sublime — similar to awe or wonder — I employ the work of Lyotard and Derrida to pave the way for the ontological sublime in next chapter. For these writers, the sublime is not merely an aesthetic category that is difficult to fit with a view of the subject as having clearcut "access" to phenomena. Lyotard and Derrida are frequently associated with post-structuralism, and for them the sublime is comfortably paradoxical and is about the limits of presentation and the presentation of limits. This yields a useful way to sort the large variety of confounding imagery to be found in virtually any popular cosmology book. In my analysis of Greene, I end up with a series of examples of the epistemological sublime triggered by four types of imagery: (1) representations of the existence of the unpresentable, (2) obscure phenomena that can be *re*presented, but which resist initial presentation, (3) phenomena that are themselves boundaries or limits and (4) instances when scale can be used to dwarf the reader. I associate the first two with Lyotard's work and designate them *apophatic*: the sublime as what simply cannot be presented, is ineffable, or can be described only negatively. This is concisely captured in Lyotard's influential view of the sublime as *the presentation that the unpresentable exists* (*Postmodern* 78). The next two I associate with Derrida's inchoate but useful concept of the sublime as an effect of the interplay between the *ergon* (the work) and the *parergon* (the supplementary frame or boundary demarcating the work): the ergon requires the parergon and vice versa. I will now briefly introduce the ideas of Lyotard and Derrida, but I will expand on them as I move through my analysis of Greene's book.

The Lyotardian sublime is negative: it simply gestures to something that cannot be positively indicated or presented. Ian Greig recognises the apophatic and sublime nature of modern physics, where the focus is on the kinds of epistemologically unattainable objects, "the presentation of which signifies an absence that has historically been taken as a metaphor for 'God,' 'the soul,' or 'the Absolute'" (124). Greig, following Lyotard, supposes that certain objects disclose the absence of other objects that cannot themselves be present. Lyotard's sublime is essentially referential: the presentable somehow denotes what is unpresentable. Hugh Silverman and Gary Aylesworth posit the text — any text — as sublime because it is always gesturing to what "is other than itself" (xi) and Porter says the sublime is the "ecstasy of representation itself" (*Sublime* 138). The apophatic feature of

language is perhaps a precondition for the sublime. What linguists call *displacement* — the ability to refer to things that are not present — seems to already contain a germ of the sublime potential that Lyotard claims is unique to the *avant garde*.

Derrida also sees the sublime as structural, in the sense that it is a reciprocal relation between the parergon and the ergon, with the one invoking the other. Derrida's conception of the sublime as outlined in *The Truth in Painting*, is more difficult than Lyotard's, but not quite as thoroughgoing as the ontological sublime we will turn to next chapter using the work of Žižek and Gasché's ontological reading of Lyotard. Derrida writes that "there cannot, it seems, be a *parergon* for the sublime" because the sublime in Kant is precisely that which is formless and unbounded (127, italics in original). But critics such as Mark Cheetham and Philip Shaw, have nevertheless adopted Derrida's analysis of the parergon as part of the broader revival of interest in the sublime in the late twentieth century; in fact Derrida precedes Lyotard and other French writers in exhuming the sublime as an aesthetic category worth considering.[21] Cheetham (97) and Shaw (172) both notice that Derrida says only that it *seems* there cannot be a limit or border to the sublime. For Derrida, even Kant's attempt to define the sublime as formless nonetheless entails reason imposing some kind of border around it. As such Kant's sublime functions the way a parergon frames an art work: the work could not exist without the parergon or vice versa. This is a classic Derridean formulation whereby the invocation of one term is shown to presuppose its opposite.

The difference between this and Lyotard's formulation is subtle but important. For Derrida there can be no unlimited without a limit and vice versa whereas for Lyotard the unlimited is unproblematically referred to within the limits of language or some other representation. Against Lyotard's negative or apophatic naming of the unpresentable, Derrida's parergon co-implicates what is within and without the limits of representation. In popular cosmology texts this is the difference between the apophatic nature of unseen, unmeasurable dimensions of space that are inferred from the characteristics of the space we *can* see or represent; versus the parergonal nature of the scales applied to astronomical distances that at once rein in an absurdly large quantity but also throw into relief its unimaginable vastness even as they

[21] Rayman claims that Derrida discussed it in a seminar as early as 1973–4 (164). This would mean Derrida pre-dates even Thomas Weiskel's 1976 monograph, which is usually seen as the reintroduction of the sublime into contemporary literary and philosophical discourse.

attempt to bound it. Rather than say that the (epistemological) sublime *is* one or the other of these two conceptions, I remain agnostic. Both are valuable, I think, and rest on serious elaborations by Lyotard and Derrida of the Kant's writings on the sublime. They also help to sort out the dozens of pieces of imagery used by Greene to invoke the wide range of phenomena that exceed imagination and even intimidate in their scope or strangeness.

Brian Greene's The Fabric of the Cosmos

The Fabric of the Cosmos is Greene's second book for a popular audience. Greene had already gained widespread praise for the exoteric explanation of string theory contained in his earlier work, *The Elegant Universe* (Turney, "Accounting" 341). *The Fabric of the Cosmos* covers more ground and attempts to give an overview of the twentieth century's most important findings in cosmology and other branches of physics, all with a view to investigating the nature of space and time. Greene notes early on that space and time, as conceptualised by modern physics, are strange and unintuitive, clashing with common-sense views of the world (x). The word *sublime* is not used in the text, but Greene's lexicon includes many adjectives deployed to emphasise the strangeness or awesomeness of the ideas being discussed (frequency in brackets): astonishing [7], astounding [7], breathtaking [3], startling [9], stunning [13], subtle [40], wonderful [9], wondrous [3].

Greene's work is exemplary in terms of illustrating the chief rhetorical tension in popular science writing: authors must make their subject matter as accessible as possible to garner a maximum of readers, all the while attempting to convey the complexity and grandeur of their ideas (Duffy 12; Turney, "Accounting" 332). This results in a curious problem whereby the author domesticates the sublime, repeatedly using everyday analogies to ground the lofty phenomena of, say, cosmology. To wit, Greene is fond of using pop culture analogies, especially from 1990s television such as *The Simpsons* and *The X Files*. We read that relativity can be explained by the Simpsons characters Itchy and Scratchy engaging in a duel, with different observers disagreeing over who shot first (53–5). But then once the explanatory burden has been carried by the homespun example, the summative paragraph assures us that the results are "stunning" (62). The ideas are still difficult,

unintuitive, hard to assimilate into our understanding, but perhaps slightly more tractable thanks to the explanation.

Greene thereby attempts to avoid a trap that science educators have noticed. E. David Wong asks whether or not there is a paradox in the sublime of science whereby one loses the sublime feeling when something is well enough explained that it ceases to be unintuitive or strange: "Should educators be concerned that an element of incomprehensibility is always present in sublime science experiences? After all, isn't the goal of education to reduce uncertainty?" (84). The putative goal of explanation in popular science is also to reduce uncertainty. Greene himself promises that "the reader should be able to walk the path of discovery and gain not just knowledge of physics' current worldview, but an understanding of how and why that worldview has gained prominence" (*Fabric* xi). But uncritically taking Greene at his word misses the chief attraction of recent popular science books, which thrive on evocations of the sublime. Greene needs the science to appear incredible when first encountered, but to still have the glow of incomprehensibility even after a thorough, jargon-free explanation has been carried out. For instance, he dedicates 20 pages to explaining quantum measurement experiments (examined in Chapter 2 of this thesis) in a step-by-step fashion, adding one additional variable at a time, complete with simplified diagrams. But he makes sure to repeat how strange and confounding the results are. The section closes with a description of how "elated" he felt when he first learned about the experiments (199) and he assures us that the results are "dazzling" (197).

The question naturally arises as to whether the sublime is lost once the object that triggers it has been normalised by explanation:

> Can what was once sublime remain sublime? If sublime experiences are characterized by an awakening of perception, or an inability to comprehend something fully, how do these experiences change with the passing of time and the gaining of knowledge? Is it possible for the sublime to remain fresh? For example, when Copernicus asserted that the Earth revolved around the Sun rather than the other way around, the idea was shockingly original. (Wong 84)

According to Wong we are now jaded, apparently unimpressed by the Copernican model and its attendant shock to humanity's ego. Possibly only with hindsight will we be able to judge whether Greene's demonstrations of the quantum measurement problem or the overall geometry of the universe, will become mundane once people have assimilated them into their everyday understanding of the world. But the fact that the basics of quantum mechanics have been around since the 1920s suggests that some ideas may be less easy to incorporate than others. This is why, I argue, the objects of *modern* science — especially twentieth century physics — which are accessible only via instruments or inference, are perfect examples of the epistemological sublime.

If understanding is represented by a frontier moving outwards to annex new knowledge, to bring into the known what was previously unknown, and if the sublime is located at the boundary, then many theorems from modern science may remain in this penumbral zone, never being fully absorbed into the known. (Indeed, in the ontological sublime of Chapter 2 I will suggest that even what seems known is compromised by what is at the frontier.) Adam Smith, one of many who wrote on the sublime in the eighteenth century, suggested that once a natural phenomenon is explained — he uses the example of solar eclipses — and the "gap" or "interval" in understanding is "bridged" we lose our sense of wonder (Ashfield and de Bolla 237–40). Perhaps this is how the territory of the sublime gradually shifts outwards. But quite possibly the findings of twentieth-century physics present too great a gap to ever be properly bridged by the understanding. The modern scientific sublime may therefore be a more durable sublime. This is prefigured in the fact that phenomena revealed by telescopes and microscopes are given as examples in Burke and Kant (Burke 138; Kant, *Judgement* 95; pt. 1, sec. 25). Unusual vast phenomena like volcanoes and storms can overwhelm the senses, but phenomena that are undetectable to the unaided senses *necessarily* overwhelm or undermine the senses. Warped spacetime and extra dimensions overwhelm even the faculty for mental imagery, something that Wong's example of the Copernican model does not do. I suspect that these highly counterintuitive ideas, that comprise a modern scientific sublime, will never be completely demystified. Moreover, as the frontier of knowledge moves outward, the known in the centre is itself destabilised, called into question, by the most extreme probings of modern science. The uncertainty principle

in quantum mechanics is a well-known example and I will detail more examples of this ontological sublime in subsequent chapters.

Popular science thrives on the use of analogies which aid in the demystification. Greene is considered to be unusually adept at grappling with the most difficult subjects in contemporary physics, especially when it comes to use of analogy (Turney, "Accounting" 341–2). But even he admits the limits of his explanatory acumen when dealing with some phenomena. Greene struggles with an unwieldy analogy for energy transfer during cosmic expansion (310), admits that human language is inadequate for some explanations (142) and simply "can't think of a good analogy" for branes (387). But even in the cases for which he does provide elegant analogies, we are presented with the refrain of how the discoveries of physics have no obligation to conform to human understanding or common sense.[22] Greene contributes to a trope in popular physics books of celebrating, boasting of — perhaps pre-emptively — the confounding or even inexplicable nature of much of modern physics (Hawking, *Brief History* 145, 181; Krauss, *From Nothing* xiii; Levin, *Spots* 1; Randall, *Warped* vii; Tegmark 11). Whereas the global goal of popular science and much of non-fiction more broadly is to demystify, in the subgenre of popular cosmology demystification can go only so far. Instead of avoiding the more difficult topics, authors are forced to confront and even advertise the mystified and in doing so they drive their texts into the discourse of the sublime.

I now turn to specific examples of sublime imagery in *The Fabric of the Cosmos*. I examine the apophatic and the parergonal. Within the apophatic I look at the unpresentable as well as the obscure. Within the parergonal I examine both boundary and scalar phenomena. These two species and four subspecies are not to be taken as perfectly circumscribed categories or neat taxonomies. They are ways that I hope will aid exploration of the imagery in Greene's work. More important is the broader class they are examples of: triggers of the *epistemological sublime* found in popular cosmology texts.

[22] Reality according to physics is "strange and unfamiliar" (x); we would not recognise the world at smaller scales (5); there are more profound levels of understanding beyond our "frail human senses" (21); human language is inadequate at expressing newly discovered natural laws (142); quantum experiments are "a magnificent affront to our common sense notions of space and time" (199); the geometry of space is impossible to visualise (236n); space and time are only "familiar strangers" whose fundamental nature is concealed (492).

The apophatic I: presenting the unpresentable

Greene introduces the unpresentable by alluding early on in the text to the fact that the nature of space and time, as described by twentieth-century physics, is complicated on very large or very small scales. Einstein's work in relativity predicted that space would be warped by gravity, to an extent detectable only around massive objects such as stars. This was subsequently confirmed by observations during a solar eclipse of light from distant stars bending around our own sun (273–4). Einstein also determined that time is relative, inasmuch as different observers will have different chronologies of the same set of events depending on their relative motions (56). In the 1920s, once physicists probed down to the level of particles, they found that everyday notions of space were even more inadequate, with the discovery that the fundamental matter contained in space is subject to the bizarre laws of quantum mechanics. The definition of space has thus been called into question, with even empty space — space devoid of particles — being capable of manifesting matter seemingly from nowhere because of the uncertainty or instability of the vacuum fields that permeate a space we may previously have considered empty (330–1).

Most of Greene's text is therefore dealing with ideas that defy graphical representation in anything but a highly schematic form and that strain linguistic, analogic representation too. Greene employs dozens of figures to visualise different explanations, but readily admits that the basic structure of spacetime is unpresentable (412). In addition to the complications mentioned above, the ultimate limitation for the author is the extra-dimensional nature of space as suggested by the results of string theory. Greene repeatedly takes mathematically intelligible theorems, which in their original form can deal trivially with details such as any number of dimensions, translates them into natural language, but stops short of representing them graphically. This makes *The Fabric of the Cosmos* a highly textual text, with all mathematical notation restricted to the endnotes and introduced with the refrain, "for the mathematically inclined reader," to further shepherd the lay-reader away from any potentially distracting Greek letters. The main text is a plentiful series of explanations, with summaries, recaps, methodical step-by-step explication of simplified experiments and dozens of analogies. Such a form makes it well suited to presenting the unpresentable.

Yet Greene is not content to provide a depleted version of reality to the reader. When confronting the expansion of space, a commonly used analogy (*e.g.* Levin,

Spots 93) is that of the balloon being inflated: draw some dots on the deflated balloon and then blow air into it to see the dots keep their relative positions but the spaces in between all dots increase; the further away one dot is from another, the greater the rate of the increase in distance. Physicists almost always invoke this analogy — with dots representing galaxies — when explaining the expansion of space, occasionally substituting in some other expanding medium, such as the raisins in a rising loaf of bread (Tegmark 43–4). Greene uses the balloon analogy to explain the findings by Edwin Hubble in 1929 that galaxies are moving away from us and that more distant galaxies appear to be moving away at a greater speed, proportional to their distance (229). Three points are worth noting about Greene's use of the balloon analogy. First, he takes the unusual step of noting the provenance of the analogy, citing its first appearance in 1930, in a Dutch newspaper (231, 516).[23] Second, Greene praises the elegance of the explanation:

> By attributing the observed motion of galaxies to the swelling of space, general relativity provides an explanation that not only treats all locations in space symmetrically, but also accounts for all of Hubble's data in one fell swoop. It is this kind of explanation, one that elegantly steps outside the box (in this case, one that actually uses the "box" — space, that is) to explain observations with quantitative precision and artful symmetry, that physicists describe as almost being too beautiful to be wrong. There is essentially universal agreement that the fabric of the space is stretching. (233)

Greene's use of "beautiful" sits well with Burke's and Kant's usages of the word as an aesthetic category defined against the sublime. Where the sublime is ambivalent and challenging the beautiful is pure delight and does not tax the imagination. Elegant explanations are supposed to be what Greene is known for and what popular science offers. And yet Greene later admits that the analogy is inadequate in a basic sense and that the actual case is impossible to comprehend:

> To go beyond the two-dimensional metaphor of a balloon's surface and have a spherical three-dimensional model is easy mathematically but difficult to

[23] Oddly, Gross castigates Greene for having "filched" this analogy (Gross 83).

> picture, even for professional mathematicians and physicists. You might be tempted to think of a solid, three-dimensional ball, like a bowling ball without the finger holes. This, however, isn't an acceptable shape . . . But if that still leaves you groping for an image, do what just about all professionals do: stick to the easy-to-visualize lower dimensional analogies. They capture almost all of the essential features. (236n)

Greene moves here from the beautiful to the sublime. Even as he propounds the elegance, simplicity and accessibility of a good analogy on the one hand, he ultimately yields to unrepresentability. Knowingly or not, these calm assertions of something beyond representation but which is nonetheless — we are given to think — completely real, is a paradigmatic case of Lyotard's formulation of the sublime: the presentation of that which is unpresentable. In the concluding paragraph of *The Postmodern Condition,* Lyotard further urges that in the postmodern era it is "our business not to supply reality but to invent allusions to the conceivable which cannot be presented" (81). This is almost the creed of popular science writers, especially physicists, who are happy to admit a provisional or fuzzy image of reality. The balloon analogy, precisely because it is ultimately inadequate, can only be a presentation of that which it cannot present, despite Greene's praise of its elegance.

The problem of discussing extra dimensions is just as difficult with spatial dimensions beyond four. In the second half of the book Greene introduces his professional specialty (and the subject of his earlier work, *The Elegant Universe*), string theory, whose formulations typically involve at least nine spatial dimensions. This "bizarre sounding claim" (359) involves additional spatial dimensions that are so tightly curved in on themselves that they escape detection on any scale scientists can measure. Greene initially illustrates this with a figure depicting small loops under a microscope magnifying matter on an impossibly tiny scale. But in the explanation on the same page, he repeats the rhythm of demystification–mystification and directs the reader to now ignore what the "graphic limitations of the figure might lead you to think" because the extra dimensions are actually in "a new direction, completely distinct from the three we know about" (365).

> Now comes a leap. Although it is impossible to draw, imagine that at every point in the three extended dimensions of everyday life, the universe has not

> one extra dimension [as depicted in one figure], not two extra dimensions [as depicted in another figure], not three extra dimensions [as in a third], but six extra space dimensions. I certainly can't visualize this and I've never met anyone who can. But its meaning is clear. (368)

Greene models his own overwhelmed imagination, which inducts the reader into the difficult material, while also signalling its unrepresentability. The "meaning" he refers to is that the texture of spacetime is richer even than the already enriched texture implied by the four-dimensional warping outlined above. In the summation to this section, Greene concludes that the fabric of the cosmos is very rich and that it actually becomes more complicated with more recent aspects of the theory (370). The extended version of string theory postulates that the infinitesimally small strings which constitute the fundamental structure of matter and energy are woven into a fabric of *branes* (387–90). A brane is essentially a higher dimensional string; where a string is a one-dimensional expression of a particle or force, a two-brane is a two-dimensional equivalent that exists in a higher dimensional space and a three-brane ("increasingly hard to visualise") is three-dimensional existing in a four- or higher-dimensional space (385). In this model, we could never observe anything outside our three-brane, although the three-brane may exist in a higher dimensional space, called the bulk with other *braneworlds* floating nearby but obscure to anyone in our braneworld (482). Of course it is impossible to represent a multidimensional brane world "floating" close to another. But the theory suggests that most of reality is beyond our universe, even though *universe* is generally defined as all that exists. By redefining it as all that can be observed, it is possible to have limited epistemological access — to employ Sircello's term — to another universe whose existence can be inferred by the results of string theory within *this* universe. According to Sircello — and *a fortiori* Forsey — this should be an incoherent discourse, making the sublime an incoherent category. But mainstream cosmology regularly, standardly, makes claims about the unobservable

Such problems are encountered every single time Greene writes about a phenomenon that exceeds three spatial dimensions. This includes how gravity would be different in four dimensions (397) and whenever the warping of time is discussed (419, 531) which follows the same relativistic warping around massive objects as do space. The problems are especially evident when even more exotic ideas are explored,

such as wormholes, which are tunnels linking disparate points in space that are "difficult to show in this representation" (462); or the idea of the holographic universe which involves all our observed three-dimensional experiences being a projection of a two-dimensional boundary surface which is the actual universe (482) — which I discuss below.

The tension between the seen and unseen is played out most explicitly in the section devoted to the small-scale geometry of the universe, according to string theory (366–75). Greene runs over the development of potential geometries for the shapes that the extra dimensions of space assume. A *Calabi-Yau shape* is offered as a candidate: this is a six-dimensional manifold that has been described mathematically but obviously cannot be visualised or depicted. Indicative diagrams are given of a curvy, involuted polyhedron that is a three-dimensional analogue of a higher-dimensional object. Greene stresses the far-fetched nature of this possibility by mingling it with our everyday experience. If the theory is right then we are "filled with these little shapes" (369) and as we move, our bodies "would move through all nine dimensions, rapidly and repeatedly circumnavigating the entire shape," unwittingly moving through six invisible dimensions without noticing them (370). Greene's reliance on these unseen facets of the cosmos to shape the sentiment of the text are the clearest examples of his drawing on an aesthetic of the sublime — at least the epistemological sublime, which has the subject encounter the limits of their understanding. This aesthetic might be said to be modern or postmodern, depending on one's interpretation of Lyotard. Lyotard says the modern is still nostalgic, relying as it does on conventional forms even as it gestures to what those forms cannot contain. But the postmodern does not adhere to familiar categories or rules of presentation: "Those rules and categories are what the work of art itself is looking for. . .in order to formulate the rules of what *will have been done*" (81, italics in original). Greene hopes that string theory will be similarly self-contained or self-generating and allow for "all particle properties to be determined by the theory itself" (374). Compare Lyotard's use of the future perfect tense above to Greene's unusual tense and aspect in describing how, in the early pre-inflation universe, most of the Calabi-Yau shape's dimensions remained small, while three were blown up to give us the spacetime we recognise. Greene says that *if* string theory is correct then the rapid expansion of space "in a way that we don't yet understand, *would have had* to pick three of their spatial dimensions as special" (374, italics added). Although Greene

advertises the unanswered questions in cosmology and the provisional nature of string theory, it is nonetheless offered as a theory of everything that will somehow explain the unseen, unpresentable past according to its own new rules of explanation. Greene's motif of impossible-to-depict phenomena is certainly sublime according to Lyotard and Greene's advocacy of string theory may even cross into Lyotard's postmodern. But Greene never doubts the potential of scientific knowledge to explain all, which means this remains a purely epistemological sublime produced by *current* limitations.

Other unpresentable phenomena are peppered throughout the text. These include the plainly unpresentable like supernova brightness (298) and more conceptual unpresentables: it is more likely than not (according to the laws of thermodynamics) that the universe appeared out of nothing a moment ago complete with memories from the past (319). This makes a mockery of re-presentation itself, as even our presentations of the past might be fake. But it is the materially unpresentable that forms the basis of the sublime in cosmology. Black holes, warped spacetime and the study of dark matter and dark energy, all show that there is "something which can be conceived and which can neither be seen nor made visible": Lyotard's defining feature of the sublime in modern art (78). I mentioned in the Introduction the examples Lyotard gives from art and literature of the sublime aesthetic in modernism and postmodernism. Here we might say that the Calabi-Yau shapes are the Malevich squares of modern science writing, as they present only *negatively* what cannot be presented. And the inadequate balloon analogies could be Greene's equivalent of Proust's evasions that do not, unlike Joyce, question "the identity of writing" (Lyotard, *Postmodern* 80) but do allude to the inadequacy of comprehension.

The apophatic II: the obscure

In addition to that which is known indirectly but cannot be represented, there is a related source of the sublime that I designate with Burke's notion of the obscure. Burke says that anything obscure can produce the sublime effect. As examples, he provides a description of Satan from *Paradise Lost* which emphasises his indistinct aspect and how in some paintings "a judicious obscurity" can better represent dim parts of nature (57–8). But more so than the tenebrous imagery of paintings, it is the

abstract, intangible nature of poetry that, according to Burke, is the real source of sublime obscurity: "poetry with all its obscurity, has a more general as well as a more powerful dominion over the passions than any other art" (57). For Burke it is ultimately "our ignorance of things that causes all our admiration" (57) and thus the images conjured by poetry are more admirable than painting, which must — before modernism — be imitative. The "apparitions. . . chimeras. . . [and] allegorical figures" (59) that poetry evokes are so obscure, so unattainable they are a special form of the unpresentable.

Burke's obscure sublime is similar to Barnett Newman's notion of the abstract sublime (Newman 51–2). Burke cannot prescind from his historical context to consider the possibility of non-figurative art, or indeed the Islamic art of his time.[24] But the appeal of Newman's abstract expressionism, for example, is also its "remote presence that we can only intuit and never fully grasp" (Rosenblum 40). An analogue in another medium is that of music which, according to Burke's contemporary James Usher, is sublime because it is completely free of associations, unlike other art forms and so provides a "shadowy beauty" like the "dissolving ideas of a delightful dream" (Usher qtd. in Ashfield and de Bolla 158–9). This is perhaps simply the difference between being beyond *re*-presentation as in the phenomena in the previous section and beyond initial presentation because the source resists coming into focus. I do not think this is a rigid, categorical distinction from the unpresentable phenomena already discussed, but it might aid in seeing the plurality of ways that popular science authors mystify in their putative attempts at demystification.

In *The Fabric of the Cosmos* many of the exotic objects being discussed are obscure in a literal sense: they cannot be seen. It is not so much that they cannot be represented in the imagination, or represented in some medium, but that they are resistant to presentation to the subject because they are invisible. Dark matter is the most prominent example. Its existence can only be inferred by the gravitational effect it has on galaxies, as it seems not to reflect, emit, or otherwise interact with light of any wavelength (295). Nevertheless it accounts for 26% of all the mass/energy of the known universe, compared to only about 5% for all the matter and energy we can observe directly (Randall, *Dark Matter* 21). The remainder — close to 70% — is attributed to dark energy, which is even more inscrutable. Both dark matter and dark

[24] Unlike Longinus and Kant, Burke does not commend the Abrahamic prohibition on graven images as sublime, though it would seem to fit with his claims about obscurity.

energy are unseen and yet ubiquitous, providing for a model of the universe that is weighted (literally) towards what is beyond the senses, beyond appearances. These phenomena are unpresentable in a different sense to the warped spacetime and extra dimensions discussed above.

There are other ways that obscure, inscrutable things are presented in the text. Some of the postulated phenomena are beyond presentation because of physical limits. The earliest moments of the universe, for instance, were probably characterised by violent field fluctuations and temperatures so enormous that no information survives from that period (257). Only the cosmic microwave background radiation remains, which is a remnant of the advent of atoms about 300,000 years after the Big Bang (257, 287). The first 300,000 years are unpresentable inasmuch as they seem to have existed, they can be written about and mathematically modelled, but they cannot present anything to scientists and Greene can only present *this* fact to the reader. Similarly, black holes are so dense with such extreme gravitational pull, that they absorb matter, energy and even light from surrounding areas. All that can be known about a black hole is encoded in three pieces of information: its charge, its mass and its spin (477). The interior of the black hole is utterly unpresentable although it is trivially easy to present this fact.

The obscure is a kind of known unknown: there is *something* to be considered but its outline, extent, or form is beyond apprehension. Burke claims that to see something distinctly "and to perceive its bounds is one and the same thing" and thus: "A clear idea is therefore another name for a little idea" (57–8). This is the second hint at an ontological sublime that not only makes clear the limits of presentation, but the limits of what it is that is being presented. After all, something like dark matter is potentially all around us and may even be responsible for the periodic mass extinctions on Earth (Randall, *Dark Matter* 168–79). It is not that dark matter is too small to see but that it cannot be seen. Kant did not entertain anything like dark matter, which does not fit neatly within his mathematical or dynamical sublime. But it clearly confounds both the senses and the imagination. Again, Lyotard said that in the era of postmodernity and the sublime it is "our business not to supply reality but to invent allusions to the conceivable which cannot be presented" (81). Greene offers such an allusion with an analogy for the discovery of dark matter. The astronomer Vera Rubin deduced that more stars should be flung out of galaxies than do so and that they must be held in orbit by some unseen gravitationally potent mass: "And so,

like an audience that infers the presence of a dark-robed mime even though it sees only his white-gloved hands flitting to and fro on the unlit stage, astronomers concluded that the universe must be suffused with dark matter" (Greene, *Fabric* 295). Burke, for whom the sublime is obscure — and masculine — would approve.

The parergonal I: boundaries

The theme of the boundary or limit is a preoccupation of writers describing the sublime and it recurs throughout most popular cosmology books. Greene and others grapple with the edge of understanding, the shifting boundary of the visible universe, the extent of precision in measurement, the borders of the universe itself and the inherent limits involved in the uncertainty principle and the Planck scale. Nor is the boundary always clear; sometimes it is shadowy or fades out. But whether the boundary is distinct or fuzzy its recognition implies something beyond the boundary and the discerning of the limit presupposes the limitless. This is how the logic of Derrida's parergon operates.

The parergon is the border, frame, or boundary that demarcates the work — the ergon — from what is not the work. Derrida cites the parergon in the form of columns in architecture, the frame in painting, as well as more abstract frames such as the gallery or institution that mark off an object as a work of art (127). The ergon and parergon cannot exist without each other. The parergon can be found, conceptually, in texts as well. Derrida reads all three works of the *Critique* and claims that the transcendental–empirical dichotomy to be found in Kant's work is a kind of parergon: a co-implication of two ideas that are supposed to be distinct, yet each bears traces of the other (Shaw 116). Even the discussion of the parergon in *The Critique of Judgement* (68; pt. 1, sec. 14) is a brief, marginal note in a seemingly unimportant chapter, although it discloses this crucial point about the integral relation between the centre and boundary: "I do not know whether the passage in the third *Critique* where the *parergon* is defined is itself a *parergon*" (Derrida 63, italics in original).

The sublime in Kant is also a kind of parergon (Shaw 120) or at least another supposedly marginal element to the text — "a mere adherent appendix" (Derrida 103) — which actually has a structural necessity. It is supposed to mediate the two great realms in Kantian philosophy: the sensible, empirical and natural on the one

side, with the rational, moral and transcendental on the other. In beholding some natural object that is large in relation to us — like mountains as in the "dynamical sublime" — or some object of thought that exceeds measurement — like infinity as in the "mathematical sublime" — we become aware of something beyond the phenomenal: reason. The sublime is clearly central to the *Critique* as it mediates between two large and otherwise separate domains. But Derrida claims that Kant cannot achieve this mediation without the keystone of the parergon. Derrida says that whereas the beautiful is bounded and finite, the sublime is *meant* to be formless — this is Kant's argument — but it never can be (Derrida 127). For Kant's dynamical sublime, produced by vast mountains, perspective matters because an object must be close enough to be impressive, but far enough away that one can appreciate its massiveness (Derrida 108). It is therefore an effect of framing or alignment. Kant's mathematical sublime of infinity is likewise reliant upon some kind of framing, albeit a conceptual one. The effort to comprehend infinity is "bounded" by the "unbounded" power of reason (Shaw 131).

Infinity recurs throughout popular cosmology texts and is the definitive example of a Kantian mathematical sublime. By symbolising and defining infinity, mathematicians and theoretical physicists reason their way to a limit on the inherently limitless. For Derrida, it is the setting of limits — even if they are purely part of the system of signification — on what seems to be limitless that is the essence of the sublime (Shaw 118). In fact Cheetham claims that Derrida is complicit in this same project: "Derrida and Kant are obsessed with borders and legislation of conceptual boundaries. Both thinkers, I will argue, employ the term 'sublime' — despite its putative boundlessness and uncontrollability — as a cipher of circumspection" (102). This is one point at which the ontological commitments of theorists of the sublime ultimately determine how they conceive of it. Derrida cannot conscience the idea of the limitless being evoked in a text without it entailing the limit. Whereas for Lyotard the unpresentable can be unproblematically — from his own perspective — removed from the presentable as something that is truly distinct (the further ontological commitments of Lyotard are introduced in next chapter).

Returning to Greene, we see a more Derridean sublime in the interplay between the border and the territory that is involved in describing the shape and size of the universe as a whole. The "edge" of space is a fraught concept and Greene details the three possible shapes of the universe and what their boundary conditions

are (238–43). In the first shape the universe has constant positive curvature and therefore bends around on itself, like the surface of a sphere (*sphere* is another analogy of two dimensions curving into three, whereas the actual case involves three dimensions curving in this manner). With positive curvature, the universe has no boundaries, but is finite in extent. The parergon here is not spatial — this is literally an unbounded space — but conceptual. Greene illustrates the idea of a finite, unbounded universe with the example of Magellan voyaging all the way across the globe and appearing back where he started. Thus we have a space that bends around on itself that is imagined by way of a globe *with* an edge (its surface); Greene has to delimit the space to explain how it has no limits; when he then extrapolates the principle into a three-dimensional space, he is up against the limits of imagination.

The second candidate for the geometry of space is flat — and analysis of better data subsequent to Greene's publication has strongly suggested this is the shape of our universe (Randall, *Heaven's Door* 364–5). But flat space can still be confounding. It can be finite or infinite. In the finite case it again wraps around on itself and Greene employs another two-dimensional analogy, that of a video game screen where a character can disappear off the right hand edge of the screen and reappear on the left hand side (240). But in translating to the three-dimensional case we are again beyond the bounds of visualisation.

Finally Greene explains the third option of a space with constant negative curvature, demonstrable in two dimensions by the surface of a saddle, which is the topological opposite of a sphere (241). In such a space there can be a finite or infinite version, but again neither can be bounded as even the finite version will fold back on itself. This space is just as difficult to imagine in a three-dimensional form and Greene cannot even offer an analogy in two dimensions, as he did with the globe and computer game — "I won't discuss this further" he adds in a footnote (241n).

Although none of these possibilities entertains the idea of a physical boundary, by doing so they provoke a conceptual boundary where the author must admit they have no way of adequately explicating the idea. The reader is taken to the limit of what she can envision, but has been guided through the conceptual sequence, step-by-step, such that she can comprehend what she is missing. With this known unknown, a kind of Kantian two-stage movement of the sublime is in place, whereby the subject has their imagination confounded, but then becomes aware of how reason — or at least science writing — can nonetheless grapple with what is beyond other

faculties. Except that in the marginal note where Greene gives up on providing an analogy, there is a hint at the unpresentable nature of the shape — the frame — of space as a whole. In a work dedicated to explaining the nature of space this footnote is reminiscent of the parergon passage in Kant.

Another physical example of Derrida's parergon is the theory of the holographic universe which emerged from study of black holes in the 1990s. A spherical black hole's entropy (roughly, a measure of disorder) is determined not by its volume but by the surface area of its event horizon, its boundary (479). This is suggestive because black holes are regions of maximum possible entropy. If that fundamental feature of the universe — entropy and information — is bounded by a two-dimensional surface in the situation where entropy is maximal, then seemingly any region of space's entropy could be described in two-dimensional terms. Extending this idea to the universe as a whole, physicists have speculated that the seemingly three-dimensional space in which we and everything else exists is merely a projection of conditions on our universe's two-dimensional boundary or surface. Greene reserves some of his more effusive prose for this section (481–85), including the note that the "fantastically strange" holographic principle is a bizarre inversion of Plato's cave, such that the shadows are the reality and we are merely "evanescent projections of the shadows" (482). Such a scenario provides a new kind of parergon, with the marginal border not simply demarcating but actually constituting the interior of the work.

In the final part of *The Fabric of the Cosmos* Greene goes even further than the unintuitive ideas of additional spatial dimensions or the equally unintuitive idea of fewer spatial dimensions as in the holographic principle. The text's through-line of determining the nature of space and time culminates in this section, with the statement that space and time may be merely emergent properties of some "ur-ingredient" (474). Following the implications of string theory Greene admits that the same configuration of spacetime can be described by physicists using two different geometries, mathematically distinct but equivalent, suggesting that spacetime is not a fundamental phenomenon, otherwise observers should agree on its mathematical description (476–7). Such a notion seeks to undermine even the figurative origin of a frame or parergon, drawn as it is from spatial metaphors of paintings and architecture. Perhaps this is the boundary condition for the Derridean notion of the sublime, as Greene tries to articulate in language saturated in spatial imagery a

reality that is non-spatial. At this point it arguably becomes something closer again to the unpresentable of Lyotard and speaks to a more ontological sublime that may undermine the knower of such unpresentables.

The parergonal II: scale

Another view of the sublime of limits is in terms of scale. A standard part of the popular science repertoire is to overwhelm the reader's imagination with some gigantic or miniscule scale, something incomprehensible because of its distance from everyday magnitudes (Turney, "Abstract" 94–5)[25]. Authors will then offer a resized version of the magnitude, to place it within a human context. For example, Carl Sagan's famous device of the cosmic calendar aligns the 13 billion year history of the universe with a calendar year, making the 100,000 year span of human history equivalent to only the last 15 seconds of December 31st (Sagan, *Dragons* 13–6). This might be seen as an echo of a common device employed by painters in the Romantic movement. In the pictures of Caspar David Friedrich, for example, the human figure is placed near the bottom of the scene, all but invisible next to the craggy cliffs or daunting gorge, providing a visual scale, with the human as a key or legend. This is the pictorial equivalent of Greene's grain of sand analogy.

Greene often avoids the second stage in this manoeuvre, settling for the impact of vast numbers on their own. When explaining entropy, for instance, Greene calculates the out of order permutations of the pages in *War and Peace*: approximately 10^{1870} — a number that takes almost an entire page to write out in full (152–3). Perhaps the impact is lessened, however, as the number might be so outsize that the reader fails to feel the impact.

One passage where Greene attempts to domesticate a vast scale is when he explains a scale too outsize for any analogy. The expansion factor of the early universe when it underwent rapid inflation has been conservatively estimated at 10^{30} in 10^{-35} seconds, which would "be like scaling up a molecule of DNA to roughly the

[25] In fact Randall explicitly uses this as her example of the sublime in science and in so doing accepts a conception of the sublime that is essentially Derridean: "The sublime proffers scales and poses questions that just might lie beyond our intellectual reach. It is for these reasons both terrifying and compelling. The range of the sublime changes over time as the scales we are comfortable with cover an increasingly large domain" (*Knocking* 41–2). Hence the sublime is still bounded by the scales that obtain at a given time, even as it refers to the allegedly unbounded or limitless.

size of the Milky Way galaxy in a time interval that's much shorter than a billionth of a billionth of a billionth of the blink of an eye" (284–5). Both the DNA molecule and the galaxy are themselves usually the subject of such resizing, because they too are of incomprehensible scales. Later on in the same passage Greene observes that with such an expansion factor in place the universe would have expanded well beyond what we can currently observe: "If the entire cosmos were scaled down to the size of earth, the part accessible to us would be much smaller than a grain of sand" (285). That is the classic scale effect of the science communicator, like Sagan's cosmic calendar, and can be seen as a way to reason with the unreasonable magnitudes and multitudes offered by modern science.

The former effect, however, with DNA and the Milky Way, is a deeper mathematical sublime. I liken it to what Timothy Clark has called a "derangement of scale" (Cark 150). In his ecocritical writings (discussed further in Chapter 3), Clark has lamented the scale effects of climate change discourse, whereby the planetary scope of the problem is irreconcilable with the scope of everyday political action (151). The political consequences of Greene's explanation of cosmic inflation are not as acute. But the derangement of scale illuminates the same problem: the human is utterly alienated from the larger scale involved, in Greene's case astronomical, geological in Clark's. Kant would have it that human reason is capable of dealing with these imponderable magnitudes, even if analogies fail. For ecocritical writers, however, the ecological or environmental sublime is self-effacing: against Kant, it is not meant to end with the apotheosis of the human subject and her reason but with a recognition of the alterity of the nonhuman in an encounter with something exceeding representation or reason (Hitt 616–7). Hence Greene's derangement of scale, although it is so remote from human concerns as to seem apolitical, is the same as what we will encounter in the life sciences in Chapter 3, where the human is implicated by these scales that cannot be reconciled with the human. One's response to these alienating scales is perhaps itself an effect of framing. In Greene's book about space, the dwarfing of the human does not imply some radical political point. And yet the same scale effects in an environmental discourse — where some human action is expected and the impotence of that action is suggested — seem to throw the reader into a much more complicated relation whereby the second part of the Kantian sublime cannot be relied upon to restore the subject's sovereignty. The scale effect in cosmology is still the province of the epistemological sublime where the

limits of the subject's understanding are made plain, but not any threat to their existence or integrity — as in the ontological sublime.

Another derangement of scale occurs when Greene discusses the Planck length. It is the theoretical minimum size for anything (approximately $1.5 \ 10^{-35}$ metres), the level at which reality "bottoms out" and space cannot be further divided. This seems to put a hard limit on scale itself and suggests that the universe at the most fundamental level is not continuously divisible, continually resizable, but discrete:

> It [the Planck length] forcefully challenges the conventional notion that the fabric of space and time is continuous — that you can always divide the distance between here and there or the duration between now and then in half and in half again, endlessly partitioning space and time into ever smaller units. Instead, when you get down to the Planck length (the length of a string) and Planck time (the time it would take light to travel the length of a string) and try to partition space and time more finely, you find you can't. The concept of "going smaller" ceases to have meaning once you reach the size of the *smallest* constituent of the cosmos . . . If string theory is correct, the usual concepts of space and time, the framework within which all of our daily experiences take place, simply don't apply on scales finer than the Planck scale. (350, italics in original)

This is a proposed limit on how much space or time can be divided and therefore a physical end of the scale. Like the idea that space itself is non-fundamental, this is another hint at an ontological sublime, where the results of modern physics rudely intrude on the categories that a Kantian would employ in describing their (epistemological) sublime. The idea of there being building blocks of a particular size that cannot be further divided, means that something analogous to the doctrine of atomism is thrust back into consideration. If true, this hypothesis would adjudicate one of Kant's famous antinomies: that of atomism and whether there are only simples or composites (*Reason* 478–80). Indeed, Kant's other antinomies were to do with space, time, causality and the origin of the cosmos: all of these have postulated explanations that can be found in almost any recent popular cosmology book. I am not claiming these explanations are proven. I am claiming that the purely

epistemological sublime that elevates reason as a way to recover from the senses being overwhelmed, is compromised by ideas in popular science that interpose metaphysical implications.

Kant had it that no matter how vast or miniscule the scale, the mere fact of human minds being able to apply a scale to anything results in nature "sinking into insignificance before the ideas of reason" (*Judgement* 105; pt. 1, sec. 26). Really, then, the scale effect is a form of parergon, where the subject's boundless capacity to impose quantitative limits on any large or small thing, either with the aid of numbers or a resized example, is convolved with the physically bounded thing. Any scale effect must by definition involve limits and measures and is therefore amenable to conceptual analysis, in the Kantian system.

But the passages that most engage this analysis are the ones that convey the sublime effect most strongly. When Greene offers a large number, for example when he states the speed of light as being 670,000 miles per hour (45), the text is hardly interrupted. However, when a large number is offered along with a comparison for scale (*e.g.* the grain of sand analogy above) the reader's scale is incorporated into the analogy and the magnitude of the number becomes apparent, as happens while gazing at a Friedrich painting. The most disquieting breach in the textual flow is the doubly outsize example where even the scaling analogy is beyond our intuition: the DNA and the Milky Way. Such an example involves a bounded quantity, fairly precisely bounded in fact, but without a final return to a digestible range, leaving the reader with a ratio of scales to put in comparison, but unable to really envisage that comparison. Although almost nonsensical in its incomprehensibility, this scale is strictly speaking *rational*, in the mathematical sense of being able to be put in proportion (into a ratio) and therefore fulfils Kant's strictest criteria for what is sublime and also Derrida's imperative that the sublime be colossal but not totally formless (124–5). We should distinguish, however, between the deranged scale of the DNA–galaxy analogy and an attempt to go beyond any scale whatever. Such an effort should not be possible according to Derrida and yet the endpoint of scale implied by the Planck length may suggest otherwise.

It is noteworthy that the image with which Greene closes the book is of the possibility of one day detecting strings, not with equipment that can somehow resolve those miniscule domains, but by finding strings that stretch across whole regions of the observable universe. If string theory is correct then some of the strings

from the early universe would have been blown up along with cosmic inflation to now be "writ large across the sky" (308). This would not only repair the deranged scale of the expansion analogy, by bringing the world of strings into the world of astronomy, but also lend credence to a theory that aims at an unprecedented explanatory breadth.

And so a final point is worth making about the scale *of* scientific theories themselves, in terms of how extensive their reach is. As early as Joseph Priestley, writing at the height of the eighteenth-century fashion for the concept, we can see the emergence of a scientific sublime, particularly evinced by the wide applicability, generality, or extensiveness of scientific theories:

> The sublime of science consists in general and comprehensive theorems, which, by means of very great and extensive consequences, present the idea of vastness to the mind. A person of true taste may perceive many instances of genuine sublime in geometry, and even in algebra; and the sciences of natural philosophy and astronomy, exhibit the noblest fields of the sublime that the mind of man was ever introduced to. (Priestly qtd. in Ashfield and de Bolla 121)

Alexander Gerard has a similar view that "the sublime of science . . . lies in universal principles and general theorems" with "multitudes of corollaries and subordinate truths" flowing from them (Gerard qtd. in Ashfield and de Bolla 169). John Baillie urges those appreciating science not to dwell on "minutiae" but "rather to consider their universal relations: studies which seem dry, become exalted and agreeable, by such a management" (Baillie qtd. in Ashfield and de Bolla 100). And in modern popular science, authors, especially physicists, frequently extol the fact that a set of simple equations can have such gargantuan applicability.[26] These laudations for specific equations or theories often accompany homilies for the scientific enterprise as a whole (although this is not so in Greene). For commentators such as Wong and Gross, this bombast *is* the scientific sublime. But what I call the modern scientific sublime is more to do with the confounding realms or questions raised by scientific theories, rather than their success in explaining broad classes of phenomena or their

[26] See for example Carroll's *Big Picture* (437), Greene (*Fabric* 15–16), Hawking (*Brief History* 12), Randall (*Knocking* 122); and this is the subject of Rees' entire book, *Just Six Numbers*.

rhetorical boasting of that success. In fact, once phenomena are subsumed within a well working, well understood theory, when explanation is as effective as possible, that is precisely not when science writers evoke the sublime. Recall the question raised by Wong about whether effective explanation or effective education actually denudes the sublime. Perhaps this has happened with Copernicus and maybe even with some cosmological phenomena like black holes. But the preposterous scales of cosmology, especially when put into apposition with intuitive human scales, seem impossible to render normal. In that vein, the next chapter will explore popular accounts of quantum mechanics, where no amount of explanation seems capable of demystifying the content, even though it is 100 years old.

The threat of the ontological sublime

Nothing encountered in this chapter would necessarily perturb Kant or one of his followers, unless they acceded to the idea that new notions of space undercut the Kantian project as a whole. The phenomena discussed certainly tax the imagination more greatly than anything Kant wrote about. But they could also be seen as extensions of phenomena that Kant had personally encountered: as an astronomer early in his career he observed nebulae and argued that they were other galaxies in an expanding space which, throughout eternity, would create everything that could be created (Rubenstein 133–9). But infinite space and time do not in themselves undermine the subject contemplating them. Although they *dwarf* the subject, Kant's sublime is instantiated by the ability to account for this dwarfing, to reason with magnitudes and ideas unpresentable to imagination.[27]

Space and time are not merely objects or concepts for Kant, but something more vital for the subject. This is where we start to shade into the ontological sublime, because Kant claims they are innate "conditions of sensibility" (Kant, *Reason* 369) outside of which we cannot consider any phenomena:

> We can never represent to ourselves the absence of space, though we can quite well think it as empty of objects. It must therefore be regarded as the

[27] However, the extra dimensions of string theory or the reduced dimensions of the holographic universe both contradict Kant's arguments about the veridical nature of our innate sense of three-dimensional space. And his argument about Euclidean geometry being an example of synthetic *a priori* knowledge (*Reason* 176) is undermined by the non-Euclidean geometries of relativity.

> condition of the possibility of appearances, and not as a determination dependent upon them (*Reason* 38–9).

Greene is not unaware of Kant's privileging of space and time:

> Frankly, I can see where Kant was coming from. Whenever I sit, close my eyes, and try to think about things while somehow not depicting them as occupying space or experiencing the passage of time, I fall short. Way short. Space, through context, or time, through change, always manages to seep in. (471)

Yet Greene is acutely aware of the fact that space and time may be emergent phenomena that manifest based on the behaviour of more fundamental constituents (471). Thus he is able to reason about something he cannot imagine. We have already seen how it is straightforward for physicists to work not only in non-Euclidean geometries of four dimensions, but also within superstring theory which posits eleven dimensions. Kant could not entertain the possibility of thinking other kinds of space. Modern physics almost breezily introduces four-dimensional spacetime, nine-dimensional string theory, abstract Hilbert spaces whose relation to physical space is ambiguous and the notion that space of any kind is an emergent result of underlying laws. Even expressing that idea is difficult without recourse to spatial language, such as *underlying*. All of these start to eat away at the Kantian version of the sublime. But clearly a Lyotardian could still say these are all cases of unpresentable phenomena that modern physics can nonetheless present the existence of. The subject whose presentation is overwhelmed is not directly questioned. In the next chapter we encounter ideas from modern physics that *do* impact upon the integrity of the subject.

Considering the vastness of the cosmos, including the nebulae he discovered, Kant speculated that rational beings must inhabit other worlds. But he never put this idea into conjunction with the possibility of infinite space. Doing so yields a terrifying conclusion: there must be doppelgänger worlds with doppelgänger Kants in far reaches of the universe, as real as the one who wrote his words. In his *Universal Natural History and Theory of the Heavens* Kant pulls back from the thought of an infinite cosmos, perhaps because of that implication. Contemplating an infinite succession of worlds, he confesses, "There is no end here but an abyss of a true

immeasurability in which all ability of human concepts sinks" (Kant qtd. in Rubenstein 136). We have shifted from the limit to the abyss. In the next chapter, the results of quantum physics — among other disciplines — suggest that the many worlds of an infinite cosmos are the thinnest slice of the real scope of reality. Along with the completely unintuitive nature of the world at the quantum scale, these theories do not simply overwhelm the imagination and present the unpresentable, they attack the givenness of things, the basis of cause and effect and the identity of the subject. Phrased in cosmological imagery, we have moved from the blurry edges of the frontiers of the galaxy to the supermassive black hole right at the heart of the system, around which the system wheels. This is the ontological sublime.

CHAPTER 2: Quantum weirdness

Cosmology is the physics of grand scales and strange heavenly objects. It boggles the mind but does not threaten the subject. Cosmologists vie for attention and funding as they propose speculative theories for what will happen to black holes in the far future, the nature of dark energy and the overall shape of the cosmos. But in the physics of the very small, the quantum realm, there is a surprising mismatch between how well established the science is and how reticent the practitioners are to dwell on the imponderables. Quantum mechanics is the most fundamental theory in science, inasmuch as it describes reality at the smallest physical scales that are in any way measurable or manipulable. The rudiments of the theory are now 100 years old and predictions in quantum mechanics are more accurate by far than in any other branch of science. But amid this respectability and orthodoxy lurks paradox, undecidability and fantasy. According to quantum mechanics everyday notions of cause and effect, identity, continuity and location break down. For example, particles can appear out of thin air, so long as they disappear after a brief enough interval, ensuring they do not affect the system around them (Levin, *Spots* 69).

Because of this kind of strangeness, quantum physics is a favourite topic for popular science authors who love to comment on the highly counterintuitive ideas in quantum theory and experiment. But these are just comments. There is an unusual — for the genre more broadly — lack of attention paid to the *details* of counterintuitive quantum mechanics. This is best illustrated in contrast with popular books about cosmology. Lisa Randall's *Dark Matter and the Dinosaurs* emphasises the unintuitive, hard-to-imagine content of her cosmological topic: dark matter. As mentioned in Chapter 1, dark matter accounts for roughly 30% of the mass of the known universe, yet it does not interact with the electromagnetic spectrum. It is invisible, detectable only by inference via its gravitational effects on nearby visible objects like stars. Dark matter is a sublime object, one that is inscrutable, vast, even menacing: it may be responsible for the periodic mass extinctions in Earth's history, as our solar system, in its orbit around the Milky Way galaxy, enters a zone that is thick with dark matter, thereby increasing the number of comets and asteroids that careen into the earth. This object confounds the imagination and is unpresentable, yet is amply described and its inscrutable nature is dwelt upon for effect: "Dark

matter passes right through our bodies — and resides in the outside world as well. Yet we don't notice any of its consequences" (Randall, *Dark Matter* 2).

Randall's text invokes dark matter and triggers a sublime experience, in keeping with Longinus, Burke, Kant and the early Lyotard. Other objects encountered in popular cosmology books — black holes, warped spacetime, the Big Bang, supernovae and the edge of the observable universe — are described in ways that emphasise how hard they are to properly conceive of and the authors are happy to admit temporary ignorance, safe in the assumption that further funding, more powerful instruments, or more flashes of individual genius will extend the ever advancing frontier of scientific understanding (Randall, *Knocking* 340–4). In short, confidence defines the rhetoric of popular cosmology.

But in describing the quantum world, popular authors are more reticent. This is especially evident in books which contain both topics. The same author will happily describe experts' incomprehension about current issues in cosmology while avoiding the more intractable problems in quantum physics. Typically, authors describe the quantum world as "weird", "bizarre", or "crazy" but do not elaborate the most confounding features of the theory, even though equivalent features in the cosmology subgenre form the most prized examples for popular consumption. There is a vacuum at the heart of popular accounts of quantum physics and this absence is present even in adjacent genres, such as textbooks on the subject.

This void in the subject matter corresponds to a different tradition of the sublime, one that is ontological rather than epistemological and which dwells on a void in the subject and matter. Where the cosmological sublime is the direct inheritor of Longinus, Burke and Kant and finds its expression in the vast majority of contemporary theory on the sublime, the ontological variety is a minority discourse, found in Žižek and the later Lyotard and whose only well-known historical antecedent is Lucretius. The crucial distinction is seen in sharp contrast in these two subgenres of popular science. The epistemological sublime is a short-lived sense of being overwhelmed followed immediately by self-affirmation; the ontological sublime is a potentially irreconcilable confounding followed often by self-abnegation. In Kant's version of the sublime, reason comes to the rescue when the imagination fails; warped spacetime is visually unpresentable and may short-circuit the imagination but it is easily described mathematically and easily analogised with lower-dimensional examples. But the infamous collapse (or non-collapse) of the

wavefunction — a central aporia in quantum physics, as we will see — is destabilising in an enduring fashion. In the popular texts and the textbooks, wavefunction collapse is occluded, repressed, or even renounced.

I begin this chapter with a brief survey of the unusual popular literature on quantum mechanics, in order to illustrate what it leaves out. I then examine the imagery in two atypical examples from the popular nonfiction genre: David Deutsch's *Beginning of Infinity* and Max Tegmark's *Our Mathematical Universe*. They are atypical because they do actually entertain some of the stranger consequences of quantum mechanics and offer an *interpretation* of the results: both authors are more ontologically confident than others in the subgenre. But it is still the case that neither of them fully face up to the most ontologically threatening implications of their own theories. I then more closely define an ontological sublime, drawing on Lyotard and Žižek, which will also be central to all subsequent chapters. Finally, I return briefly to Greene's *The Fabric of the Cosmos* as a brief example of a rare text that confronts the more daring ontological sublime.

The quantum field and its vacuum

I looked at 40 popular science books that contained at least substantial sections on quantum physics.[28] Most contained no details about the stranger quantum experiments, or the interpretation of the results, or the broader scientific and philosophical implications of such interpretations. One might offer the explanation that philosophy is unlikely to arrise in popular science books in any case. But it is *this*

[28] They were *Life on the Edge* by Jim al-Khalili and Johnjoe McFadden; John Barrow's *The Book of Nothing*; Brian Cox and Andrew Cohen's *Wonders of the Universe*; *The Quantum Universe* by Brian Cox and Geoff Forshaw; *The Big Picture* by Sean Carroll; Paul Davies' *Ghost in the Atom*; *The Fabric of Reality* and *The Beginning of Infinity* by David Deutsch; Timothy Ferris's *The Whole Shebang*; *The Character of Physical Law* by Richard Feynman; *The Elegant Universe*, *The Fabric of the Cosmos,* and *The Hidden Reality* by Brian Greene*;* John Gribbin's *In Search of Schrödinger's Cat* and his follow-up *Schrödinger's Kittens; A Brief History of Time, The Universe in a Nutshell* and *The Grand Design* all by Stephen Hawking (the last co-written with Leonard Mlodinow); *Hyperspace* and *Parallel Worlds* by Michio Kaku; Manjit Kumar's *Quantum*, Lawrence Krauss's *Quintessence*, *A Universe from Nothing* and *The Greatest Story Ever Told…So Far*; Janna Levin's *How the Universe Got its Spots*; *The Emperor's New Mind* and *The Road to Reality* by Roger Penrose; *Warped Passages, Knockin' on Heaven's Door* and *Dark Matter and the Dinosaurs* by Lisa Randall; *Just Six Numbers* by Martin Rees; Carlo Rovelli's *Seven Brief Lessons on Physics* and *Reality is Not What it Seems*; Simon Singh's *The Big Bang*; *Three Roads to Quantum Gravity* by Lee Smolin; Leonard Susskind's *The Black Hole War*; Max Tegmark's *Our Mathematical Universe*; *Black Holes & Time Warps* by Kip Thorne; *Death by Black Hole* by Neil deGrasse Tyson; *Welcome to the Universe* by deGrasse Tyson *et al.*; Steven Weinberg's *Dreams of Final Theory* and *A New Kind of Science* by Stephen Wolfram.

point which divides the quantum subgenre from its cousins. The authors of popular books on cosmology, evolutionary biology, or neuroscience generally show no hesitation in expanding on the philosophical or cultural import of their scientific topics; frequently they are criticised for doing so.[29] This leaves us with a curious absence or gap in most books about quantum physics.

There is also the problem of authority and interpretation of texts. When analysing popular cosmology books, although I have no professional expertise in that area, I was able to synthesise a rough consensus merely by reading many books written by authors who were themselves scientists, who were esteemed and legitimated in their academic community and in the public sphere.[30] There is also little disagreement about the fundamentals of the science and even when authors confront philosophical issues — for instance science versus pseudoscience — there is at least a common understanding of the ground of dispute and the boundaries of the discipline were fairly distinct. But in books on quantum physics there are authors who both quietly and loudly avoid anything they deem to be philosophical or speculative. This makes it difficult to examine the quantum reticence from within the subgenre and so I had to move beyond it.

There is an institutional history to this phenomenon which itself could be the subject of a separate sociological or historical study. But even on that front, I could only find one extended work that asked *why* there was this absence in quantum texts, both popular and specialist: *How the Hippies Saved Physics* by the historian of science David Kaiser. It is a history of quantum physics and its involvement with the New Age movement, 1960s counterculture and the Cold War. I also consulted quantum physics textbooks to get some understanding of what was missing from the popular texts, but even the textbooks generally omitted the same information. According to Kaiser, a "shut up and calculate" mentality came to dominate physics departments in the early years of the Cold War (Kaiser xiv; see also Papineau). This extended to pedagogical methods in the instruction of quantum physics at a undergraduate and postgraduate level (Kaiser 17–20). My own researches in that

[29] Some examples of expansive, philosophical topics included in popular science are deconstruction and deep ecology in Lynn Margulis and Dorian Sagan's *Microcosmos*, personal responsibility and free will in Richard Dawkins' *The Selfish Gene*, the sources of morality and aesthetics in V.S. Ramachandran's *The Tell-Tale Brain*, or the existence of god in Stephen Hawking and Leonard Mlodinow's *The Grand Design*. For criticism see Gross, Sideris and Curtis White.

[30] I do have professional experience as a science communicator and have studied some university level mathematics, which does help somewhat with topics in physics.

area confirmed a notable lack of discussion of different interpretations of quantum physics, or even a mention that there were different interpretations.[31]

I did find some useful mid-level texts — as I call them in this study — that were not intended to be used as textbooks, but which were aimed at an audience with some technical knowledge (engineers, physicists who did not specialise in quantum physics, *etc.*) who wanted a fuller understanding of quantum physics including its mathematical basis. Interestingly, these texts were much more forthcoming than specialist quantum physics textbooks.[32] It cannot be that authors fear the results are too hard to explain — this seems unlikely given the highly counterintuitive phenomena gleefully expanded upon in popular cosmology. I propose, following Kaiser, that there is a stigma attached to quantum interpretation in the physics community and this stigma extends to popular expositions of the subject; it is perhaps more acceptable in mid-level texts because they have a smaller, specialised audience and are less likely to draw criticism from high level colleagues.

Amid this background, popular texts can be defined as being intended for a non-expert audience, one with no prior knowledge of quantum physics or even modern physics of any kind. They are typically written by scientists or science journalists, although in this chapter as in others, I have restricted my sample to books written by professional scientists merely as a way of removing one more variable from the analysis and to make my field more unified.

Different popular texts reached different thresholds in terms of detail and how much they were willing to engage in interpretation. Of the 40 examined, 14 went no further than merely making some reference to "quantum weirdness", wave–particle duality, or the irreconcilability between quantum physics and the physics of larger scales.[33] There were ten texts that tried to explain the central problem of quantum

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[31] I looked at several textbooks, including Rainer Dick's *Advanced Quantum Mechanics*, *The Dreams That Stuff is Made Of* (edited by Hawking), Kaku's *Quantum Field Theory*, R. Shankar's *Principles of Quantum Mechanics*, J. J. Sakurai's *Modern Quantum Mechanics*, Townsend's *Quantum Physics*, and Weinberg's *The Quantum Theory of Fields*. They contained almost no discussion of interpretation or philosophical matters. Townsend, for example, mentions a hidden variable theory (one of the oldest candidate interpretations of the collapse of the wavefunction) without elaborating or even citing any names (154).

[32] The mid-level texts I consulted were *Quantum (Un)speakables* by Bertlmann and Zeilinger, *The Quantum Challenge* by Greenstein and Zajonc, *Quantum Mechanics for Scientists and Engineers* by David Miller and Rosenblum and Kuttner's *Quantum Enigma*.

[33] They were Barrow; Feynman's *Character of Physical Law*; Kaku's *Parallel Worlds*; Hawking's *The Universe in a Nutshell;* Mlodinow and Hawking's *The Grand Design*; Krauss's *Quintessence* and *A Universe from Nothing*; Randall's three books; Rees; Rovelli's *Seven Brief Lessons on Physics*; Singh; Thorne's *Black Holes & Time Warps*; and deGrasseTyson's *Death by Black Hole*.

physics, by either summarising the measurement problem in the abstract, or explaining wavefunction collapse with reference to the famous double-slit experiment.[34] I found 12 books that went further and discussed the possible interpretations of these results.[35] This set includes the works by Tegmark and Deutsch discussed below. Lastly, there were only four books that not only discussed interpretation but also included more elaborate variations on the basic double-slit experiment — including the delayed-choice version, see below — which raise the questions of retroactivity and further ontological problems.[36]

Most of the books were general physics texts, with substantial sections on quantum physics, but some were solely dedicated to quantum physics and yet still did not go beyond allusions to quantum weirdness or some basic facts about wave–particle duality and superposition. Many recycled the quotation attributed to Richard Feynman: "If you think you understand quantum mechanics, you don't understand quantum mechanics". This seems to be deployed as another rhetorical device aimed at foreclosing further discussion of the ideas. The instrumentalist approach is often emphasised, which says that predicting results in laboratory experiments is all that a scientific theory can and should do; although, based on popular texts, this attitude seems only to apply to quantum physics and not to other branch of science. In sum, the texts tended to refer obliquely to the strangeness of quantum physics, without detailing that strangeness, which is totally unlike the treatment of large-scale strange phenomena such as black holes, curved spacetime and dark matter as discussed in Chapter 1.

A curious result of the reluctance to discuss anything that might stray into philosophy is that even other physicists whose speciality is not quantum physics get their interpretation from popular science books. This creates a feedback situation

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[34] Cox and Cohen; Cox and Forshaw; Greene's *Elegant Universe*; Hawking's *A Brief History of Time*; Kaku's *Hyperspace*; Krauss's *The Greatest Story Ever Told…So Far*; Smolin's *Three Roads*; Susskind; deGrasse Tyson *et al.*; and Weinberg.

[35] Aside from Deutsch and Tegmark, there was al-Khalili and McFadden; Carrol's *Big Picture*; Deutsch's other book, *The Fabric of Reality*; Greene's *The Hidden Reality*; Kumar; Levin's *How the Universe Got its Spots*; Penrose's *The Emperor's New Mind* and *The Road to Reality*; Rovelli's *Reality is Not What it Seems*; and Wolfram.

[36] Greene's *The Fabric of the Cosmos* and Gribbin's *Schrödinger's Kittens* contained substantial discussions. Ferris had one chapter which very briefly included some of the more radical aspects of quantum theory, but not in much detail. Davies' *Ghost in the Atom* is a series of interviews with physicists discussing their views of quantum physics in the wake of Alain Aspect's experimental test of Bell's inequalities. It includes a very brief but useful summary of issues surrounding the interpretation of quantum results, but again did not go into the detail of Greene or Gribbin. Anil Ananthaswamy's *Through Two Doors at Once* was published too late to be included in this chapter, but it also goes into considerable detail.

whereby the popular books act as textbooks for experts as well as introductions for amateurs. Sean Carroll's *From Eternity to Here* relies on the interpretation of quantum mechanics found in Deutsch's *The Fabric of Reality*; Natalie Angier's *The Canon* and Janna Levin's *How the Universe Got its Spots* both draw on Brian Greene's popular texts; Hawking and Mlodinow's *The Grand Design* and Michio Kaku's *Hyperspace* (Hawking and Kaku also wrote *textbooks* about quantum physics) outsource their *interpretation* to Richard Feynman's *QED*, an early popular text. I cannot think of any equivalent situation in other disciplines.

One telling passage comes from Levin's humorous anecdote about an experience on BBC radio where she was invited as an expert on quantum mechanics. She was asked to explain the double-slit experiment and blanked because she had "not even thought about it" in ten years (*Spots* 55). She goes on to ask whether quantum mechanics has "abandoned us to a terrifying abyss" and concludes with: "I don't know the answers, but it does give us some divine questions to ask" (57). But even the questions rarely appear in popular texts. John Gribbin has to open his book with a disclaimer that even if you learned about the double-slit experiment in a physics lab you probably did not learn its significance, merely its demonstration of the wave properties of light (1). Physicists are stopped from learning the more seditious parts of quantum theory and seem to avoid or forget them if they did learn about them.

The question as to exactly what is missing from popular quantum texts (and textbooks for that matter) is therefore only answered by using the scanty resources of the few texts which summarise the more radical ideas, implications and experiments. In addition to those mid-level books mentioned above, two popular authors have written multiple popular texts that deal with the uncertainty and indeterminacy over interpretation. Brian Greene's *The Fabric of the Cosmos* and *The Hidden Reality* along with John Gribbin's *Schrödinger's Cat* and *Schrödinger's Kittens* comprise the entire corpus of popular works that truly delve into the quantum field.

When authors did offer thoughts on interpretation they generally allied themselves with one or another established school of thought. Those who tended to engage more with the implications of quantum physics generally favoured many worlds interpretation (MWI). The more reticent writers favoured the Copenhagen interpretation (named for the influence of Danish physicist Niels Bohr), which was the orthodoxy until recently. The crux of interpretive debates is the nature of

wavefunction collapse, whether the observer has some intrinsic role (as in some versions of the Copenhagen interpretation), or if there is some way to account for the wavefunction never collapsing (as in MWI). Both of these interpretations — along with alternatives like David Bohm's hidden variables approach or the compromise solution of decoherence — present deep ontological challenges.

The two *theoretical* texts that explore some of these challenges happen to advocate the Copenhagen interpretation: Žižek's *Less Than Nothing* and Barad's *Meeting the Universe Halfway*.[37] Meanwhile Tegmark, Carroll, Deutsch and Greene — the most expansive popular authors, save for Gribbin — all advocate MWI. They note the fact that because wavefunction collapse is not part of MWI, no modifications of the Schrödinger equation — the key equation describing the evolution of a quantum system through time — are required and so they champion the approach on the grounds of Occam's razor.[38] This is seen by other writers as a bizarre reversal of Occam's razor, considering that the additional entities postulated by the theory are a possibly infinite ensemble of new universes (Davies, *Mind* 190, 219; Gribbin, *Kittens* 245; Penrose, *Emperor's* 382). But this steadfast adherence to the implications of equations and experiments, regardless of the affront to common sense, is part of the general turning away from the threat of metaphysics entering physics.

Philosopher of science Evelyn Fox Keller proposed a case of "cognitive repression" and an unwillingness to let go of the tenets of classical physics as the reason for the failure of a definitive interpretation to take hold.[39] But her article was

[37] Although Žižek and — to a greater extent — Barad present major theoretical approaches to quantum physics, their work does not relate as closely to the concerns of popular quantum texts as one might expect. Neither concerns themselves with the now popular MWI although they are both very focused on ontological questions. Rather than the plenitude offered by MWI and Tegmark's mathematical universe hypothesis, their texts actually have more to do with the interaction — or indeed intra-action — between humans and other matter. Such concerns are actually more relevant to the *ecological sublime* offered by microbiology texts, examined in the next chapter. Also Barad's interpretation is extremely detailed and represents an advance on the Copenhagen interpretation as she rereads Bohr's complete writings and produces an entire metaphysics based on her knowledge of modern physics.

[38] An article in *Aeon Magazine* in 2017 by a respected theoretical physicist admitted that the MWI is now seen as the "hard-nosed realist" and somewhat orthodox position (Frank).

[39] Interestingly, experimental physicist Anton Zeilinger responded to Keller's idea, saying that it is the evasion of the radical consequences of the Copenhagen interpretation that physicists are avoiding (qtd. in Barad 287; qtd. in Žižek *Nothing* 916). Zeilinger himself is clearly unafraid and is currently working to put larger and larger objects into quantum superpositions, including a virus (Tegmark 227). He proposes the German word *Verschränkung* in lieu of its English translation, entanglement. *Verschränkung* is closer to *crossing* or *folding over*, a resonance that might appeal to Barad and indeed Zeilinger is a proponent of a sophisticated version of the Copenhagen interpretation, as is Barad.

written before the MWI had gained popularity and Keller only devotes one paragraph to it:

> In an effort out of this quagmire, more and more outlandish alternatives are proposed. . .Thus, for example, a number of physicists have expressed enthusiasm for a resolution called "The Many Worlds Interpretation of Quantum Mechanics," in which the universe is seen as continually splitting into a multitude of mutually unobservable but equally real worlds. In each world, measurement yields a definite result. Schrödinger's cat is unequivocally alive in some, dead in others. All that remains equivocal is in which world we shall find ourselves. This interpretation demonstrates remarkable ingenuity in that it manages to retain both the confidence in the object reality of the system, and its literal correspondence with theory. Of course, a price has been paid — namely the price of seriousness. (720)

Times have changed. Younger physicists generally adhere to the MWI while older physicists — Feynman, Weinberg and Penrose for instance — favour the Copenhagen interpretation, inherited from Niels Bohr. MWI was first articulated by Hugh Everett III in 1957, but was not widely heard of until the eminent physicist Bryce de Witt published a book about it in 1973. Tegmark presents the results of two straw polls he conducted at conferences that suggest MWI is now the most popular view (228). I contend that the MWI represents a perfect illustration of the ontological sublime. In contrast with some interpretations of quantum mechanics that emphasise the limits of measurement — *i.e.* an epistemological sublime — MWI suggests we already know the fundamentals of quantum mechanics and so our epistemology is sound. MWI suggests that our ontology is fundamentally strange.

I also read into the philosophy of quantum physics to get an idea of which interpretation philosophers favour.[40] Even here there were significant absences, with a dearth of sources from the continental tradition, other than Barad and Žižek. Žižek's *Less Than Nothing* contains a final chapter called "The Ontology of Quantum Physics" in which he engages with popular accounts of quantum physics and some of

[40] I found the following very useful: *On Physics and Philosophy* by Bernard d'Espagnat, *Quantum Theory and the Flight from Realism* by Christopher Norris, Hilary Putnam's "A Philosopher Looks at Quantum Mechanics (Again)" and *The Emergent Multiverse* by Wallace along with various papers and talks by David Albert.

the mid-level texts too. Barad's *Meeting the Universe Halfway* is an even more serious attempt to take the confounding results of quantum physics along with the interpretational problems and construct an entirely new theoretical framework (Barad is both a professor in feminist theory and a particle physicist). In writing for an audience of non-experts, as regarding the physics, Barad actually goes into significantly more experimental detail than any popular work; only Greene's *The Fabric of the Cosmos* comes close.

The range of popular texts I examined and the works from supporting discourses are sufficient to support my central claim about the genre: that there is an evasion of the radical ontological implications of quantum physics and an accompanying void at the heart of the ontology presented by quantum physics itself, which is obviated only by an equally ontologically challenging fix courtesy of the MWI.

Now I turn to two texts that do include *some* discussion of interpretive matters and did so in an unusually forthright way, precisely because their authors do not think there are unsolved mysteries in quantum physics. Both Tegmark and Deutsch offer grand theories of reality as a whole. Both of them utilise the increasingly orthodox MWI of quantum mechanics. Both find the MWI to be sufficiently compelling in explaining apparent quantum enigmas (such as the results of the double-slit experiment) to the extent that they deny there are any ontologically threatening gaps in reality or epistemologically threatening gaps in our understanding of it. But this reassurance comes with an assertion of the literal existence of a perhaps infinite number of doppelgängers of the reader. Whereas the Copenhagen interpretation — which makes measurement and in some variants *human* observation the cause of wavefunction collapse — gives the subject a crucial and even agential role in constructing reality, the MWI annihilates the subject's uniqueness and renders obsolete the very idea of choice.

Max Tegmark's platonism

> This means we can think of the fundamental Legos of particle physics as being not the particles themselves, but the conserved quantities! . . . So what are quantum numbers like energy and charge made of? Nothing — they're just

> numbers! A cat (the standard quantum animal) has energy and charge too, but it also has many other properties besides these numbers. Our elementary-particle friends, on the other hand, are completely described by their quantum numbers, and appear to have no intrinsic properties at all besides these numbers! In this sense, we've now come full circle back to Plato's idea: the fundamental Legos out of which everything is made appear to be purely mathematical properties. (Tegmark 165)

Max Tegmark's *Our Mathematical Universe* makes the ontologically bold case that because the properties of the most fundamental entities in physics are only described mathematically, reality is at bottom mathematical and the universe itself is a large mathematical structure. Along the way to this conclusion he initiates the reader into four levels of *multiverses*: spaces that are causally separate from the currently observable region of spacetime, *the universe*. They are: contiguous regions beyond the observable limit of the universe which may go on forever; bubble universes arising from sudden, rapid cosmic inflation of regions within the first level multiverse; the many branching universes postulated by the MWI; and the landscape of all conceivable mathematical objects, including all the aforementioned multiverses (139).

All four types of multiverse imply the possibility of multitudes of universes that contain permutations of matter nearly or completely identical to our own planet, our own history and indeed our own personal biographies. Tegmark offers perhaps the most fecund model of reality ever articulated, albeit with precursors in the visions of Giordano Bruno, Jorge Luis Borges's "The Garden of Forking Paths" and the modal realism of the philosopher David Lewis, who contends that all possible counterfactual worlds exist (Lewis 2).[41] But Tegmark's Level IV Multiverse is more

[41] I am indebted to Mary-Jane Rubenstein's *Worlds Without End*, the only comprehensive treatment of the idea of the multiverse through history and across various discourses including theology, philosophy and modern cosmology. Her work confirms that Tegmark's model is *almost* the most expansive. There is one ontology which is even more commodious than Tegmark's, that of the philosopher Robert Nozick, which includes every physically possible universe as well as *nothing*. Greene also addresses Nozick's multiverse, calling it "the most expansive [multiverse] possible" noting that Nozick included "a universe that consists of nothing. Absolutely nothing. Not empty space, but the nothing that Gottfried Leibniz referred to in his famous query 'Why is there something rather than nothing?'" (*Hidden* 338). The conception of possible worlds is standard in many contemporary theories of semantics. Linguistics textbooks have no compunction in postulating an infinite set of possible worlds to explain how words and sentences can be referential, how they can possess extensionality and intensionality, truth value and modality; see for example Kearns (8–10). Lewis was

profligate, easily subsuming Lewis's possible worlds, all of which must necessarily be physically extensive. Tegmark's includes all of Lewis's worlds in his first level of multiverses and then again in the second and third levels. On top of this there is an infinite set of mathematical objects that do not contain any matter, but still "physically" exist: "mathematical existence and physical existence are equivalent, so that *all* structures that exist mathematically exist physically as well" (321, italics in original).

What Tegmark offers is certainly uncanny: the existence of (along with almost all other things) multiple copies of ourselves, perfect doppelgängers, existing in various types of universes parallel in spacetime and in a higher dimensional mathematical realm called Hilbert space. This latter is the n-dimensional space in which the many worlds theorised by MWI exist (Tegmark's Level III multiverse). Tegmark is invoking a fantastic proposition. Every time a particle is measured (and *measured* can here mean anything that leads to decoherence, *i.e.* interaction with anything surrounding the quantum system) multiple realities branch off from one another in which different outcomes of that measurement are instantiated. In other words, a plurality of worlds is produced at every instant in a ramified proliferation that began with the Big Bang and has been expanding at an increasingly stupendous rate ever since (Tegmark 190). Even without Tegmark's elaborations, the first two levels of the multiverse are already accepted by many modern cosmologists — if they adhere to the inflationary model — and imply the existence of doppelgängers provided space is large enough. Even if finite, a large enough expanse in *this* universe will nonetheless mean that as a case of probability, matter assumes the same permutations that give rise to us. That is unsettling enough, but if the MWI does become the undisputed reading of quantum mechanics and assumes the status of an accepted scientific theory, then it will surely be the strangest model of reality yet to be taken seriously by mainstream experts.

And yet Tegmark extracts very little *significance* from the MWI, despite his refrain of exploring "crazy" physics ideas, his liberal use of exclamation points and his motif of renegade physicists who have pursued unpopular or counterintuitive theories, often to professional disadvantage. Instead, this obvious fodder for an appeal to the rhetoric of the sublime is largely ignored. Nonetheless, there is clearly

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the first philosopher to take the postulated worlds of semantics and modal realism to be *as real as our own world* (Lewis 2–5).

more scope for ontological confounding, rather than merely epistemological confounding as in cosmology texts. Already, in the basic premise of Tegmark's book, the reader is confronted with metaphysical claims about parallel worlds, the reader's own doppelgängers and the view that numbers, polygons and other mathematical objects are as real as familiar material objects.

Early on in the text Tegmark assumes the role of the scientific maverick who is undeterred by popular opinion and the restraints of the academy's expectations of professionalism. He reminds the reader that he is "normally on the opposite side from scientific orthodoxy" (207) and tells of "a totally crazy sounding idea I'd just had" (216) and also assures the reader that he realises how "weird" his ideas are: "I know. This stuff sounds seriously nuts" (221). But he also frequently appeals to the intellectual and institutional cachet of mainstream science, especially as opposed to the humanities. Kant's unknowable *das Ding an sich* is mentioned in an historical recap of insufficiently confident approaches to reality, along with the view that, "Science is nothing but a story (postmodern answer by Jacques Derrida and others)" (9). Neither Kant nor Derrida are in the index and this dubious summary of "postmodern" thought is deployed antagonistically to contrast with more stolid, empirical approaches to truth. And yet Tegmark's extreme platonism is sufficiently totalistic that it hypostasises all mathematics such that all that exists are mathematical structures, some substructures of which are self-aware, *i.e.* conscious beings (Tegmark 323). The conflating of the map and the territory entailed by this mathematical platonism is far more radically representationalist than even the caricature version of postmodernism above. Tegmark has to balance his reputation as a maverick bucking the strictures of mainstream science, against the rhetorical usefulness of the prestige of that same mainstream science.

The MWI is also framed as an example of a maverick idea. Its originator, Hugh Everett, was spurned by the physics community for pursuing an unorthodox theory (186–91). Tegmark notes that he had never met anyone who had read Everett's PhD thesis containing the theory that wavefunction collapse does not occur. Tegmark usefully points out that the thesis does not actually specify the splitting off of many worlds, but merely implies it by saying that even measurement does not collapse the wavefunction (187n). This is slightly confusing as Tegmark later states: "Everett showed that if the wavefunction never collapses, then the familiar reality that we perceive is merely the tip of an ontological iceberg, constituting a minuscule

part of the true quantum reality" (190). This is one of several instances of Tegmark introducing ideas gradually, only to undermine them later,[42] most notably when he introduces the hypothesis that the whole of physical reality *is* mathematics: a proposition that somewhat undermines the import of his earlier discussion of the less radical idea that the observable universe is infinitely expansive beyond what we can see (129–31). This shadows Tegmark's strategy for enjoying an unconventional career. He describes, in terms of Jekyll and Hyde personae, the way he publishes respectable "mainstream" papers in cosmology and strategically publishes his "wacky" papers, only at times when he is not seeking promotion or funding (245).

This strategy finds an echo in the structure of his book, with his gradual unveiling of increasingly "wacky" levels of the multiverse, interspersed with personal anecdotes about exploring new ideas and having preconceptions destroyed, or with brief sketches of his scientific heroes. The effect is to destabilise the ground of comprehension, allowing for some of the seeming paradoxes or antinomies of modern physics to be offered more boldly. Intuition is no defence and the "gut feeling" that we are not "constantly splitting into parallel versions of [ourselves]" is answered with the retort, "Do you feel like you're orbiting the Sun at thirty kilometres per second?" (191). A later anecdote about waiting for his son to be born is Tegmark's way of showing that emotions do not always reconcile with reason, given that he knew, intellectually, that in a certain proportion of parallel universes there were complications with the birth (191). This graduated series of increasingly counterintuitive ideas performs the standard popular science move of modelling a sense of awe. The aim is to instil in the reader an esteem for the scientific enterprise and the impressiveness of physics. The reader's comprehension of all the phenomena may not be guaranteed — they are not demystified — but the epistemological sublime of modern physics is reaffirmed.

But these justifications for abandoning intuition are the extent of the ruminations on the significance of the MWI. In a section called "Shifting Views: Many Worlds or Many Words" Tegmark bemoans how a "century-old debate" on interpretation "shows no signs of abating" (226), unwittingly ironising the absence of discussion in popular and educational texts as well as his own brusque conclusion to

[42] It also occurs in his discussion of his quantum suicide thought experiment, where he concedes at the end of the section that it cannot work because it requires an infinitely divisible continuum, which Tegmark claims is not found in nature (220).

the discussion: "the experimental verdict is in: the world *is* weird, and we just have to learn to live with it" (228, italics in original). All this reiteration of weirdness, of eccentric ideas and of unconventional theories serves to prepare the reader for the gargantuan claim that reality is purely mathematical. But consider that this is actually a very old ontology stretching back to pre-Socratic philosophers. Tegmark eschews quantum imponderables even while claiming to be a quantum radical. His craziness and zaniness is perhaps what Žižek might see as an example of *jouissance* that allows for seeming non-conformism as a way of avoiding real radicalism (*Ideology* 79–84). Tegmark presents as a renegade while actually reaffirming perhaps the oldest, perhaps the most conservative ontology there is: Pythagoreanism.

The real ontological strangeness of MWI is passed over[43] and the problem is instead characterised as an epistemological one, a case of struggling with outré knowledge that the establishment has not yet accepted. In the same mode typical of popular writers exploring cosmological ideas (which take up the first quarter of *Our Mathematical Universe*) Tegmark sees the sublime of science as the pushing of the limits of enquiry or the attempt to "see" things that are unpresentable:

> Everett's PhD thesis totally blew me away. I felt like the scales had fallen from my eyes. Suddenly it all made sense to me! Everett had been bothered by exactly the same things that bothered me, but rather than just leaving it at that, he'd pushed ahead, explored possible solutions, and discovered something remarkable. When you have a radical idea, it's so easy to say to yourself, "Of course that can't work," and drop it. But if you hold the thought just a little longer and ask yourself, "Well, why exactly can't it work?" and find that you're struggling to come up with a logically watertight answer, then you might be onto something big. (186)

This is a typical popular physicist's call to free thinking, to exploring unintuitive ideas at any cost. But it also contains an identification between Everett and Tegmark himself, with the implication that Tegmark is on the right path — to the Damascus of MWI — just like one of his "physics superheroes". The arcane nature of this

[43] The exception is a detailed discussion of a thought experiment of Tegmark's own devising, which is intended to theoretically test the MWI: quantum suicide (216–22).

knowledge is emphasised in a passage where he notes that he finally found Everett's out of print PhD thesis in a Berkeley bookshop that specialised in "radical publications" (186). Rather than a discussion of what the MWI means, or how strange it is, or even why it can be justified ontologically, there is only a contribution to the scientist-as-hero myth, the most hackneyed element of popular science texts (Broks 137; Landau 175–8). I should note that Tegmark's mythmaking is not solipsistic. He does indeed operate a non-profit organisation that raises funds for high-risk, high-impact physics research that traditional funding bodies avoid (221). And Kaiser's book attests to the negative reception from the physics community granted to any researcher who pursued these ontological questions thrown up by quantum mechanics (273); although Kaiser himself makes no mention of MWI. But even the scientific hero apparently baulks at straying into anything that might be confused with the "many words" — Tegmark's descriptor — of philosophy.

One final omission from Tegmark's book is worth highlighting. There have in recent years been advances on the double-slit experiment that confound common sense to an even greater degree. The quantum eraser experiment is the most elaborate and is detailed in Greene (*Fabric* 194–9), Gribbin (*Kittens* 138–41) and discussed in Barad (306–17), Rosenblum (123–4) and Greenstein and Zajonc (240–4). In earlier versions of the double-slit experiment, information on which of the two slits an individual photon passes through can be obtained, but doing so destroys coherence, *i.e.* the wavefunction collapses and the measured photons behave as individual particles, not as part of a wave and hence there is no interference pattern registered on the detector screen. When the eraser is employed to "re-destroy" the information recorded by the which-path detectors moments earlier in the experiment, the interference pattern is preserved, suggesting the photons *revert* to behaving as part of waves. Thus it seems that the photon "knows" whether the which-path information is preserved or re-destroyed. There is even a delayed choice variant which involves setting the eraser to fire randomly and to delay the erasure of the which-path information until arbitrarily long after the photon has either gone through a slit or not. This gives the impression that the path of the photon is determined retrospectively, depending on whether or not the eraser fires. The challenge to standard notions of cause and effect and linear time is obvious. Although a few physicists believe this challenge can be answered with a theory, surely these experiments warrant discussion or at least a mention as they present a view of

quantum mechanics that is even more counterintuitive than the already puzzling facts of superposition and wave–particle duality.

In the case of many writers on physics, even quantum physics, it is entirely possible that they are not aware of these more elaborate experiments and the radical implications that follow, drawing as they do on other popular works for their own information about the interpretation of quantum mechanics. But Tegmark presumably is well aware. At a minimum it can be said that two of the works in the quantum mechanics section of his suggestions for further reading refer to the quantum eraser experiment (a single reference with no explanation in Giulini and Vignale 78; some discussion in Kaiser 78–80). Possibly Tegmark is aware of these more elaborate experiments and this is exactly what he is referring to, enigmatically, when he writes of the "weirdness" and "craziness" of the quantum world. But he does not confront these stranger experiments or even mention quantum entanglement: the other major source of anxiety for physicists trying to explain reality.

I claim the popular science genre is ironic because it boasts of sublime phenomena that cannot be understood even as it claims to make everything understandable for the reader. Tegmark certainly amplifies the rhetoric of the unpresentable. And sections of his book display the cosmological imagery of the epistemological sublime detailed in my previous chapter. I further claim that the genre is ironic because in invoking the epistemological sublime, the ontological sublime creeps in and undermines the subject that would enjoy the epistemological sublime. Tegmark keeps ontological threats at bay by avoiding explanation of the strangest quantum ideas. It is therefore a strange gap in the text, redolent of the gap in descriptions of reality that Žižek takes quantum mechanics to be (see below). The central irony of this text, then, is that it proposes a plenitudinous platonism with room in the Level IV multiverse for everything *except* ontological voids; that is, everything except nothing.

David Deutsch's doppelgängers

A slightly different attitude pervades David Deutsch's *The Beginning of Infinity: Explanations that Transform the World*. Deutsch is even more confident in his ontology than Tegmark, because he has an even stronger belief in the epistemological reach of scientific genius. The book is partly a work of popular science and partly a

manifesto for a new kind of epistemology, one based on Deutsch's reading of the history of science, the philosophy of Karl Popper and his own research into quantum computing: a nascent field wherein he is a leading theorist. It is not purely a work of explication and — as the subtitle suggests — it advances an extremely ambitious thesis. As such, Deutsch is not at all reluctant to go into the philosophical implications of quantum physics at least as far as the meaning and significance of *his* interpretation, which is a variant of MWI.

Deutsch is also confident in his own ontology. He adheres to a version of the MWI in which there has always been an infinite set of universes as part of one multiversal object (Davies, *Ghost* 85–7). When different outcomes are observed — *i.e.* information is transferred from one part of the multiverse to another — on either a macro or micro level, it means the *proportion* of the total set of histories (universes) in which a given bservation has been recorded changes accordingly (Deutsch, *Infinity* 281–7). Deutsch's theory also differs slightly from the common version of MWI, in that histories can fuse back together in special circumstances. Unlike the branching model of Tegmark and others, the total measure of universes stays the same, while previously distinguishable histories become *fungible* when they fuse (*Infinity* 282–3).

Fungibility is a key ontological idea for Deutsch, who claims it is implicit in the unadulterated equations of quantum mechanics (*Infinity* 265–6). Deutsch says that fungibility discredits Leibniz's doctrine of the identity of the indiscernibles, by saying that multiple instances of a particle are identical and can not only be treated as fungible (like the different dollars in a bank account) they are literally the same. It is "an even weirder attribute than Leibniz guessed — much weirder than multiple universes for instance, which are, after all, just common sense repeated" (*Infinity* 266). Multiple universes are not to be thought of as being side-by-side, they are "superposed objects" and universes consist only of the objects contained in them, they are not the containers (*Infinity* 280). Deutsch's "weird" is less opaque than Tegmark's and more ontologically troubling; even his "common sense" is arguably stranger than Tegmark's hinted at "craziness". For Deutsch, the existence of the reader's doppelgängers in different universes is not as weird as the fact that they are fungible.

For Deutsch, the results of quantum experiments exhibiting apparent wavefunction collapse, like the double-slit, are indirect evidence of other parallel

histories in the multiverse.[44] A particle is generally only able to interact with other particles in its own history. But if no information of that particle is destroyed (through measurement) it is able to interact very slightly with other histories (*Infinity* 283–4). In other words, while it is *un*entangled, a particle can interfere slightly with other worlds; when it is entangled with a measurement apparatus or anything else in a particular world, it is no longer fungible and effects only that world. For Deutsch the interference phenomena observed in simple experiments with light are thus evidence that for brief moments particles have been interacting with fungible and therefore indistinguishable versions of themselves in parallel universes (284, 288). In double-slit language, when the photon is travelling through the slits no information is extracted and therefore it is still unentangled with other objects in this world and is superposed in other worlds; once it strikes the screen it becomes entangled again with this world and can no longer interfere with other histories.

What is truly novel about Deutsch's presentation of these ideas is that he begins the relevant chapter entitled "Multiverse" with a discussion about good and bad science fiction. Deutsch admits to being of a class of "pedantic science fiction enthusiasts" who "prefer the fictional science to make sense" (*Infinity* 259). He then attempts to create a science fiction story dealing with a stock plot from the genre: doppelgängers from parallel universes. In explaining his scenario, which involves teleportation devices in parallel universes malfunctioning and accidentally interfering slightly with one another, he gradually closes off loopholes that do not satisfy the laws of physics. Only after establishing the very exiguous conditions under which a plot like this would be internally consistent, does he reveal that he has essentially told an allegory of the MWI and the actual laws of physics — as he sees them — of our non-fictional universe (292).

Fiction is a recurring theme in Deutsch's chapter on quantum physics, which is introduced as "more astounding than any fiction" (*Infinity* 262). He notes that purely by chance, some universes will contain events that are extremely unlikely but still physically possible, but will seem like magic to the inhabitants (301). Hence the corollary that all "fiction that does not violate the laws of physics is fact" somewhere in the multiverse (300). In his sci-fi example, he even concocts a situation in which

[44] Deutsch actually discusses a Mach–Zehnder experiment rather than the classic double-slit (286–7). But the interference phenomena it demonstrates are the same.

minor differences in two universes' histories mean that identical items are printed in identical newspapers in the two universes, but in one the item is a factual report and in the other a fictional story. But the two newspapers must still be considered fungible if they are atom-for-atom physically identical: "here the fact/fiction attribute has diversity within fungibility" (*Infinity* 278). This reification of certain fictions, based on physical possibility, is a tantalising hint at a novel way to view narrative, temporality, representation and language. But is not elaborated by Deutsch beyond the previous quotation.

Deustch's text raises other ontological questions. He refers to the "ancient dichotomy between the discrete and the continuous" and pronounces that quantum physics "adjudicates this conflict in favour of the discrete" (*Infinity* 274). And, as Rubenstein notes, discussions of MWI are essentially rehashes of the conflict originating between Parmenides and Heraclitus over monism versus pluralism as regards the basic stuff of the universe (227). Recall that one of Kant's supposedly irresolvable antinomies was on this point. Adding these to the aforementioned questions over the identity of the indiscernibles, the nature of mathematical objects and the nature of time, it is clear that quantum physics carries serious ontological implications. And on this front, Deutsch is unusually confident, even grandiose.

Accordingly, Deutsch does not shrink from the gaps in explanation that typify other popular texts: "We can understand infinity through the infinite reach of some explanations" (194). And Deutsch's ontology itself has no gaps — except perhaps his theory that scientific knowledge is created *ex nihilo* by creative individuals (104). This provides justification for a Great Man view of the history of science and jibes with Deutsch's classical liberalism. Meanwhile, his ontology is certainly not platonistic like Tegmark's. In *The Beginning of Infinity*, even mathematical proof and computation are ultimately dependent on the laws of physics (186). In fact Deutsch's multiverse is actually based on information flow, where this flow is always via physical instantiations as changing proportions of discrete values in a region (Deutsch and Hayden 1761–2, 1773). Particles themselves are "excitations of the vacuum" where the vacuum is therefore not empty (*Infinity* 267). Even the past and the future are special cases of parallel universes (*Infinity* 299) and all of these make up a giant multiversal entity governed by the laws of physics, which Deutsch admits are only approximated by current theories, with better explanations possible in the future.

Here is Deutsch's sublime then. Rather than the ominous or troubling ontological void of the Žižekian sublime (which I outline in the next section), he offers a lofty vision based on the expansion of epistemological limits. In fact Deutsch says *knowledge* is the one special effect in the multiverse:

> There is only one known phenomenon which, if it ever occurred, would have effects that did not fall off with distance, and that is the creation of a certain type of knowledge, namely a beginning of infinity. Indeed, knowledge can aim itself at a target, travel vast distances having scarcely any effect, and then utterly transform the destination. (*Infinity* 275)

Knowledge that can be "a beginning of infinity" (a jump to a new level of complexity or universality) is a strange, unique phenomenon in Deutsch's worldview. The above example of a small signal having massive effects constitutes a conflation of scales as well as a kind of creation *ex nihilo*; or, if not out of nothing, at least a creation where the output is much greater than the input.

Like Tegmark's, there is no nothing in Deutsch's book: no limit to scientific explanation and no gaps in the MWI's account of quantum mechanics. Reared on the tropes of science fiction, Deutsch sees multiple universes and the doppelgängers they entail as essentially extensions of common sense, albeit stranger than any pure fictions. Thus his sublime is really a Kantian sublime *par excellence* with the creation of *human* knowledge being the main source of transformation and change in the universe and affronts to the imagination being no impediment to knowledge creation via scientific conjecture. The reading subject is exalted as a potential creator of that cosmically significant commodity: scientific knowledge. Only the disquieting implications of the doppelgängers threaten the subject's integrity. Given Deutsch's valorisation of the individual and his Popper-style classical liberalism, it is perhaps unsurprising that *this* uncanny consequence of MWI is less dwelt upon than the reality of fiction. The uniqueness of the individual, even the very idea of individual identity — in the face of fungibility as described by Deutsch — seems at least questionable in light of the multiverse and thus a more self-abnegating, ontological sublime is glimpsed.

Although Deutsch emphasises the notion of entanglement, even entanglement between universes, his ideas are thoroughly incompatible with Barad's notion of

entanglement. Hers would hold out the promise of the imbrication of different parts of reality, including the subject (agent in Barad's terms) and material parts of the world (phenomena in Barad's terms). But Deutsch must preserve the autonomy of the subject even amid the ontological strangeness of quantum physics. And so the liberal humanist subject is retained even as it is belied by the MWI.

Horror vacui: the ontological void

Lurking offstage from Tegmark's and Deutsch's texts is an ontological sublime of quantum physics that is arguably more horror than delight, to use Burke's terms. And against Kant's self-apotheosis when the subject is made aware of nothing but her indomitable power of reason, quantum indeterminacy undermines such power. It reveals not only the smallness of the subject, as does the cosmological sublime, but the insufficiency of the subject's reason in the face of fundamental uncertainty. There is also the ontological nature of the quandaries thrown up by quantum physics. They are unlike the epistemological quandaries of cosmology, which take the reader merely to the limits of current knowledge or representation. And so different perspectives on the sublime are required, ones that go beyond Derrida's parergon and Lyotard's unpresentable.

The ontological sublime plays out in one of two ways. If authors are unwilling to support or even outline an interpretation of quantum mechanics that addresses these ontological enigmas, then there remains a manifest gap or void in their picture of fundamental reality and thus a corresponding gap in their explanations of it. Otherwise, a few writers take the option of delving into interpretation and even discussing the greater significance of a given interpretation. For MWI enthusiasts (Carroll, Deutsch, Greene, Tegmark), the ontological gap disappears (according to them) and so the sublime reverts almost to a traditional Kantian epistemological one, where the quantum indeterminacy is something we have to live with as finite beings, even as reality itself is complete in a way we simply cannot have access to. This might as well be Kant's distinction between phenomena understood by the human mind and the unknowability of *das Ding an sich*. But the unmentioned result of this move is the loss of the subject's identity, as other worlds and their attendant doppelgängers are summoned to cover the gap. For those favouring the Copenhagen interpretation (al-Khalili and McFadden, Levin, Penrose, Susskind) there is a gap in the theory

which either means a void in physical reality that must be confronted (only Greene does so) or, more commonly, a failure to do so that manifests as a gap in the text. And just like in Tegmark's book — but with even fewer details and no interpretation — the absence is indicated with the presence of vacuous signifiers like *weird*, *crazy* and *bizarre*.

Very few theorists of the sublime have plunged into ontological ideas, content to have the subject overwhelmed by epistemological limitations, but with their own and the world's existence intact. Rodolphe Gasché was the first writer to consider a specifically ontological sublime, which he identifies in Lyotard's later writings (especially *The Inhuman* and *The Differend*). Lyotard's view of the sublime is standardly taken to be any presentation that the unpresentable exists (*Postmodern* 78). The *limit* of representation is identified in painting, literature, or philosophy inasmuch as it signals the limits of what can be known or imagined. In this way it follows neatly from Kant's formulation, as explored in the previous chapter.

But Lyotard was also interested in ontology and his idea of the sublime follows from his work on the *differend*. As Gasché explains, with every *phrase* that occurs — in Lyotard's writing *phrase* is roughly synonymous with *event* — there is raised "the possibility of non-Being, of nothing happening anymore, of a last phrase" (122–3). For Lyotard this is an ontological matter and presentation is not a purely aesthetic concept, as has been assumed by many subsequent writers on the sublime. Presumably this is because the main source used for Lyotard's sublime is *The Postmodern Condition*, in which the classic formulation appears with reference to Malevich's squares and Joyce's later novels (78, 80). But Lyotard's other writings make it clear that presentation is also an ontological notion, with each phrase (event) being at first presented with some openness of possibility, with its meaning only being fixed once it is situated (*Differend* 70–4; *Inhuman* 72–3, 111). For Lyotard, this characterises reality at the most primitive level accessible (*Differend* 65–7). There is an affinity — I would not say *analogy* — to the quantum ontology, whereby a particle's specifications are in superposition until a measurement occurs and the wavefunction collapses (in the Copenhagen interpretation). Like the apophatic nature of Lyotard's sublime discussed in Chapter 1, this ontological sublime is negative: "when we are surprised that there is something rather than nothing, we are surprised that there is a phrase or that there are phrases rather than no phrase"

(Lyotard, *Differend* 65). Being implies the possibility of non-Being just as presentation implies the unpresentable.

Žižek also confronts the sublime and ontology. In *Less Than Nothing* Žižek engages seriously with popular science texts (including Greene's earlier work, *Elegant Universe*). He uses them as culturally relevant points of access to current ideas regarding consciousness (715–37), the evolution of life (156–9) and the ontology of quantum physics (905–61). His overall stance is critical, but he earnestly assesses the ontological claims and implications of quantum physics, citing the quantum measurement problem as central to the development of his own preferred metaphysical outlook (*Nothing* 906). Žižek takes as given a version of the Copenhagen interpretation (*Nothing* 907), although he does discuss points of disagreement between Barad, Bohr and his own specific reading.

The Copenhagen interpretation ostensibly places the subject in a position of centrality and seems even to affirm the subject's individual consciousness as what collapses the wavefunction, thereby determining macroscale reality. But Žižek guards against such radical subjectivism, warning us that it will lead to "obscurantism" or "New Age mysticism" (*Nothing* 915). He seems to be worried about the more spiritual readings of quantum mechanics or the interpretations that link it to consciousness, such as Roger Penrose's. Žižek nonetheless argues that the epistemological limits encountered in the Copenhagen interpretation actually reveal the limit of — and in fact a gap in — reality:

> Therein lies the ultimate philosophical consequence of quantum physics: that what its most brilliant and daring experiments demonstrate is not that the description of reality it offers is incomplete, but that reality itself is "incomplete", indeterminate — the lack that we take as an effect of our limited knowledge of reality is part of reality itself. . . it is our very epistemological limitation which locates us in the Real: what appears as the limitation of our knowledge is the feature of reality itself, its "non-All." (*Nothing* 925)

This kind of revelation that an apparent epistemological challenge is actually ontological, is what I call the ontological sublime.

Žižek does not explicitly discuss the sublime in *Less Than Nothing* but has written extensively on it, especially in earlier decades. In *The Sublime Object of*

Ideology (1989) he identifies the sublime not with the intimation of some transcendent object beyond our imaginative capacities, but with any indicator of a primordial lack, gulf, or void in the heart of the entire system of signification (49, 127). I argue that this is basically the same ontological sublime offered by Lyotard — via Gasché — and that Žižek's characterisation of the gap revealed by quantum experiments is this same notion of a void at the centre of a system which is actually necessary for the system to cohere. Lyotard's is simply the obverse; he has it that phrases are connected like parataxis connects clauses in discourse: "Paratax thus connotes the abyss of Not-Being which opens between phrases" (*Differend* 66). For Žižek and Lyotard the gaps are as integral as the non-gaps.

But although Žižek is sanguine in the face of the ontological void, others may only see the terrifying lack or rupture that the ontological sublime discloses. Žižek's project — including his interpretation of quantum physics and his theory of the sublime — is all predicated on his reading of Hegel and Lacan. In Lacan especially, the notion of a gap or emptiness in subjectivity, the unfaceable Real, and other indications of void are part of the analysis. But this is clearly not the attitude of popular science authors (save for some writing in neuroscience, see Chapter 5). As yet unexplored questions are offered as part of the scientific enterprise's ongoing journey. But this does not include inexplicable aporia in what should be well understood phenomena. The evasion of quantum "weirdness" even in books purporting to explain it is symptomatic of this fear.

There is a precedent for a fear of the void and the link to the experience of an ontological sublime. Porter's work on Lucretius describes the vacuity present in Lucretius's atomism. And, just as in Žižek, it has an active rather than passive role. Porter highlights the recurrent imagery in *De Rerum Natura* of:

> physically empty spaces that arguably stand in for cosmological void and bring some of the more extreme consequences of atomism into the immediate periphery of the viewing subject. Void, which in atomistic terms is invisible and intangible, here becomes, in its visible analogues, phenomenally apparent and sublimely so. ("Lucretius" 170)

The invisible is presented in a visible analogue, just as in the modern art described by Lyotard. But this is not just the invisible — or unpresentable — object, but the

intangible void, the nothingness that subtends the material world. For Lucretius and the atomists, this is not an arcane or esoteric realisation. The void is not unknowable and therefore does not signal an epistemological impasse, only an ontological one.

The feeling that attends this recognition of the void is not empowering but vertiginous: the falling away of solidity engendered by such a picture of the universe is, Porter argues, a kind of *memento mori* and Lucretius uses the atomistic nature of the world as a way to express the mortality of all things ("Lucretius" 171). Porter notes the frequency of synonyms for *emptiness* in Lucretius and calls the general fear of things falling apart, the fear that the seeming cohesiveness of matter is actually comprised largely of vacuum, "a pervading *horror vacui*" (171).

Here is where Porter's and Žižek's ideas intersect. Žižek argues that there are two vacua involved in quantum ontology, citing the two energy levels of the Higgs field, which, like all fields, permeates all space and takes on different values (energy levels). The Higgs field is crucial because it allows some particles (various bosons) to take on mass, meaning that matter can occur. When the Higgs field is "switched off" there can be no particles, no matter, yet it requires a non-zero energy level to sustain what Žižek calls this "false" vacuum; then there is the "true" vacuum in which the Higgs field is expending zero energy, but in which matter is possible — the current state (*Nothing* 944–5). Žižek argues that the state in which the Higgs field has non-zero energy, is a complete vacuum, a "weird pre-ontological 'something' which is less than nothing" (*Nothing* 945). There is a "double vacuum" whereby there is a nothing of direct negation (false vacuum) and a nothing that is really a something (true vacuum), the "less than nothing". But it seems somewhat contrived for Žižek to use the Higgs field for this central claim in his ontology. Just because the Higgs is in a non-zero value in an empty world, it is not clear that this amounts to a something which is less than nothing — a world empty even of the Higgs field, the philosopher's nothing, is surely less than Žižek's "less than nothing". And just because the Higgs field is currently at zero, it seems unhelpful to call the incumbent situation the true vacuum.

I do think there are two vacua at play in quantum physics but that they are best distinguished in the following way. The first is a kind of nothingness that is without: the nothingness that preceded the beginning of time or will succeed the end of time, the nothingness beyond the edge of space: Žižek's pre-ontological nothing (that is nonetheless a something in its potentiality). Then there is the nothingness *in*

space that will come to dominate as the universe expands forever, with matter becoming more and more sparse. This is also the nothingness at the smallest scales, the vacuum field that oscillates even in the absence of all matter. When matter is there it is still present and particles can pop in and out of existence as long as the timescales involved are small enough (Randall, *Warped* 225–9). The first void is terrifying: the idea of a primordial nothingness seems to conjure the possibility of nothingness returning. The philosopher Derek Parfit, "reminded of the aesthetic category of the sublime," said that: "No question is more sublime than why there is a Universe: why there is anything rather than nothing" (25). This first vacuum is the same as Lyotard's presentiment of non-Being given in every phrase's allusion to the possibility of there being no more phrases.

But this vacuum seems to raise an even more troubling idea that is, as it were, closer to home. The more integral vacuum is the possibility of conceptual categories being torn asunder by unassimilable quantum results. This is compatible with Žižek's writing on quantum physics, the void and the sublime, even though it departs from his characterisation of the two vacua given in *Less Than Nothing*. Here is a relevant passage from a much earlier work:

> What actually breaks down in the experience of the Sublime is the very notion that, behind the field of phenomena, lies some inaccessible positive, substantial Thing. In other words, this experience demonstrates that phenomena and noumena are not to be conceived as two positive domains separated by a frontier: the field of phenomena as such is nothing "beyond" this limit. The limit ontologically *precedes* its Beyond: the object we experience as "sublime," its elevated glitter, *Schein*, is a mere secondary positivization of the "nothing," the void, beyond the limit. (*Tarrying* 37–8, italics in original)

Unlike the epistemological sublime that gestures towards something beyond the limits of representation, this ontological sublime triggers the thought that there is nothing beyond. Although Kant and others might "fill out" the experience of the sublime with some positive content, this is simply an attempt to cover "the original void opened up by the breakdown of the field of representations" (Žižek, *Tarrying* 37). The final move for Žižek is to claim that this breakdown, this Kantian sublime, is

not only an indication that there is no beyond. The Real (in Lacan's sense of the term) is not the inaccessible beyond either; instead it is "*nothing but* the gap or antagonism that thwarts the symbolic from within" (*Nothing* 959, italics in original). This gap or failure is both the inevitable failure of the symbolic to reach itself and in fact the symbolic is constituted by this very failure.[45] And so this second vacuum is not to do with some pre-ontological nothingness like the first, but with a nothingness that is revealed to be necessary for articulation of any kind, including therefore the experience of the sublime. It is an inescapable part of representation or even subjectivity.

Although I remain uncommitted in terms of Žižek's overall philosophical project, his writing on quantum physics, ontology and the sublime is the type of analysis that is, I think, an appropriate response to the ontological implications of modern science. His notion of the gap or failure that is nonetheless necessary for the symbolic order to exist, is an example of the ontological troubling the epistemological. The failure of representation entailed by the sublime is not simply an indication of an epistemological limit, it signals something ontological. Hence the Kantian sublime — as it is usually adopted — is insufficient to describe the response prompted by an encounter with quantum mechanics.

The bare vacuum in Greene

Greene is the popular author most willing to simply *show* the horrific vacuum: the examples that evoke a sense of the loss of integrity of things and even their imminent dissolution. In *The Fabric of the Cosmos* he demonstrates this not only in his admirably extensive explanation of quantum quandaries, but also other topics that tend to the ontological rather than the merely epistemological: the entire universe sliding inexorably to maximal disorder because of the second law of thermodynamics (174); the potential for space itself to rupture (386); the sudden creation of black holes in a particle accelerator (403); the possibility of wormholes tunnelling through spacetime (462); the jittery, unstable nature of the Higgs field permeating all space; and — in the most obviously apocalyptic instance — the theory that our universe is

[45]Žižek parallels this to Lacan's view of the subject: it tries to say something, fails and this failure *is* the subject (*Nothing* 959). This idea is taken up in Chapter 5 in discussions of consciousness in popular neuroscience.

hovering close to another universe into which it may collide in an utter cataclysm (407).

This last is closest to the eschatological imagery of Lucretius when he explains how earthquakes make us feel (and this is the passage Porter uses to describe the vertigo-inducing *horror vacui*):

> Let them go on imagining that the sky and earth are indestructible and destined to life everlasting. From time to time the visible presence of peril stabs them in one quarter or another with a secret qualm of fear that the earth may suddenly be whisked away from under their feet into the abyss and, robbed of its foundation, the whole world in a wild chaotic welter may follow it to perdition. (235)

In Lyotardian terms, this is an intimation of the possibility of there being a final phrase. And yet it is not Lucretius's aim to utterly terrify his readers by plunging them into darkness. He wants to examine nature's "darkest mysteries" in the hope that "facts throw light upon facts" (59). This could be seen as the credo of the popular science writer and in a sense Lucretius's epic is the prototype for modern popular science. Lucretius and his inheritors both attempt to give a non-supernatural account of the workings of the universe and both do so by self-consciously enticing the reader with certain aesthetics, chiefly that of the sublime. Lucretius uses his "sweet" verse "coated with the honey of the muses" (54) where Greene and other popular science authors use contemporary prose, purged of mathematical notation, aided by diagrams and liberally peppered with analogies and relatable anecdotes, along with narratives of discovery and of eccentric geniuses. Although Greene's books are very successful and have launched his career as a public intellectual, he is highly unusual in the genre in provoking the reader's *horror vacui*. Like Lucretius, he is evidently confident enough in his style that he can frighten the reader with the abyss as he includes enough honey on the rim to ease in swallowing the bitter medicine.

But even for a consummate science communicator like Greene, there is one more gap that threatens to undermine any professional scientist. That is the one that threatens scientific realism itself: wavefunction collapse. Quantum theory is better established than anything else in science so this gap is at the heart of the scientific enterprise. The wavefunction collapse is an *ad hoc* addition adopted to explain the

results of experiments; no wavefunction collapse has ever been observed and it is unclear what the ontological status of the wavefunction is, if it is something that can go from being a mathematical object to something that is physically affected by measurement (Greene, *Fabric* 119). In the elaborated versions of the double-slit experiment, wavefunction collapse is apparently dependent on decisions made well after the fact about what information will be destroyed or preserved. And so a further question arises as to how this happens in a universe that otherwise precludes non-local (temporally and spatially) effects.

Greene summarises the possibilities:

> there is still no universally agreed-upon way to envision what quantum mechanical probability waves [*i.e.* wavefunctions] actually are. Whether we should say that an electron's probability wave *is* the electron, or that it's *associated* with the electron, or that it's a *mathematical device* for describing the electron's motion, or that it's the *embodiment of what we can know* about the electron is still debated. (*Fabric* 91, italics in original)

Compelling answers are offered by Barad's agential realism and by MWI — provided one is comfortable with the ontologically extravagant alternative of parallel universes. But otherwise, wavefunction collapse invokes into its interpretation a whole set of metaphysical considerations that some physicists may wish were absent. Greene sums the discussion of this phenomenon in a slightly anticlimactic tone:

> much ingenious work on the quantum measurement problem has yielded significant progress, but a broadly accepted solution still seems just beyond our reach. Many view this as the single most important gap in our formulation of quantum law. (*Fabric* 204)

This follows his account of the quantum eraser experiments which he describes as "stunning" (194) and "dazzling" (197) and he admits to feeling "elated" for days after learning about them (199). Perhaps tellingly, Greene suggests the reader skip that section of the book. Greene's acknowledged "gap" in "quantum law" — a gap at the conceptual heart of the most fundamental scientific theory — does seem to constitute the "true" vacuum. And yet readers of quantum physics texts other than Greene's or

Gribbin's could easily reach the opposite conclusion. The basics of quantum physics suggests that there is no void, that even empty space is a teeming potentiality, an unstable quantum vacuum field. But as we saw with Žižek's reading of popular and mid-level physics texts, there seem to be gaps, voids, vacua and abysses in representation and in reality.

The scientist's *horror vacui* may be triggered by the clearly unresolved ontological status of wavefunction collapse. But the reader of most popular texts in this field, is not informed about this absurdity and its illumination via delayed-choice experiments. Instead they may infer that a gap in explicability exists because the authors only refer to quantum weirdness without explaining it. Otherwise, if they read Carroll, Deutsch, or Tegmark, then the MWI will conceal the gap but present a whole new ontological sublime. Only if they read Greene or Gribbin, will they be inducted into the uneasy implications of wavefunction collapse.

The effect on the subject of this ontological sublime is ambiguous. It is not as threatening to the subject as the variety we will encounter in microbiology texts in the next chapter. Depending on interpretation, the quantum measurement problem is actually self-affirming in the role it affords measurement in constituting reality. It is the integrity of the object that is threatened, not the subject and seems to therefore imply an epistemological sublime based on encountering the limitations of what can be known about the object. The rationalist subject assumed by popular science can be preserved in the same way as in popular cosmology. On the other hand, with the MWI, there is a more fragile arrangement. The postulated doppelgängers in a sense provide multiple self-affirmation, but with an associated loss of autonomy and individuality: all possible outcomes are realised in the multiverse, compromising the possibility of free will and arguably making decisions meaningless. That outcome seems more detrimental to the liberal humanist subject than do most variants of the Copenhagen interpretation.

The world explored in quantum physics is strange: branching parallel universes, doppelgängers, wavefunctions, quantum suicide, viruses in superposition, entangled particles, delayed-choice experiments and vacua that are not empty. Most popular authors evade this imagery even though it is obvious fodder for technoscientific titillation. It seems, however, to be an ontological sublime too threatening to the scientist's aims of uncovering more of reality with better instruments or theories. The epistemological sublime in cosmology taxes imagination

and understanding, but it does not question the role or coherence of the scientist and the reader learning from that scientist. The ontological sublime in quantum physics is largely occluded, but in the next chapter I investigate a subgenre that is much more willing to openly question the liberal humanist subject otherwise favoured in most science writing.

CHAPTER 3: Invisible biology and entanglement

> [W]hen we push our discoveries yet downward, and consider those creatures so many degrees yet smaller, and the still diminishing scale of existence, in tracing which the imagination is lost as well as the sense; we become amazed and confounded at the wonders of minuteness; nor can we distinguish in its effects this extreme of littleness from the vast itself. (Burke 66)

I call the subgenre of popular science in this chapter *invisible biology* and its subject matter *invisible life*. The texts include topics that come under the following discipline areas: microbiology, cell biology, molecular biology, biochemistry and parasitology.[46] *Invisible life* captures the most important focus of the texts: microbial life (microbiology, parasitology), the organic molecules inside cells (molecular biology, cell biology, biochemistry) and life as a larger phenomenon (the biosphere, Gaia, the origin and definition of life itself). Life seen with the naked eye will be the focus of next chapter: plant and animal species (including humans) as described by *evolutionary biology*. I examine several texts, but focus primarily on Lynn Margulis and Dorian Sagan's *Microcosmos* and Ed Yong's *I Contain Multitudes*.

I argue that the sublime of invisible biology is — like quantum physics in Chapter 2 and unlike cosmology in Chapter 1 — an ontological one. It not only presents the reader with highly unintuitive phenomena, but also destabilises the ontological status of the subject herself. This is achieved through a trick of perspective, almost a *trompe-l'œil*. First, humans are recast as collections of semi-autonomous cells, many of which are foreign (parasites, gut bacteria, *etc.*); second, the constituents of cells that govern the processes of life, such as proteins, ribosomes and mitochondria, are described in highly mechanistic ways often as robots or micromachines. This defamiliarisation of the human and the body also complicates

[46] I read *Gut* by Giulia Enders, *Life's Engines* by Paul Falkowski, *The Machinery of Life* by David Goodsell, *Life's Ratchet* by Peter Hoffman, *At Home in the Universe* by Stuart Kauffman, *The Vital Question* by Nick Lane, *Microcosmos* by Lynn Margulis and Dorian Sagan, *Chance and Necessity* by Jacques Monod, *Gene Machine* by Venki Ramakrishnan, *Life at the Speed of Light* by Craig Venter, *I Contain Multitudes* by Ed Yong; and relevant chapters in *Life on the Edge* by Jim al-Khalili and Johnjoe McFadden, *The Canon* by Natalie Angier, *Deadly Companions* by Dorothy Crawford, *The Ancestor's Tale* by Richard Dawkins, *Life* by Richard Fortey, *This is Your Brain on Parasites* by Kathleen McAuliffe, *Creation* by Adam Rutherford and *Your Inner Fish* by Neil Shubin.

habitual categories of thought. The neat divisions between nature and culture, subject and object, and living and nonliving, are all blurred by the view of life as primarily microbial and yet at the same time global. In doing so a derangement of scales is achieved that differs from those seen in earlier chapters. Rather than a mere dwarfing of the subject in comparison with the astronomical, in invisible biology the traditional subject is erased from both ends of the spatial scales discussed. The subject is subsumed into the concept of life as a whole in the form of the biosphere, while also disaggregated into cells and rendered almost irrelevant beside the dominant life form on Earth, bacteria.

The natural environment is a familiar, perhaps the original, source of sublime imagery. Some critics (discussed below) have attempted to characterise the sublime produced by terrestrial nature as an ecological or environmental sublime and as one that is drawn from an encounter with the radical Other of nonhuman nature. The hope for these critics is that such an encounter can prompt a more responsible attitude towards the environment. I contend that these theories follow the eighteenth-century tradition and assume an image of nature that has been bequeathed by Romanticism. Such an image is of nature as experienced in a certain northern-hemisphere type of encounter, in landscapes deemed aesthetically pleasing by that culture, where everything natural is visible to the naked eye. But in the invisible biology texts explored here, a much more capacious sense is attached to the word *nature*, which entangles the subject with the rest of the biosphere and hints at a surfeit of objects beyond the inventory captured by the Romantic image of nature. This populates the nonhuman world with a vast set of organisms that the human depends on for existence, which adds to the ontological claims of this version of the sublime.

Invisible biology texts are more overtly political than physics-based ones. Writers in this subgenre cannot help but make normative claims about the expanded nature they present. Depending on political views, the biosphere is valued in different ways by different authors. They represent a spectrum from deep ecology to neoliberalism, but most advocate that there is value beyond the human inherent in the living world. The rhetoric of this subgenre is not so much about the unknown or the far-flung, as in cosmology, as about the unseen or unappreciated. Rather than making a case for more funding to discover new frontiers, these authors make a case

for responsible action towards the environment and the existence of meaning that is immanent in the biosphere yet only partially accessible.

Finally, I also argue in this chapter that the recent preoccupation in contemporary theory and popular science with the concept of the Anthropocene, is relevant to the sublime. The Anthropocene can be seen as a species-level analogue of the sublime experience for the individual subject. The Kantian model has the subject encounter something that exceeds their sensible powers, but the recognition of this elevates the faculty of reason which can still grapple with the existence of the sublime object. For humanity, the confrontation with the Anthropocene presents the vastness of the global geological and biological processes that seemingly exceed the human, yet the knowledge of the human impact on these processes provides a possibility for human agency in grappling with the problem. I argue, therefore, that the Anthropocene is currently an ironic concept that reinforces anthropocentrism even as it attempts to increase environmental responsibility. However, in light of the ontological sublime offered by invisible biology, which suggests a much more entangled subject, the Anthropocene can be re-visioned.

Before moving on to the first part of the argument, I will briefly define the subgenre, as it is the least prominent of those I have studied in terms of scholarly attention paid to it. In fact I am largely defining the subgenre myself. The texts studied in this chapter constitute a group of popular, recent texts that circle around the same topics and are written by professional scientists. The authors are easily grouped because they are all biologists of one type or another, whose professional focus has turned to microbial life, cells, or organic molecules.[47]

The subgenre has a long but thin history. It is outside of my scope to do a thorough investigation of the lineage of texts, but the modern subgenre's antecedents can be briefly established. Robert Hooke's *Micrographia* was published in 1665, with detailed illustrations of small insects and the first description of cells. Ernst Haeckel published *Kunstformen der Natur* ("art forms in nature") between 1899 and 1904, including several plates of microorganisms. Paul de Kruif wrote a book called *Microbe Hunters* in 1926. It details the pioneering days of bacteriology and appears to be a largely forgotten example of early twentieth century popular science. The more acknowledged beginning to popular interest in invisible life (Yong 276n26) is

[47] A slight exception is Yong who is now a science journalist but who previously worked as a biochemist.

Theodore Rosebury's *Life on Man* (1969), which looked at microbes living on and inside the human body. Another milestone is *The Double Helix* (1968) by James Watson, which presents a personal story of the discovery of the DNA molecule. As well as bringing molecular biology to a popular audience, it presented an early example of the tales of discovery and scientific hero myths now commonplace in popular science. The arrival of the truly modern subgenre, however, begins with either Monod's *Chance and Necessity* (1970) or Margulis and Sagan's *Microcosmos* (1986).[48] Part of the recent spike in this subgenre is owing to the recent discovery of the importance of the human microbiome. A distinct subgenre of books about the microbiome, with a more dietary or self-help focus, has appeared in the years since 2015. I include only one work that borders on that type of text: Enders' *Gut* which contains plenty of dietary and health advice, but also a large amount of basic science.

Selves disintegrated into cells

Much of the content of invisible life is beyond easy envisioning. The smallest scales of invisible life involve processes at the level of electrons and protons. At the planetary scale, the contemplation of the earth's surface and inner atmosphere as a single biosphere regulated by microbial interaction, is likewise at the edges of our frame of reference. By contrast, works of popular ecology and nature writing generally describe objects easily seen with the naked eye and essentially contain the same *mise en scène* as the works of high Romanticism: mountains, birds, forests, mammals, rivers, oceans, *etc*. In invisible biology, this familiar imagery is replaced with miniscule things like bacteria, archaea, cells, ribosomes, chromosomes, mitochondria, chloroplasts, proteins and viruses; and on the planetary scale by global electron marketplaces, carbon cycles, nitrogen cycles, the global oxygen holocaust, the biosphere and Gaia.

Monod offers another way the scale of molecular biology is confounding:

> In the case of physics, microscopic or cosmological, we can see what the trouble is: the scale of the envisaged phenomena transcends the categories of

[48] I refer mainly to Margulis by herself as she was the creator of the original scientific ideas in the text and a well-known research scientist; Dorian Sagan, her son, is primarily a science writer who co-wrote several popular science books with Margulis.

> our immediate experience. Only abstraction can supply this deficiency, but without curing it. In the case of biology the difficulty is of another order. The elementary interactions upon which everything hinges, thanks to their 'mechanical' character, are relatively easy to grasp; it is the phenomenal complexity of living systems which defies intuitive global representation. (Monod 131–2)

This is a neat encapsulation of the difference between the purely epistemological sublime of cosmology and the deeper, ontological sublime prompted by invisible biology. The "phenomenal complexity" of these "mechanical" elements is present within all of our own cells. Monod tracks the development of complex life as it leverages purely chance events — describable in the lifeless, physical language of thermodynamics — to create local order amid global disorder. Monod is aware that this vision of living things as chance assemblies of intricate but mechanical parts is terrifying and that it has "blasted at the roots" our "system of values" (159).

In a similar fashion to the ontological sublime discussed in Chapter 2, the vision of living things in Monod and his successors presents a *horror vacui*. In the harshest version large multicellular organisms, including humans, are disaggregated into nothing but their microscopic component cells, which are semi-autonomous. Angier (191) and Lane (34) both point out that a single cell taken from a human body looks like any other eukaryotic cell under a microscope and will carry on the procedures of life if kept in a suitable medium. Within those cells are what most authors refer to as *micromachines*, *molecular machines, molecular robots, nanobots,* or *nanomachines*. Hoffman declares that at the smallest scale of life we are made of "autonomously moving molecules performing specific tasks like tiny robots" (5). Hoffman concludes that:

> the mechanists [like Democritus and Helmholtz] were right: life is based on machines — on pumps and motors. What these scientists could not know is that these machines are molecular nanobots that work very differently from any machine they could have imagined. (212)

The machine metaphor is pervasive in the subgenre, evident even the titles of some works: *Life's Engines*, *The Machinery of Life* and Hoffman's own *Life's Ratchet*. And

it spreads out into neighbouring subgenres too. Here is Steven Pinker in a book about cognitive science: “The stuff of life turned out not to be a quivering, glowing, wondrous gel but a contraption of tiny jigs, springs, hinges, rods, sheets, magnets, zippers and trapdoors” (*Mind* 22).

Even the less mechanistic writers delight in dissolving the subject into cells. Here is Yong summarising the strange perspective of the individual prompted by invisible life:

> Knowing what we know, how would we even define an individual? If you define an individual anatomically, as the owner of a particular body, then you must acknowledge that microbes share the same space. You could try for a developmental definition, in which an individual is everything that grows from a single fertilized egg. But that doesn’t work either because several animals, from squids to mice to zebrafish, build their bodies using instructions encoded by both their genes *and* their microbes. In a sterile bubble, they wouldn’t grow up normally. You could moot a physiological definition, in which the individual is composed of parts — tissues and organs — that cooperate for the good of the whole. Sure, but what about insects in which bacterial and host enzymes work together to manufacture essential nutrients? Those microbes are absolutely part of the whole, and an indispensable part at that. A genetic definition, in which an individual consists of cells that share the same genome, runs into the same problem. (24, italics in original)

The self is not even delimited by the genome, which might be the obvious choice for identifying a multicellular arrangement as an individual organism. Entangled with microbes that are on a sliding scale from plainly hostile to essential life support, the human individual is at best a fuzzy-edged thing, even according to the very taxonomically inclined discipline of biology. Yong adds, “It is a dizzying change in perspective, but a glorious one” (25). Dizzying and glorious: a close synonym for the horror and delight of the Burkean sublime.

The traditional autonomous subject is blurred from both ends of the spatial scale. In addition to this disintegration into cells, nanobots and communities of microbes, Margulis subsumes the individual organism into a larger superorganism as well, which she calls the “planetary patina”, a rough synonym for biosphere (126).

The planetary patina has a life of its own and later in the text it is described with reference to the Gaia hypothesis (265–9). Even the use of "patina" suggests that life itself is a surface phenomenon, a marginal byproduct of the nonliving earth. It recalls Stephen Hawking's comments that, from a cosmic point of view, life is just "chemical scum" (qtd. in Deutsch, *Reality* 177). Humans are lost in the multitudes of the microcosmos, subsumed into the superorganism and even the superorganism is a kind of spin-off of nonliving geological processes.

This is a particular kind of scale effect. As discussed in Chapter 1, scale effects are the most common rhetorical device used to evoke the sublime in popular science texts. In invisible biology a special type is employed whereby the subject is dwarfed — as in the typical scale effects seen in cosmology — while at the same time incorporated, almost literally, into a larger identity, *i.e.* the biosphere. Thus the subject is compromised from two different directions. Margulis's text contains the most extensive example of this technique, which she uses to emphasise human humility and the limits of comprehension: "Our microcosmic portrayal of *Homo sapiens sapiens* as a kind of glorified sludge has the merit of reminding us of our bacterial ancestry and our connections to a still largely bacterial biosphere" (19).

A brief detour is needed to situate Margulis's perspective. Margulis is famous for her now vindicated thesis of endosymbiosis, which explains the origin of *organelles* in eukaryotic cells. Organelles are parts of a cell that perform specific functions, somewhat akin to organs in an animal's body. Eukaryotic cells (those of plants, animals, fungi, algae and protists) are more complex than bacteria or archaea and only eukaryotic cells have ever become multicellular organisms. Two well-known organelles are chloroplasts in plant cells (crucial for performing photosynthesis) and mitochondria in animal cells (crucial for respiration). Margulis claimed that both chloroplasts and mitochondria had origins as separate, single-celled organisms that were incorporated into other single-celled organisms to form a symbiotic relationship. This view is now the biological orthodoxy. Margulis also argued that some other organelles also have a history as freestanding organisms, but these latter claims have not been accepted by the scientific community.

One such organelle is the microtubule which is particularly important in nerve cells (neurons). Margulis postulates that they derive from a bacterium, the spirochete, specially suited to rapid movement (138–40). Although this idea is not

now supported, the passage discussing it aptly demonstrates Margulis's use of scale to subsume the human:

> Once, microscopic spirochetes had to swim furiously for their lives. Now, millions of years later, packed into an organ called the brain, their nucleotide and protein remnants conceive and direct the actions of a highly complex amalgam of evolved bacterial associations called a human being. Perhaps groups of humans, sedentary and packed together in communities, cities, and webs of electromagnetic communication, are already beginning to form a network as far beyond thought as thought is from the concerted swimming of spirochetes. We stand no more chance of being aware of the totality of such a form of group organisation than do the individual components of brain cells — microtubules, the putative remnants of spirochetes — understand their own mission in our human consciousness. (153)

The human is here deflated to "bacterial associations" and broken down into a coalition of myriad tiny entities. At the same time the speculation of a state of being that is necessarily beyond our awareness is a presentation of the unpresentable in the Lyotardian sense, but also represents the diminution of the subject at the opposite end of the scale. Humans are rendered as being at once merely a concatenation of cells, many of whose components used to be separate organisms and also merely part of some larger congeries beyond our comprehension. This is a nested hierarchy of groups with humans being somewhere in the middle and not in a position of priority. Indeed Margulis remarks that, "Nature has a certain subsuming wisdom; our aptitudes must remain meagre in comparison to the biosphere of which we form relatively tiny parts" (152). The need for humility is emphasised in this dual undermining of the stable, cohesive subject. The Russian-doll logic of nested groups suggests that each group is just a larger version of the one below it. But Margulis is further speculating about the *emergence* of new phenomena at each level, or at least at the higher level she postulates of human communities. Emergent phenomena are central to invisible biology as all of these authors, going back to Monod, try to account for the functioning of complex life and mind based on comparatively simple molecular "machines".

In a more tangled hierarchy, Enders (150) and Yong (4) both use the whole globe or some large ecosystem as a metaphor for the communities of bacteria living on and in a human body. Yong refines this metaphor later in his text, figuring the individual human as an archipelago of islands of bacterial colonies (17). In a relatively rare second person address to the reader (Yong generally relies heavily on the collective first person) he writes: "your right hand shares just a sixth of its microbial species with your left hand. The variations that exist between body parts dwarf those that exist between people. Put simply, the bacteria on your forearm are more similar to those on my forearm than to those in your mouth" (17). Yong invokes the individual reader only to show how various she is, with bacterial colonies distributed laterally across separate humans' common body parts, rather than over the same human. The figuring of the human body as a world and the life in it as whole colonies, while in the same text constantly referring to life as a whole and as a global microbial phenomenon, establishes in a more circuitous and synecdochic fashion the same nested set of scales as in Margulis. Yong entreats us in his prologue to "zoom out to the entire animal kingdom, while zooming in to see the hidden ecosystems that exist in every creature" (5). The whole (an ecosystem) is subsumed into the part (the creature) in a tangle of scales peculiar to this subgenre of popular science.

The interpenetration of scales is in keeping with the ontology advocated by Barad in *Meeting the Universe Halfway*. Here she is discussing connections between scales:

> This "connectedness" should be understood not as linkages among preexisting nested scales but as the agential enfolding of different scales through one another (so that, for example, the different scales of individual bodies, homes, communities, regions, nations, and the global are not seen as geometrically nested in accordance with some physical notion of size but rather are understood as being intra-actively produced through one another). (Barad 245)

The cell, the organism, the society, the biosphere are imagined in invisible biology to be mutually constitutive. Yong's archipelagos, bodies, colonies and body parts are produced and framed *through* one another.

Additionally there are the usual scale effects to (dis)orient the reader that are typical of popular science books in any subgenre. Lane gives us the scale of the ribosome: one of the most complex "nanomachines", present in all living cells. Its structure "epitomises a contradiction that is hard for the human mind to fathom — scale" (Lane 7). Inside an already microscopic cell from a human liver, Lane points out, there are approximately 13 million ribosomes. And yet on the scale of atoms a single ribosome is a large structure "composed of scores of substantial subunits, moving machine parts that act with far more precision than an automated factory line" (7–8). This has the double effect of emphasising the incomprehensible remoteness of the scale and the sense of the coherent self being disintegrate into unthinking parts effected by the machine metaphor. In other words, this is a trigger for the epistemological sublime and a trigger for the ontological sublime.

Another popular way to conflate biological scales and thereby complicate habitual frames of reference, is through the action of viruses, parasites, or bacterial infections which effectively jump scales to manifest macro-level effects. Here is a passage from Enders' *Gut* about salmonella infections:

> It takes between 10,000 and one million of these single-celled creatures to put us out of action. A million of these bacteria take up about one-fifth as much space as a grain of salt. So how does an army of such tiny soldiers manage to move a colossus like us, with the volume of about 600,000,000 grains of salt, inexorably towards the toilet? It's as if one hair of Obama's head were to rule over the entire population of America. (185)

Enders is always defusing the most shocking revelations of infections and their effects on the subject. Her writing is unusually colloquial for this genre and often addressed to the reader in the second person. In the quoted passage there is plenty for the reader to latch onto, with two scale effects, a metaphor, an explanatory analogy and some mild toilet humour. The topic is personal as the book is mainly about the salience of microbes in recent studies on diet and digestive health. But there is still an intent to wow the reader with the tiny scale and the loss of agency implied by having behaviour altered by ingested bacteria. And, like Margulis, Enders continues the zooming out beyond the human to the global. She observes that infectious diseases are spread more easily in a globalised world with lots of human

migration (183). Even this lighthearted book, still leans heavily on the horror/delight dyad and the disruption of categories, typical of the modern scientific sublime.

Enders also exemplifies two recent trends in the subgenre: the focus on the microbiome in the human gut as a second brain or even second self, and the effects on human behaviour of parasites. McAuliffe's *This is Your Brain on Parasites* is a book-length exploration of this new area of research. Some parasites have "an awesome hidden power that astounds and confounds even scientists" and are "masters of mind control" (2). Human agency is undermined but scientific wonder is reasserted even and especially in the face of bafflement. McAuliffe concludes on a more ontological note "Only this much is certain: Parasites are woven into our psychology and the very fabric of our being" (219).

Enders discusses one of the most notorious neuroparasites, toxoplasma, which is a bacterium that reproduces in cats' guts (196—204). It is known to affect the behaviour of infected rats, making them unafraid of or even attracted to cats. The rats are therefore more likely to be eaten and therefore toxoplasma is more likely to make it back into its favoured reproductive environment of the cat's gut. It also seems to affect human behaviour, with some studies suggesting that people with pet cats can contract the parasite from faeces in cat litter and then become less risk-averse in their behaviour. Rates of car accidents, for example, appear to be higher in those carrying toxoplasma and most people carry the parasite at some point in their lives (197–200). The condition has also been linked to depression, suicide and schizophrenia and people carrying the parasite even believe themselves to be more susceptible to hypnosis (McAuliffe 63, 70–3). The effect of this violation of the autonomy of the subject seems to be a kind of terror. But Enders attempts to restore self-determination via the fruits of knowledge: "Is this spooky? Well, maybe a little bit. But isn't it also exciting to see how we are gradually decoding processes that we used to believe were part of our inescapable destiny? This could help us grab the risks by the scruff of the neck and defy them" (204). From the threat of self-annihilation, with our behaviour determined by unseen parasites piloting our bodies, science or reason offers an escape in the very act of learning about this limitation. The parallel with the Kantian sublime is clear.

This mix of self-reinforcement and self-dissolution is exemplified in Yong. Like Enders he features toxoplasma and other microbes that influence the behaviour of host animals. Yong goes into a lot of detail on the links between certain behaviours

— anxiety, risk-taking and depression — and gut flora. But, like Enders, he also details the many beneficial and in fact vital effects of microbes in the human body. The work's title, *I Contain Multitudes*, prompts the fuller quotation from Whitman's poem of subjectivity, *Song of Myself*:

> Do I contradict myself?
> Very well then I contradict myself,
> (I am large, I contain multitudes.)

Yong is stressing the impossibility of invisible biology offering a neatly determinate position on subjectivity. The contradictory statement of the title invokes the singular first-person pronoun: the very signifier of the unitary self and the grammatical subject. But it is juxtaposed with the multiplicity it contains. Yong fortifies this attitude by the frequent repetition of the collective first person. Indeed the word *we* is used more in his text than in any of other texts examined here.[49] The subtitle of Yong's book is: "The Microbes Within Us and a Grander View of Life". The title complicates the subject and the subtitle expands the focus to include ourselves and others and gestures to the complicated but improved vision of life itself. Through zooming in and out to spatial scales outside of experience and beyond ready comprehension, Yong simultaneously invokes the scientific sublime, while altering the very subject that experiences that sublime.

Once again, this can be read against the Kantian sublime. Kant's three-part movement goes from (1) a starting point of habitual thinking; to (2) disruption of the subject's imaginative faculties when confronted with the sublime object — say a vast mountain — which physically dwarfs the subject and exposes the limitations of her imagination; to (3) a reaffirmation of the subject when the supersensible faculty of reason processes what the imagination cannot. Yong's sublime, however, could be schematised like this: (1) habitual thinking is (2) disrupted with the vision of the cellular self, including its effect of unimaginable scale; along with (3) the dissolution of the subject entailed by that same object; finishing on (4) the renewed but decentred subject able to comprehend — scientifically at least — the sublime of the

[49] 173 times in Yong's text versus 93 in Falkowski's, for instance. It also appears more per page than in any other text.

cellular self. Because of this implication of the subject in this sublime, incomprehensible object, this is an ontological sublime.

Scale: conflations and tangles

Scale is prominent in invisible biology in a new way compared to earlier chapters. In Chapter 1 I outlined the epistemological sublime encountered in the stupendous scales and the edges of current exploration in popular cosmology. In Chapter 2 there was the more ontological sublime of quantum mechanics and the void or gap in the very smallest scales with the attendant gap in their understanding and representation. This chapter further complicates the modern scientific sublime, with a sublime of scale itself.

As I argued in Chapter 1, *conflations* of scale can produce the sublime in fairly straightforward ways, as in the dwarfing effect of an astronomical spatial or temporal scale recast in human terms. Sagan's cosmic calendar condenses 13.5 billion years into a calendar year (*Dragons of Eden* 13–7) and Yong uses this same device at the beginning of his book to illustrate how multicellular life is a relatively recent phenomenon.[50] But that is the bringing together of two remote scales, into conflation, to disrupt habitual thinking. The deeper disruption offered by invisible biology is also to do with scale, but not merely to dwarf the subject by putting them into a cosmic context. Rather this less obvious effect can be seen in invisible biology's insistence that happenings at a scale much smaller than that of the human nevertheless influence the scale of human happenings. Rather than a conflating of scales this could be seen as a leaking or bleeding of a remote scale into another. The biochemical imperatives of the cell (Lane), the life-cycles of microscopic parasites (Enders), the makeup of the microbiome (Yong), the global yet microscopic cycles of carbon and nitrogen (Falkowski) and the self-regulating superorganism of Gaia (Margulis) are all processes well beyond unaided human perception. And yet unlike

[50] Yong attributes the figure to David Attenborough's 1979 documentary series *Life on Earth*. This postdates Sagan's usage by two years. But I suspect very similar rhetorical devices have a longer history. One example I stumbled upon was in the text of John F. Kennedy's 1962 speech in Houston announcing the NASA moon missions. He asks the audience to "condense, if you will, the 50,000 years of man's recorded history in a time span of but a half-century. Stated in these terms, we know very little about the first 40 years." He continues, "[F]ive years ago man learned to write and use a cart with wheels. Christianity began less than two years ago. The printing press came this year. . . we will have literally reached the stars before midnight tonight" (Kennedy 1).

astronomical phenomena they are intimately connected to human concerns, indeed human survival and human identity.

The confounding aspect of this mingling or entanglement of scales is that these low level (lower inasmuch as they operate on smaller physical scales) phenomena and the higher level phenomena of human activities are not easily put into correspondence. Although the complexity of the molecular realm is repeatedly emphasised, there are many higher level properties or categories that are simply inappropriate to that molecular level. Biological molecules perform tasks, but cannot be said to have a will, or reasons, or a politics. And yet their collective actions manifest, at a larger physical scale, a subject that has a will, reasons and politics. This is troubling because of the mismatch between the properties of parts and the properties of the whole: the puzzle of *emergence*.

I think emergent phenomena may be conducive to the sublime because they confound intuitive frames of reference. An important question arises as to how our intuitive or culturally inherited notions of scale itself are violated by invisible life. Are we innate emergentists who assume new properties of phenomena loom into focus at different scales? Or are we naturally fractalists who assume that the world is scale invariant? I could not find any scholarly work devoted to this question, despite the existence of a growing literature on "folk physics": the native assumptions people have about how objects behave and how space, time and causality operate.[51] The question may be moot because we evolved to only interact with and comprehend objects on spatial scales visible to the naked eye and on temporal scales anchored to a human lifespan. Certainly vast phenomena and microscopic phenomena both seem apt to produce the sublime experience. In Burke's words, "we become amazed and confounded at the wonders of minuteness; nor can we distinguish in its effects this extreme of littleness from the vast itself" (66). I conjecture that we are closer to habitual fractalists. Take for example the way the popular preformationist theories of the seventeenth and eighteenth centuries depicted spermatozoa as encasing homonculi: fully formed humans in miniature (Hrdy 70–1). The persistent attraction of vitalism, too, could be read as an enduring assumption that things at the bottom are essentially the same as things at the top: that whatever is the vital spark that characterises living things on a macro level must be present at the micro level as well.

[51] Sometimes also called "naive physics" or "intuitive physics". See Sperber (ed.) for discussions of folk psychology, naive physics and folk biology.

The sublime vision of the cellular self, built of organic nanorobots, seems to strike harder at intuitions about living things and their character at smaller scales, than do the vitalist or preformationist ideas. The cellular self implies that the stuff we are made out of is very different in character to ourselves. In other words the whole is unlike the parts and life is not synecdochic. Again, this suggests we may tend towards thinking fractally and be surprised at the crude nature of the lower level constituents of emergent phenomena. This reflects Monod's point that it is not only the tiny scale of molecular biology that confounds, but its additive *complexity*.

If my conjecture is correct then the mere description of emergent phenomena is a scale effect productive of the sublime. If scale invariance is a frame of reference we possess, then confounding it is a special case of the sublime-inducing techniques frequently used in popular science. As already alluded to, conflating scales is certainly a feature of the modern scientific sublime but mixing up scales in a tangled hierarchy of levels such as those found in invisible biology is more elaborate. Breaking an intuitive frame of reference in terms of scale can be seen as an example of a *metalepsis* (which will be explored in detail in Chapter 4). In literary theory, especially narratology, metalepsis refers to a mixing of diegetic levels, most commonly as in a story within a story. An ontological metalepsis is a special case whereby the real world — the world of the implied reader or the actual author — is somehow blended with the fictive world of the text (Fludernik 388). In the non-fiction texts I am studying, transgressions of *real* ontological levels are represented.

I emphasise the ontological aspect here to deliberately conjure recent ideas from the "ontological turn" in the humanities. Barad (a theoretical physicist) and Myra Hird (who trained as an environmental scientist) are two relevant examples of theorists who have drawn upon contemporary scientific ideas to make new and fascinating interventions into cultural theory. Barad's ideas will be discussed later in the chapter, but here I want briefly to note Hird's work, because she is the only scholar I have found who talks specifically of a sublime of the microcosmos. In a tantalisingly brief article, citing Margulis, Hird hopes to go beyond humanism and beyond the human/animal split with an ontology of the microcosmos. This "micro-ontology" involves an "incalculable enmeshment" (36) and:

> proceeds from a different, non-human-centered ontology than Kant's sublime, Wittgenstein's lion, Lyotard's inhuman and *differend*, Heidegger's Hand-

> Werk, Levinas's dog Bobby, and ultimately Derrida's cat, each of whose epistemologies pivot on a comparison between humans and (the) animal that leads to the latter's ultimate disavowal . . . [F]ocusing on animals "big like us" (Margulis, 2007, personal communication) encourages a profoundly myopic humanism. (36)

I see in Hird's and Barad's emphasis on entanglement and enmeshment, an attempt to think past the sublime of scale that I have just outlined. Perhaps some of the difficulty in thinking in this new ontological manner is down to the entangling of phenomena on different scales and how that confounds our habitual ways of thinking. If that is true then the sublime presented by invisible life is something worth overcoming for philosophical reasons. But, as I hope to show in the next section, there is also an ecological reason for indulging or lingering in the sublime of invisible life.

A new ecological or environmental sublime

Books about invisible life present a sublime not so much at the edge of knowledge, in the sense of pushing the boundaries as in cosmology. Nor do they offer the ontological sublime of a gap or undecidable vacuum at the heart of the system of knowledge or the world, as in quantum physics. Invisible life texts invoke the sublime in their undermining of categories within existing epistemological and ontological frameworks, rather than undermining those frameworks. In this subgenre, distinctions between self and other, living and nonliving, culture and nature are called into question.

What distinguishes the sublime of invisible biology from the dynamical sublime of Kant (vast nature) is that *nature* in this subgenre is much stranger and traverses more scales than did the nature of Kant and his contemporaries. This means any ecological or otherwise ideological messages about nature examined here draw on a richer set of significations for the term and point to a more entangled relationship between the subject and that nature. I propose the idea of a *new environmental sublime* prompted by invisible biology.

First, however, I will briefly summarise the existing perspectives on the *environmental sublime*, as Emily Brady would have it, or the *ecological sublime* as in

Christopher Hitt's terminology. Brady and Hitt both cite the work of the environmental historian William Cronon who criticised the aesthetic of the sublime as being generally inimical to environmentalism. Brady, in recognising the anthropocentric or even egotistical nature of the Romantic conception of the sublime, notes that it has the potential to turn nature into an Other (194). This entails a necessarily anthropocentric dualism between the self and this Other. Rather than the self-abnegation one might assume to be the outcome of a Romantic encounter with nature, it actually engenders self-apotheosis as one is set apart from nature in a relationship of dominance (195). This uncertain effect on subjectivity is emphasised by Hitt too, who notes that Ralph Waldo Emerson's experience in nature led first to him recognising his smallness, but ultimately to being ennobled by an encounter with the forest; after which he returned to society restored rather than shaken or radically altered (609).

Brady and Hitt differ on whether the sublime encounter with nature includes anything like the final stage of the Kantian movement. Brady stays reasonably close to Kant but insists that certain experiences with the natural environment can simultaneously make us feel closer to and distanced from nature and that this dual feeling *is* the environmental sublime (192–3). She further argues that this kind of encounter is one we should try and cultivate on environmentalist grounds (203). Hitt is less confident and favours an ecological sublime that omits the final phase of the Kantian movement, leaving the subject destabilised by the encounter. He cites Henry David Thoreau as an exemplar of someone trying to express with language the presence of something in nature beyond language, something that cannot ever be assimilated into easy comprehension (615–6). In short, neither critic is so old-fashioned as to say the subject completely triumphs in the sublime encounter, but both acknowledge some kind of potentially useful political effect: environmental awareness in Brady, awareness of the unknown in Hitt.

Crucially, both critics neglect Cronon's other reason for rejecting the aesthetic of the sublime, namely that it draws on a particular set of natural objects, *i.e.* those inherited from the Romantic epoch:

> wilderness tends to privilege some parts of nature at the expense of others. Most of us, I suspect, still follow the conventions of the romantic sublime in finding the mountaintop more glorious than the plains, the ancient forest

> nobler than the grasslands, the mighty canyon more inspiring than the humble marsh. (22)

Drab landscapes are ignored in favour of those that inspire some measure of fear. This is reminiscent of the focus by sustainability movements on endangered species that attract public favour, such as dolphins and eagles, rather than less photogenic species.

I take Cronon's point further. Contributors to the wilderness debate, as well as traditional writing on the sublime aesthetic and indeed virtually all ecocritical discourse too, all favour a very narrow idea of nature even when the less celebrated landscapes or species are included. Even if we widen our gaze to include the grasslands and marshes — the less *glorious* examples offered by Cronon — they are still landscapes which happen to exist in Cenozoic era conditions.[52] And they are still macro-level objects visible to the naked eye, features of the landscape that are, as Hird and Margulis say, "big like us". Cronon may be alluding, in the above quotation, to Nicolson's *Mountain Gloom, Mountain Glory* and her history of the changing aesthetics of mountains and other landscapes.[53] Europeans apparently did not consider the mountaintop more glorious than the plain until the seventeenth century and the advent of the incipient science of geology (Nicolson 3). An increase in knowledge of what mountains are and how they are produced along with the fashion for reading new translations of Longinus led to, according to Nicolson's analysis, a rapid shift in what is considered beautiful or sublime landscapes (143–7). Our received canon of aesthetically pleasing natural objects, both beautiful and sublime, is historically and culturally situated and was influenced by scientific discourses, among others.

In invisible biology, the imagery associated with *nature* exceeds what is visible to the naked eye. Not only are well-known objects recast, as was the case with mountains in the seventeenth century, but new classes of objects populate a new nature, far more intricate, large and ancient than that of the Romantic imagination. The vision of nature and the history of life offered by Margulis is, again, a striking example. She presents a timescale for life of four billion years, of which only the last

[52] The Cenozoic Era is the last 66 million years, coincident with the rise of birds and mammals, following the extinction of the dinosaurs. It is marked by a relatively stable, temperate climate.
[53] Cronon is familiar with her main thesis. He includes her in a footnote summarising some perspectives on the sublime, although he does not cite her in the main text.

quarter contain complex multicellular organisms, the original animals, who only came onto land 425 million years ago (169). Even now, the microbial world is more in the ascendency than people might realise. Even complex organisms (such as humans) are ultimately composed of cells that are fairly autonomous. And even those cells are composite forms, made up of organelles, some of which — like the mitochondria detailed above — used to be separate free-living bacteria:

> Individual bacteria became the organelles of nucleated cells; nucleated cells teamed up into many-celled "individuals" trillions of times their size. Larger beings — whose components are also beings — have been called "superorganisms." (246)

Thus we are both superorganisms constituted by tiny ones and — because of the free flow of genetic transfer and evolution that happens at a much faster pace at the microbial level — at the same time we are part of a larger superorganism that helps regulate even the nonliving parts of the earth such as the atmosphere (Margulis and Sagan 267). This prompts an almost vertigo-inducing consideration of the human subject as an assemblage of tiny unthinking beings, the sum of which somehow constitutes an ego: Hird's micro-ontology. On a higher level we are subsumed into a larger whole as part of the self-regulating super-self of the biosphere, personified — or even deified — as Gaia: Hird's "incalculable enmeshment".

Consonant with Margulis's aim of challenging hierarchical models, the superorganism of the biosphere (the highest level) is a self-regulating, self-maintaining (*autopoietic*) system that feeds back into the lower levels, right down to bacteria that produce oxygen, which in turn affect the biosphere (264–6). This feedback between the high and low levels also involves mid-sized levels such as multicellular organisms. But for rhetorical and political reasons, Margulis de-emphasises this mid-level because in previous hierarchical schemes it is organisms at this level, specifically *Homo sapiens*, that have been prioritised (18–21).

For contemporary readers, the familiar natural objects of large multicellular organisms, including people, are totally defamiliarised as complex assemblages, at once composites of tiny autonomous cells mixed with foreign but mainly benign microbes, and part of the biosphere which is itself a kind of self, at least as far as it is self-regulating and self-maintaining. Recalling Nicolson, mountains were

transformed from blots on the landscape to symbols of the sublime by the knowledge of volcanoes, geological upheavals and deep time. An equivalent shift is perhaps less likely with this new view of organisms, as this shift bears too directly on the integrity of the subject. And unlike the changing aesthetics of mountains, invisible biology bombards the subject with strange objects that are not merely seen anew, but which can never be seen at all, because they occur on spatial or temporal scales impossible to perceive. Possibly this means that whereas mountains became an ideal case for Kant's optimistic sublime that reaffirms the liberal humanist subject, Margulis's and others' new perspective on living things can produce a more equivocal sublime.

The new environmental sublime suggested by invisible biology should not be written off as a mere cipher for the unpresentable or ineffable. Margulis confronts the difficulty in comprehending life as microscopic and at the same time global: "Because we are constrained to communicate in standard English it is difficult for us to grasp the idea of the definition of life as a reproducing autopoietic system" (266). Thoreau's linguistic limitations are met in this radically decentred vision of identity that we might call the *new environmental sublime*. It follows Hitt's hope for the sublime as a way to an unmediated style of thought, operating at the edge of what *logos* can contain: "The symbolic order, after all, is a limited human construction that never fully accounted for the wholeness of 'reality' in the first place" (615). For Hitt the sublime of nature consists in that it is too big for language (or the symbolic order) to contain or grapple with. But according to Hitt's own formulation, the question remains as to whether the sublime is an experience of something *beyond* the extent of the normal symbolic order or merely a cognitive effect of having reached that extent. In this way it does not advance the idea past the Lyotardian view of the presentation of the unpresentable, with the ecological sublime intimating, through presentable nature, the fact of an excess of nature that is beyond presentation.

Hitt arguably misconstrues the role of the symbolic order, taking it to be an attempted but failed mirror of nature. Doing so only reifies a particularly crude version of the nature/culture binary. In what sense is language — or *logos*, or the symbolic order — apart from nature? Another feature of the more capacious view of nature given by invisible biology, but also evident in some recent strands of cultural theory, is that the human and the in- or nonhuman are entangled and that the notion of mirroring or reflecting nature is naive to begin with. Barad convincingly argues

that metaphors of mirroring and reflecting contribute to and are symptomatic of analogical thinking (88). Her own methodology emphasises *diffraction* (mutual interaction and indeed *intra*-action) over reflection and in place of "the symbolic order" Barad has "material-discursive practices" which already assume a more intertwined relationship between objects we would call *natural* and efforts at understanding and intervening that we would call *cultural* (66). The "nature of nature" is therefore not something to be gestured at with a remote and unnatural language, but is something that is in a state of becoming, entangled with the material-discursive practices that are making attempts at exploring it even as they are already related to it in any case (Barad 94). A sublime that produces a recognition of the entanglement of the subject, language, culture and nature is a more interesting sublime and one which I think is in evidence in this subgenre.

So neither Brady nor Hitt advance much beyond the sublime in terms of an encounter with nature, as bequeathed us from the Romantic tradition. But when mapping these critics' views onto the new nature of invisible biology, Brady's environmental sublime is the more apposite of the two, as she at least captures the equivocal, synchronous effect of the sublime:

> It embodies a form of aesthetic response which balances elements of humility and humanity in relation to more threatening or overwhelming qualities and articulates a more challenging kind of environmental experience. The sublime delivers aesthetic responses that potentially ground moral attitudes, where we grasp nature as something that is to be admired, deserving of respect. . . In a strongly relational experience, we attend to both sublime qualities and ourselves in comparison to them. This relational dimension can give rise to metaphysical, existential reflection and perspectival shifts within an aesthetic experience, opening out new ways of perceiving and valuing the world. (Brady 206)

The emphasis on the experience being challenging and of a dual nature is promising. However I still feel that Brady's attitude to the environment is one of aesthetic appreciation — which she makes plain: she is defending the sublime as an aesthetic category in an age of environmental awareness. The final sentence is where I think we should begin in looking for how the sublime might offer a useful perspective on

the environment. The "new ways of perceiving and valuing the world" can come, I argue, from the expanded and defamiliarised vision of the world from invisible biology. The ontological sublime of the cellular self — powered by micro-machinery — and the blurred-out human of the tangled scales of autopoiesis, both undermine one old-fashioned conception of the subject and old-fashioned conceptions of nature. But these same ideas enrich and complicate as well. Most of the texts examined here greatly expand the significance of *life* as well as *nature* and seem to me to be amenable to an ecological or environmental ethic, as Brady advocates. But unlike Hitt's proposal that the sublime of nature simply exceeds the symbolic order, I claim that any recognition of vast new dimensions of nature must enhance that symbolic order and it is not one-way traffic: in Barad's terms, probes into nature and the discourses in which those probes happen must act diffractively.

The nature invoked by Brady, Hitt and virtually all other writers in ecocriticism, nature writing and writing on the sublime, is but a tiny subset of the much larger, integrated, stranger, and older nature posited by invisible biology texts. Hence writers like Barad and Hird, who work with more expansive ontologies, have a more useful way of considering nature/culture. The essentially microbial nature of life — the real life of nature — does not figure even in recent accounts of the environment and the sublime. Microbes are not even seen as nature; that is, nature as wilderness, nature as Other, or nature as environment. If one writes a book about encounters with microbes it will not be labelled "nature writing". The engagements with nature promoted by ecocritics continue to revert to nature much in the way it was conceptualised by Thoreau and Emerson. Rather than the subject being threatened and then restored, or simply remaining threatened or relegated as in Hitt, the entanglement of the subject is different with invisible life: as Yong and Enders attest this is an expanded and complexified subject, not a denuded one.

The value of the biosphere

> How might human/animal/bacteria meet-with in the context of the current environmental crisis affecting animals? How does our current concern with human–animal relations obscure bacterial intra-actions that have nothing to do with humans, and are beyond human recognition? (Hird 38)

A political dimension is discernible in the invisible life subgenre and it bears directly on the new kind of sublime encountered here. Because of the new image of nature evoked by these texts, the place of *meaning* or *value* in the sublime encounter shifts its centre of gravity from the subject to the object: if the subject is entangled then the sublime experience and the meaningfulness of that experience is also entangled, rather than the subject being circumscribed or remote. But not all the authors emphasise the idea of value or meaning being dispersed throughout the biosphere. The degree to which this is done appears to depend on the author's political stance and how they read that stance in nature. In all cases, the location of a vast unseen world of life beyond the human is a rhetorical device unlike the equivalent in popular cosmology. In the Introduction I suggested that part of the rhetorical work of the sublime in popular science is to justify ongoing funding of scientific research. Invisible biology, with its stronger environmental agenda, is more hesitant to advocate large scale industrial science.

In popular cosmology a distinct confidence pervades the writing. Even though the discipline's limits of knowledge and the existence of unknowns are both emphasised, the implication — sometimes made explicit (*e.g.* Randall *Warped Passages* 458) — is that more funding, more powerful instruments and more public support for cosmology will assuredly lead to breakthroughs and new horizons in the near future. In invisible biology texts there is a different relationship to the unknown. There is certainly still the promise of future technological advances; in the case of microbes this is mainly in medicine and environmental clean-up. But there are not the discernible frontiers of knowledge that are present in cosmology. There are still of course large unknowns. Obvious examples are details of the origin of life and the origin of the eukaryotic cell. Lane calls the latter the "black hole at the heart of biology" (1). This cosmological borrowing draws on the successful ploy by cosmologists of using simple diction to name complex or occult phenomena (*e.g.* black hole, dark matter, big bang). But Lane is unusual in the invisible biology subgenre not only for transplanting cosmological terminology, but also for openly promoting his own research program investigating deep-sea alkaline vents as the site of the origin of life (131–7). He appears to be following the cosmologists' bid for ongoing funding for the conquering of unknowns as well as their tactic of avoiding polysyllabic jargon.

In the other texts examined in this chapter (Enders, Margulis, Yong) the focus is not so much on unknowns, but on what is known but cannot be seen. And what cannot be seen is loaded in these texts with significance, not merely so in terms of *human* discovery and the self-aggrandising dynamic of the Kantian sublime so evident in popular cosmology. "We certainly don't know all the answers. But the universe is about to be pried open," writes Randall, a physicist, on the promise of discovery provided by the Large Hadron Collider and of future even more powerful colliders; she continues: "Secrets of the cosmos will begin to unravel. I, for one, can't wait" (*Warped Passages* 458). That sentiment valorises the *understanding* of the world, regardless of how unintuitive it is. In other words, the epistemological sublime and any exploration of the edge of knowledge, is always still in reference to the human, to the individual subject and what they get out of it, especially in terms of sating to scientific curiosity.

In invisible biology the human is no longer the epicentre. This is demonstrated through the dissolution of the subject from both ends of the biological scale, as the subject is at once disintegrated into cells and subsumed into the biosphere. But perhaps more unsettling is the ontological aspect of this confounding perspective, which accords a stronger ontological priority to nonhuman nature than human nature. Cosmology certainly makes bold ontological claims: about the existence of far-off galaxies, or exotic objects such as quasars and black holes, and about the world's inexorable tendency toward entropy. But the liberal humanist subject of modern science is nonetheless reaffirmed by the impressive success of recent cosmological theories and the reach of physicists' ideas, which seemingly extend to the edge of the known universe and beyond the edge of easy comprehension. Yet in invisible biology the nature of microbes and cells within us, before us, and beyond us, calls into question the site of comprehension itself. In cosmology the world still divides into a dualistic roster of objects, however vast, on the one hand and the subject, however dwarfed, on the other. Margulis, Yong, Falkowski and others disrupt that dyad first by muddying the distinction between the subject and object. They further disrupt it by making the nonhuman world full of meaning, activity and hidden significance that not only exceeds our habitual understanding in the way the Kantian/cosmological sublime does, but discredits our claim to unrivalled subjectivity, as distinct from the objects that trigger the sublime.

This view also contends that the source of meaning must ultimately be the microcosmos, as we are inextricably part of it and built from it.

Again, this is a different kind of sublime from the ones standardly described in theories from the eighteenth century, or those elaborating on Kant's philosophy (including Brady, Derrida, Forsey, Hitt, Lyotard and Shapsay). It is built on the point made above, that the new nature invoked by writers in this subgenre is of a different order, in fact a different scale, to that image of nature inherited from the eighteenth-century discourse on the sublime and from Romanticism. The *mise en scène* of nature in invisible biology is ontologically more extravagant than traditional nature or even the nature offered by the ecological and environmental sublimes of Hitt and Brady. The new nature posits uncountable entities that relegate the human, the animal and even the plant to minor offshoots in the history and future of life:

> Animals are a small, relatively irrelevant branch on the tree of life and are like the many versions of motorcycles, cars and trucks that use the same basic machinery to move. In fact the metabolic machinery in animals and plants is far less diverse than it was in their microbial ancestors. (Falkowski 137)

Put in proper proportion, all multicellular life is a minority or aberration compared to the global web of microbial life. Margulis offers similar sentiments:

> More than 99.99 percent of the species that have ever existed have become extinct, but the planetary patina, with its army of cells, has continued for more than three billion years. And the basis of the patina, past, present, and future, is the microcosm — trillions of communicating evolving microbes. The visible world is a late-arriving, overgrown portion of the microcosm, and it functions only because of its well-developed connection with the microcosm's activities . . . We may pollute the air and waters for our grandchildren and hasten our own demise, but this will exert no effect on the continuation of the microcosm. (66–7)

In crude terms, the ontological import of such passages is to tip the balance of living things away from what can be seen with the naked eye by one particular species and

towards the invisible life of microbes and the planetary patina (which is perhaps not "invisible" to itself).

Critics of Margulis and Sagan, as the authors acknowledge in the preface to the second edition of *Microcosmos*, have detected a kind of antihumanism in this tipping of the scales (15). It is a radical stance. It imputes to objects external to the social-economic matrix a value or priority beyond all human activity and even plant and animal activity. This goes further than deep ecology. Although Margulis identifies the perspective of *Microcosmos* as a deep ecology one (21), that worldview emphasises the *equality* of all elements of the biosphere, especially as a corrective to anthropocentrism. But Margulis arguably elevates microbial life above all else.[54] This is a part of her reversal strategy for combating entrenched binaries (18). But rather than simply demote humans, all other multicellular life is demoted in tow. This means that in texts which do not adopt the perspective of the microcosmos — that is almost all texts ever written — "nature" and "life" have referents that are massively at odds with what Margulis and others prompt us to imagine.

Ironically, because of the urge to downplay anthropocentrism, this subgenre engages human political interests more than any other. Because of the necessarily ecological and environmental implications of shifting the view of what is life or what is nature, invisible life is more obviously political than cosmology or quantum physics. A spectrum of political views from across the subgenre can be plotted in terms of how the lessons from microbiology are interpreted. Using roughly the same set of scientific ideas, different authors occupy different places on this distribution depending on what values they extract from nature. One end is epitomised by

[54] This is not the main point of the chapter but is worth mentioning because it presents an interesting ecological viewpoint, namely a kind of *bacteriocentrism*. I am not arguing that Margulis is overtly taking this position, nor am I even criticising the position. It is difficult to argue against the proposition that life, rounded off in terms of duration or numbers, is microbial. Contrast with a classic definition of deep ecology from Warwick Fox: "the central intuition of deep ecology. . . is the idea that there is no firm ontological divide in the field of existence. In other words, the world simply is not divided up into independently existing subjects and objects, nor is there any bifurcation in reality between the human and nonhuman realms" (196). Regarding a kind of strict egalitarianism among living things, Fox writes: "The only universe where value is spread evenly across the field is a dead universe. Recognizing this, we should be clear that the central intuition of deep ecology does not entail the view that intrinsic value is spread evenly across the membership of the biotic community" (199). Fox rightly advocates for the view that value inheres in the nonhuman world, but that "organisms are entitled to moral consideration commensurate with their degree of central organization" (199). This is roughly a measure of an organism's complexity and the complexity of its relations with other organisms. By default, the authors examined in this chapter also appear to value complexity over simplicity, including valuing living over nonliving, even as they blur that distinction. Margulis simply goes further in openly attributing more complexity and richness to the bacterial world than, say, the vertebrate or human world.

Margulis and the other by Hoffman. Margulis emphasises symbiosis and thereby claims that, when viewed from a wider perspective, life is mainly a microbial, gene-swapping collective where the boundaries of individuality dissolve and the evolutionary metaphor of competition is inadequate. Hoffman, however, not only fails to cite Margulis (a unique omission in the books studied here) but advances chaos and competition as the forces driving life and uses monetary and economic metaphors to describe energy use in living things.

Somewhere in between these positions is Yong, who openly discusses Margulis's theories, their strengths and weaknesses and adopts a conclusion that life is a mixture of cooperative and cruel.[55] It may seem surprising that very simple, heuristic kernels of morality are extracted from teeming, contradictory examples from the panoply of living things. And yet authors seem inexorably to arrive at a fairly compact political or ideological meta-lesson drawn from the four billion year history of life. This could be viewed as a case of the naturalistic fallacy: deriving normative conclusions from factual statements. And eco-critics (*e.g*. Glotfelty xix) or deep ecologists (*e.g*. Plumwood 16) would no doubt point out the more particular trap of obtaining ethical insights from just one perspective on a contested and imprecise concept of *nature*.

While philosophers may decry the naturalistic fallacy, the historian Lorraine Daston makes the point that even philosophers tend to succumb to it. Even though pointing out the naturalistic fallacy has an esteemed history — with big philosophical names like Hume, Kant and G.E. Moore warning of it — the record shows that people almost always relapse to this alleged fallacy.[56] Daston's historical analysis suggests that we cannot help but draw on the natural order for our moral orders because normativity itself demands order and if we need order then nature is the place to look for it, having a surplus of orders beyond the human ("Tanner" 387, 411). In

[55] In Chapter 4 I will examine evolutionary biology texts. It is noteworthy that although they still subtly evince the author's politics, writers such as Richard Dawkins, Stephen Jay Gould and Matt Ridley — who are openly from different political allegiances — tend to avoid anything suggestive of politics. I suspect this is because of the history of social Darwinism, creationism and other infamous attempts to use evolutionary science to inform politics. However, by telling an evolutionary epic that seeks to explain the emergence of all aspects of life, including norms and values, they make an even larger grab for intellectual hegemony.

[56] In "The Naturalistic Fallacy is Modern" Daston also points out that the fallacy originally named such by G.E. Moore is a different idea (580–1). But the fallacy now gets conflated with the idea that one cannot derive an ought-statement from an is-statement and the related fact–value dichotomy. For ease I use it in its contemporary sense rather than Moore's original sense.

practice one can justify almost any normative order by drawing on the tangle — one is tempted to say chaos — of orders ostensibly available in nature.

Two things recommend this perspective. First, Daston speaks of natural orders in the plural, remaining agnostic on the features of any one natural order but still recognising that nature has orders or at least many apparent orders. Second, she implies that nature is the obvious place to look, given that orders tend not to spring *sui generis* from human institutions. Margulis, Hoffman and Yong survey the new nature and unabashedly draw from its multiple orders succinct normative conclusions, as detailed above. But more importantly, they assume that there are in nature orders previously unknown, a surfeit of order and meaning that can inform their worldview. The only alternative, I think, is that one attribute no order to nature, but then, in response to that very chaos, assert a human meaning. This is the historical sublime of Hayden White who claims that the *only* way to provide a vision of meaning for the present or future, is to recognise the past as a chaotic flux of meaninglessness, in defiance of which people can forge a meaning ("Historical Interpretation" 128, 137). Thus for White the attempts by historians to find narratives on which to hang historical events are futile, and new tropes are needed in the writing of history that allow for the welter of the historical sublime.

Few popular science writers are bold enough to write a trade book that has such a nihilistic message — the implicit plea for the funding of scientific research probably militates against such nihilism. None of the recent books studied here did so. But Monod, friend to Albert Camus, closed *Chance and Necessity* like this:

> The ancient covenant is in pieces; man knows at last that he is alone in the universe's unfeeling immensity, out of which he emerged only by chance. His destiny is nowhere spelled out, nor is his duty. The kingdom above or the darkness below: it is for him to choose. (167)

Authors do not include sentiments like that in popular science books anymore. Outside of Margulis, we do not see the self-abnegation of Hitt's ecological sublime in this subgenre. Readers of contemporary nature writing may notice such an attitude, in Helen MacDonald's *H is for Hawk* for example. The ecological equivalent of White's historical sublime would say that nature is immense, chaotic, overwhelming and beyond human comprehension; in response to that, an author would assert a

kind of meaning in the very act of writing, a way of showing, through the meaning inherent in discourse or *logos*, that meaning is possible in response to nature's chaos. This could be compatible with Hitt's exemple of Thoreau expressing with language the possibility of something beyond it.

All the texts written by scientists examined here do draw meaning out of nature, but do so by locating its sources *in* nature which is for them necessarily beyond, and larger than, the human. Regarding the sublime, this might be surprising to some theorists who would identify the sublime as a site of formlessness and therefore beyond meaning. Certainly the Kantian tradition — and that includes Hitt and Brady — tends this way, by seeing the sublime as an intimation of a totality or an absolute that is too great for the imagination, but which awakens the subject to the scope of rational Being.

But the defining feature of the sublime of invisible biology — at least what sets it apart from the sublime offered by other subgenres in this study — is that it suggests there is *more* meaning beyond the human. While dissolving the idea of a stable, integrated subject, the microcosmic sublime also imbues the object with a coherence in excess of the subject. Margulis deflates the significance of the human by writing from the perspective of the four billion year history of microbial life and by claiming that these organisms cohere into a superorganism — a super-self — beyond human scope. It is not that the human subject must find meaning amid the sublime Other of immense nature, but that non-human nature surpasses human meanings. This is a sublime of plenitude, where the microcosmos and the macrocosmos it manifests will both outlive and exceed the subject's comprehension of them, even when it is amplified by scientific knowledge. In other words, not everything beyond human understanding is formless or part of Monod's "unfeeling immensity" — it can be coherent and meaningful without a human subject to encounter it.

Writers less ecologically motivated than Margulis also support this reading. Hoffman writes that we would "shiver" with "excitement over the grandeur of our own universe and our astounding ability to understand a small, but growing corner of it" (245). Of course this is the typical scientific sublime that offers a self-apotheosis via humanity's achievement in understanding and mastering the world. Such a view reaches its apogee in popular texts on evolutionary biology, that present a *longue durée* evolutionary epic culminating in modern science's understanding of this epic (the focus of the next chapter). But Hoffman's message, though saturated with

anthropocentrism, is still closer to Margulis than might be obvious: “Life is a wonderful molecular mechanism. This should make us admire life even at its most ‘primitive’. Even a virus is a miracle of nature” (Hoffman 243–4). Admittedly the next sentence says we are “the most miraculous part” of nature, thereby reinforcing human exceptionalism (244). But at least the human is a part of nature here. More to the point, all the wonders catalogued in Hoffman’s book are things that virtually all life forms share: molecular biological innovations. The only thing unique to humans discussed in the text is the set of hackneyed Galileo myths of discovery *of* these molecular innovations. But against the idea that nature is formless and chaotic, or in Hitt’s terms “wholly other” and a “radical alterity” (613), Hoffman defines life as anti-chaos. Of all parts of the world, living things are the least chaotic, the most ordered. The small corner of understanding that Hoffman extols is differentiated not from a chaotic inhuman Other but from an Other that contains, as Daston says, a “cornucopia” of orders (“Tanner” 375), though they are beyond (human) understanding.

The basic principle of emergence, made credible by the scale-tangling phenomena of invisible biology, suggests a conclusion that authors in other popular science subgenres would not dare to draw. Namely that another sublime offering of modern science might be that there is as yet unguessed at meaning beyond the human, immanent in nature, in some sense immanent in us and yet beyond our understanding.

The Anthropocene as species-level sublime

> “The planet is the species of alterity, belonging to another system; and yet we inhabit it.” (Spivak qtd. in Chakrabarty 54)

I argue that the Anthropocene epoch and humanity’s relation to it is analogous to the relation between the subject and nature in the traditional Kantian sublime. Both summon a certain kind of subject in the very undermining of that subject’s powers. I argue that the very different sublime of invisible biology should be an interesting way to approach the ironies of the Anthropocene. The Anthropocene designates a new geological epoch defined by the impact of one biological species, *Homo sapiens*, on

the geological profile of the earth.[57] And yet the impact in question is perhaps beyond comprehension. It is also threatening to eclipse the species who is trying to understand it. The Anthropocene poses a danger, but at the same time the attendant calls to action by environmentalists require a measure of human agency, awareness and cooperation that seems to reaffirm the agency of the species in question. The Anthropocene is therefore an ironic concept. By asserting the planetary impact of *Homo sapiens*, the concept at once decries human arrogance and mistreatment of nonhuman nature, as well as validates human exceptionalism. Similarly, responses to the challenges of the Anthropocene, such as efforts to mitigate climate change, seem to assume that humans are in control of nature at the same time as a lack of control over natural forces caused the problems associated with the new epoch. And, as Paul Alberts has noted, the "success" of increased urbanised living is precisely what now threatens that success (6). The anthropocentrism embedded in the name of the epoch signals a belated and ironic recognition of our embeddedness in nature even as we try and control it.

The historian Dipesh Chakrabarty has made highly influential contributions to the recent surge in scholarship on the Anthropocene. Chakrabarty captures some of this irony in describing the Anthropocene as an era of "convergence" of three histories: the history of "the earth system", the history of life including humans and the history of "industrial civilisation" (48–9). And so from now on, says Chakrabarty, any kind of humanist history is untenable. But these histories were always entangled. Chakrabarty seems only to reinforce the distinction between nature and culture that has been critiqued above, which is a kind of anthropocentrism in itself.

Anthropocentrism is hard to escape and certainly intrudes into invisible biology, even though it is generally a discourse that decentres the human. Even in texts which emphasise the cellular nature of the self and the majority of non-human cells in a human body, anthropocentrism still obtains. First, there is the straightforward but important point that we cannot speak *as* anything other than humans, even when we try and speak *for* the non-human. But more poignant is the bind that scientists, even those with deep ecology principles like Margulis, find

[57] Impacts that help to delineate the Anthropocene from the previous epochs (Pleistocene and Holocene) include: an appreciable increase in greenhouse gases in the atmosphere, oceanic warming, depletion of fossil fuel reserves, sudden widespread extinctions, massive increase in biomass of species involved in agriculture, footprint of radioactivity from human activities, strata of human artefacts, waste and products recognisable in sediment analysis and widespread changes to soil composition (Waters *et al*.).

themselves in when they explain the science behind recent discoveries that seem to undermine the liberal humanist subject. By invoking the complex technological and methodological tools that are required to do microbiology and the unprecedented knowledge of cells, genetics, biochemistry and microorganisms that accompanies such research, the author is implicitly mounting a case for human exceptionalism. By adding to the scientific enterprise and further distinguishing the activities of *Homo sapiens* (at least *Homo sapiens* of a certain economic class, time period and so forth) the charge of anthropocentrism is re-validated.[58]

In any case, the authors studied here have ostensibly different views on human intervention in the biosphere. Margulis is more towards a deep ecology perspective that prioritises Gaia over the human and questions human abilities to shape the biosphere, even somewhat fondly imagining a nuclear winter scenario in which microbes are undiminished and ascendant (238). Other writers advocate geoengineering and other interventions into the biosphere to stave off the effects of climate change or other environmental disasters. Yong has a whole chapter on various "*à la carte*" microbial solutions to problems of disease, endangered animals and malnutrition (211–50). Falkowski is cautiously in favour of genetically engineering microbes to reduce carbon in the atmosphere (160–72).

This recalls the wilderness debate and the problematic concept of nature as discussed by Cronon. Following the logic of the Anthropocene, the pre-Holocene[59] environment is *natural*. So a catastrophic end for human civilisation and complex life is, from the perspective of the alterity of the microcosmos, merely a return to a *status quo ante*. Yet biodiversity is also prized as natural and so the preservation of it, especially via organic means, seems apt. The term Anthropocene is problematic because of its apparent insistence of human exceptionalism, as it seems to ratify the suggestion that humans *can* direct the geological fate of the earth — even without considering whether or not they *should*. But if one adopts the view, informed by Margulis, Yong and others, that the human does not exist independent of the microcosmos (and much else besides) then even an ostensibly human intervention in

[58] This is something of a hall of mirrors. Even labelling a discourse anthropocentric is itself a kind of human exceptionalism in that doing so imputes unique interests to humans. For instance, Barad levels that criticism at Foucault and Butler, claiming they only deal with human concerns, *e.g.* power (145). But this does seem to confirm that there are concerns that are unique to humans and hence that humans have exceptional status in virtue of having concerns not shared by other species.
[59] That is, prior to the advent of agriculture and widespread settlements, approximately 12,000 years ago.

the biosphere is not really human at all. I think the problem is, again, linked to a confusion of scales and how they intra-act, not merely converge, as in Chakrabarty's account.

Clark says that climate change and the Anthropocene represent a *derangement* of scale. He recognises the irony of the epoch and the self-refuting logic of trying to avoid anthropocentrism:

> The Anthropocene poses imponderable questions about conceptions of human agency. . . so vast an issue cannot be adequately understood in terms of given categories of the human or the cultural, but engages thought at a broader, impersonal biosemantic or geo-semantic level at which intentional human agency, even at its most would-be managerial, may be no more than epiphenomenal. (22)

For Clark the Anthropocene is a derangement of scale that cripples our ability to act because it demands action on a scale that is impossible for individuals to comply with.

But I argue that rather than a convergence of scale (Chakrabarty) or derangement of scale (Clark), this is another *tangle* of scales — this time spatial and temporal — so that the Anthropocene can be read as a kind of ontological metalepsis. The levels of geological time and human time, along with human individual behaviours and species-level behaviours have become intermingled, producing a disorienting effect. But looked at from the perspective of the sublime explored in this chapter, surely even something that carries the enormity of the Anthropocene should at least testify to the possibility of finding order in this tangle of scales. Scale itself is a kind of order and to say that it has been tangled, or deranged, or that it has converged is at least to recognise that it exists. It may be that the Anthropocene concept, with its acknowledgement of some level of human agency in altering the biosphere, along with its insistence that nature is far too complex to *fully* understand, allows for a view of humans as entangled with meaning-full nonhuman nature.

In the face of the Anthropocene, then, a responsible attitude towards the environment — as envisaged in Brady's or Hitt's formulations of the sublime — is made possible by the ideas conveyed in invisible biology. The way it is currently

figured, the Anthropocene has the potential to be a blown-up Kantian sublime with human agency reaffirmed as the end product. Instead it can be parsed as an encounter between the human and the nonhuman, but where the human is already entangled with and made up of the nonhuman, especially the microbial world. If the sublime encounter is ontological — in that it questions the ontic status of that subject in the encounter — then perhaps the Anthropocene can result not in self-affirmation but self-transformation. If the *anthropos* in Anthropocene is thoroughly re-visioned then the term *could* signal a new epoch of recognition of entanglement (the *cene* in Anthropocene is from the Greek *kainos* for "new"). But all this is predicated on something like the microcosmic sublime suggested by Hird actually claiming some cultural purchase. Promisingly, all the ideas discussed here are from a mass-market genre.

I think that the sublime of modern science *generally* entails a rapaciousness, allied as it is to an ideology of growth: pushing the limits, colonising the unknown. But I also think that the sublime presented in this subgenre in particular, does not conflict with or undermine an ethic of environmental sustainability, campaigns to combat climate change, or a more nuanced and responsible conception of nature. Invisible biology makes nature more complex and more meaningful and renders strange that part of nature that was previously familiar. It entangles the newly complicated subject with this new nature. And it mingles spatial and temporal scales that were previously remote from one another, in a way that is genuinely not reductive or hierarchical. The sublime presented in texts by Margulis, Yong and others is more ontological and thoroughgoing than the Kantian sublime and more radical and politically encouraging than the ecological or environmental sublimes of ecocritics.

CHAPTER 4: Epic evolution

> In one of life's giant, self-referential loops, changing DNA has led to the consciousness that enables us to change DNA. (Margulis and Sagan *Microcosmos* 34)

The Anthropocene presents a strange loop for the *anthropos* who confronts it. Like the Kantian sublime, it *seems* paradoxical: an attack on the ego that also ends up suggesting a greater kind of subjectivity. In the Kantian sublime this is a faculty of reason; in the Anthropocene it is geoengineering or some other human intervention to take control of the earth system. Both look hubristic and I have favoured a more cautious reading of both situations. The sublime, following Brady, Porter, Žižek and others examined in this thesis so far, can also prompt a more nuanced form of subjectivity, even one whose ontological status is totally recast. As for confronting the Anthropocene, I suggested in Chapter 3 that although the word itself enshrines a kind of human exceptionalism, a mixed feeling of empowerment and humility can be salvaged, following the lead of Brady's environmental sublime.

In popular accounts of evolutionary biology — this chapter's focus — there is much less of an emphasis on the environment or the nature of the human and the nonhuman. In fact the genre is preoccupied with a justification for human pre-eminence. I argue that this is achieved primarily through *narrative* means. By telling a grand narrative of the evolution of life on Earth, which culminates in the reading and writing of that same narrative, the reader is positioned as protagonist and even writer as well. *Homo sapiens* — or at least modern, scientifically informed, liberal humanist subjects — are likewise the heroes in a story of how unthinking matter became simple lifeforms, then complex lifeforms and eventually lifeforms capable of discerning and manipulating their own genetic code, their own text, their own story.

Historians have called this narrative the *evolutionary epic* (or epic of evolution). It has its origins in nineteenth-century popularisations of evolutionary theory (Hesketh 196). Although full scale evolutionary epics are again popular, especially under the moniker Big History, the plot is found in condensed form in most popular works on evolution, including several by Richard Dawkins who is the

dominant writer in the subgenre.[60] I argue that several of Dawkins' books effect a kind of *metalepsis* — a blending of diegetic levels — which entangles the reader in a strange relation to the text. This is further complicated by the subgenre's use of a textual metaphor for the genome: genes are figured as a *text* to be *read*, the reader's behaviour is *authored* by that text, and the text can be *edited* with gene manipulation technologies. In Dawkins' *The Selfish Gene*, another metaphor is in operation: the personification of the gene. The metalepsis, the genome-as-text metaphor and the personified figure of the selfish gene, all contribute to an implication of the reader in the world of the text, that is stronger than in any of the subgenres examined so far.

I argue that the evolutionary narrative offered by Dawkins is another example of the sublime because it undermines pre-established categories (like subject and object), conflates scales (especially temporal scales in evolutionary time) and overwhelms habitual thought. It is also an ontological sublime as it seems to offer a seditious account of where motivations come from: not from deliberation or reason but from the ancient and passionless survival strategies of our genes. And yet unlike the ontological sublime of invisible biology, in evolutionary biology the encounter with alienating timescales and unimaginable complexity is used in an attempted rescue of the liberal-humanist subject, precisely in the act of measuring those timescales and intervening in that complexity. The ontological sublime here is self-affirming (although examination of the marginal elements in Dawkins' text will show that it hints at the ultimate self-abnegation that I will explore in Chapter 5). The evolutionary epic not only reinscribes, in the final act, the role of the liberal humanist subject — preferably a scientist themselves — but claims to fuse together previously sundered ontological domains: the organic and the inorganic, is-statements and ought-statements, facts and values.

In this chapter I show that in popular evolutionary texts there are several prominent metaphors which contributes to interesting narratological features in the subgenre. Metalepsis is the most prominent such feature and its use in *The Selfish Gene* engenders a sublime effect produced by a tangle of scales (and frames of reference). This tangle is of not only spatiotemporal scales but also divisions between the subject and object, both grammatically and philosophically. For this reason, the

[60] Recent popular large-scale evolutionary epics include *Maps of Time* by David Christian, *Sapiens: A Brief History of Humankind* by Noah Yuval Harari, and *Big History: From the Big Bang to the Present* by Cynthia Stokes Brown.

sublime in this subgenre — although ontological — is arguably self-affirming rather than self-abnegating. The self-affirmation of the liberal humanist subject is achieved via a neo-Darwinian worldview that subsumes values, consciousness and culture all within the logic of genes and memes.

Evolution and narrative

Popular science texts, although they are not fictional, possess *narrativity*. Scholars of narrative disagree over exactly how to characterise narrativity, and how to judge the degree of narrativity of one text versus another (Ryan, *Avatars* 7–9). Necessary but perhaps not sufficient conditions of a narrative include (1) *agents* who (2) *cause* (3) *events*, which are typically told in (4) a *sequence*. Marie-Laure Ryan boils it down to events as the most necessary ingredient, with agents, cause, and sequence to follow ("Definition"). The fiction–nonfiction divide is also controversial, but Hayden White argues that history is almost always told in narrative form, because the use of "emplotment" is a device that allows for meaning to be conveyed with "the formal coherency that only stories can possess" ("Narrativity" 19). Because evolutionary biology texts are typically engaged in reconstructions of natural history, they are more sequential, more chronology-focused than other subgenres examined here. Although they are not the same kind of narrative as, say, a nineteenth-century three-volume novel, these nonfiction texts contain recognisable narrative elements that clearly aid in conveying information and engaging readers.

Some popular science books evince *less* narrativity. Neil deGrasse Tyson's recent book *Astrophysics for People in a Hurry*, for example, is simply a brief guide to the basics of modern astrophysics, rather than a narrative of, say, the history of the cosmos. An earlier book of his, *Origins: Fourteen Billion Years of Cosmic Evolution*, was such a narrative; in fact it is an evolutionary epic. But even though his newer work is not a single emplotted story, it contains micro-narratives: sketches of the lives of scientific heroes like Jocelyn Bell Burnell (186) and Michael Faraday (170) and reminders that "we've come a long way" on our "journey" of discovery (148). The scientific heroes on their quest of discovery, although presented in nonfictional frames, are narratives of a sort and endemic in the genre (Landau 175–8).

Next to the hero myth, the scientific detective story is the other dominant narrative form in popular science (Curtis 435–40; Perrault 56). Again, evolutionary

biology texts are no different. Siddhartha Mukherjee's *The Gene* is a recent popular account of the history of genetics, the study of heredity and the ethical implications of genetic technologies.[61] It frames the first part of the book as a whodunnit, with figures from the past like Charles Darwin and Gregor Mendel adducing various clues as to the mystery of heredity.[62] It recapitulates the scientific hero myth as brave scientists are shown to battle naysayers, religious injunctions and institutional conservatism as they steadfastly pursue the truth: the Galileo myth mentioend in earlier chapters.

Evolutionary texts recycle hero myths and detective stories and they retell natural history. But on top of that, there are other narrative elements that are unusual in popular science and more common in fictional narratives. The extra narrativity seems to me to emanate directly from the subject matter. Evolutionary texts are concerned with time and sequence, with development and change, and so naturally lend themselves especially to narrative forms. Curiously, the opposite conclusion has been reached by some scholars of narratology. Jay Clayton maintains that evolutionary texts are resistant to narrative, precisely because of the untimely, nonlinear nature of many of the explanations contained in them (31–3). And H. Porter Abbott argues that evolution is too big, too multi-levelled a process to ever be narratable. Evolutionary texts always take place on at least two levels, claims Abbott: the level of species and broad evolutionary change, and the level of individual organisms' struggles or "little stories of love and death" (147). Granted, the vast scope, intricacy and contingency of evolutionary history *as a whole* cannot be narrativised, much less in a 300-page trade book. But I do not think this is what Abbott means. Abbott claims that our *understanding* of the overarching process of natural selection cannot be attained through narrative, but only through some combination of the study of graphical representations, mathematics and other

[61] Other texts I studied included Nessa Carey's *Epigenetics*; Jerry Coyne's *Why Evolution is True*; Daniel Dennett's *Darwin's Dangerous Idea* and *From Bacteria to Bach and Back*; *Wonderful Life, Life's Grandeur* and *The Panda's Thumb* by Stephen Jay Gould; *The Red Queen* and *Genome* by Matt Ridley; Neil Shubin's *Your Inner Fish*; Carl Sagan and Ann Druyan's *Shadows of Forgotten Ancestors*; and David Sloan Wilson's *Why Altruism Exists*. But the focus of this chapter is on the works of Richard Dawkins, partly because he now dominates this subgenre, but mainly because of the imagery and metaleptic complexity found in his evolution-focused books: *The Selfish Gene, The Extended Phenotype, The Blind Watchmaker, River out of Eden, Climbing Mount Improbable, Unweaving the Rainbow, The Ancestor's Tale* and *The Greatest Show on Earth.*

[62] For an interesting contrast, see Franco Moretti's evolutionary history of the detective genre. Using Darwin-style genealogical trees, he plots the mutations and selection of winning traits such as the planting of clues early in the narrative (67–75).

sources allowing us to "triangulate" a clear understanding of evolution (158–60). But I do not see why *clear understanding* is a necessary outcome for a successful narrative in any genre.

Venla Oikkonen has an alternative view. She echoes Abbott in saying that evolution is hard to narrativise, but in addition to Abbott's two narrative levels she adds a third even smaller level "inhabited by microscopic entities such as DNA, genes, chromosomes, or gametes" (4). Oikkonen notes that Abbott is interested in "identifying the narrative structure implicit in evolution by natural selection and theorising the possibility of narrating evolution in a way that would not compromise Darwin's theoretical insights" whereas she is interested in "how popular texts *actually* negotiate this narrative difficulty" (5, italics in original). In doing so, Oikkonen cites *The Selfish Gene* as the origin of this molecular level of narrative that is now "a major textual device that produces narrative coherence in popular evolutionary texts" (9). But is this narrative coherence any more remarkable than that which we find in popular science books about particles, black holes, or other entities that are incorporated into a narrative despite the remote-from-human level on which they operate? The unique point about the evolutionary subgenre is not that it defies narrative form but that it manifests more narrative complexity than others, not only in the form of the evolutionary epic.

Most current popular works on evolution do not aim for the scope of a full evolutionary epic. Frequently, however, they provide mini-epics in the form of the developmental history of one species as a stand-in, almost a synecdoche, of the whole stretch of evolutionary history. Oftentimes they are framed in even narrower terms of how certain traits evolved. Examples abound: Stephen Jay Gould's title essay in *The Panda's Thumb* (19–26), Sean B. Carroll's tale of colobus monkeys' digestive mutations in *The Making of the Fittest* (91–114), Dawkins' explanation of bees' pollen dance in *River Out of Eden* (84–91) and Jerry Coyne's example of wild mice's coat variations in *Why Evolution is True* (126–30). And sometimes authors attempt a brisk sketch of the evolutionary epic in outline, but in the space of a chapter or less, which surely cannot count as an evolutionary epic proper. A good example from Dawkins is his description of the history of life as a series of thresholds of replicative complexity being crossed (*River* 135–60). These schematic views of the emergence of life's diversity resemble cosmogenic myths. The single-species narratives are nearer to animal fables. Indeed Gould himself adapted the term "just so stories" from

Rudyard Kipling and used it to criticise allegedly adaptationist accounts of how organisms get their traits, *i.e.* how the leopard got its spots.[63]

Recent authors are too savvy, in part thanks to Gould's warning, to fall into the trap of an overt just-so story, so another literary form that might be a better comparison is the Bildungsroman. In a sense, Coyne's explanation of how different wild mice populations got their coat colours to match their respective environments is a coming-of-age tale for that species, complete with a happy ending. Carl Sagan and Ann Druyan's *Shadows of Forgotten Ancestors* is framed as a note accompanying a foundling who represents the species *Homo sapiens*; it goes on to tell a rags-to-riches Bildungsroman about an orphan, echoing Victorian examples of the genre. But there are less salubrious ends for species as well. Gould's story of some of the long-extinct creatures fossilised in the Burgess Shale — which he calls a "five act drama" (*Wonderful* 208) — are an example of a detective story with the gathering of clues, but perhaps also a kind of tragedy or elegy (*Wonderful* 188–208).

Additionally there are narrative innovations peculiar to given works in the subgenre. Dawkins' *Ancestor's Tale* adopts the same framing device as Chaucer's *Canterbury Tales* to narrate a pilgrimage back through evolutionary time to the common ancestor of all species. Gould's *Wonderful Life* draws on the conceit of the Frank Capra film of the same name to consider alternate histories of evolution. Matt Ridley's *Genome* attempts a biography of *Homo sapiens* in twenty-three chapters, one for each chromosome.

All these examples suggest that there is no great struggle for popular writers to narrativise evolution in similar ways to other scientific topics. In fact there is, if anything, a diversity of narrative forms in this subgenre, compared to say, popular cosmology which almost exclusively draws on the Galileo myth and the detective story. But Abbott, Clayton and Oikkonen are correct in pointing out the multiple spatial scales inherent to the topic and the unusual temporal dynamics of evolution that do mean a purely *linear* narrative is insufficient for a good explanation of the tangle of relationships in evolutionary history. In lieu of a linear narrative, a more metafictional structure is what we actually find in these popular texts. Coupled with the multiple levels of reality they try to narrate, narratives of evolution also grapple

[63] See Gould and Lewontin for the first use of this phrase in this context. The just-so story is seen as a pitfall to avoid and indeed Brian Goodwin riffs on this with one of his book's titles *How the Leopard Changed its Spots*.

with diegetic levels. They are unsettling in part because they destabilise one of the basic elements of narrative: agents. Any narrative of evolution will at least implicitly tell the story of how agency — be it human or nonhuman — came to be and so any narrative of evolution contains the evolution of narrative. I will explore below the use of metalepsis as a way of representing this nonlinear tangle.

I should note, before moving on, that scholars have looked at the evolution of narrative itself (Dautenhahn especially), including the possible evolutionary benefits of storytelling (Dutton). Others have suggested that narrative was crucial to the evolution of modern consciousness or selfhood (Benzon; Herman "Stories"; Markkula; Schank and Abelson). None of this is quite what I am proposing. I aim to show that narratives of evolution, if they include the evolution of humans, implicitly tell a meta-story about how narratives, writers and readers came about. Against the narratological consensus, the alleged difficulty of narrating large scale evolutionary history can be recast as a case of the sublime. The terror part is the ominous threat that all narratives and all the agents or selves involved in its production and reception, are only byproducts of a self-less, disinterested process of evolution whose only actors are self-ish genes. The delight part is that another self — the liberal humanist subject — nonetheless emerges through this process, in the very act of discerning the process and intervening in it. This is a key feature of the most important narrative mode in this genre, the evolutionary epic, to which I will now turn. Later, I will show how the self-affirmative, almost Kantian, sublime of the evolutionary epic actually obscures some of the ontological aspects of Dawkins' text that would be more amenable to the Barad-inspired perspective of entanglement in Chapter 3. And, further, the ultimate promise of the evolutionary epic is also ontological: not that it presents a void or *horror vacui*, but that it claims to fuse distinct ontological realms.

The evolutionary epic

> We are built as gene machines and cultured as meme machines, but we have the power to turn against our creators. We, alone on earth, can rebel against the tyranny of the selfish replicators. (Dawkins, *Selfish* 260)

The evolutionary epic is the grand narrative of evolutionary texts and aims to be the grandest narrative of all. Recently exemplified in the fad for Big History, the evolutionary epic aims to tell a story that spans at least the entire history of life. Some evolutionary epics begin at the Big Bang and continue to the present day, often projecting into the future as well (*e.g*. Christian). At a minimum they run from the advent of life on Earth roughly three and half billion years ago to the appearance of *Homo sapiens* roughly one hundred thousand years ago (*e.g*. Goodenough).

Hesketh excavates the nineteenth-century origins of the evolutionary epic and its main features. One surprising commonality across the genre is that despite pretences to a strict naturalism or scientism and a goal of taking a wide, indeed cosmic, perspective a clear anthropocentrism prevails. Humanity is given an important place in the narrative, often by means of non-Darwinian forms of evolution (Hesketh 196). As such, a narrative that is informed by contingent evolution ends up being teleological. Further, the genre is one that:

> seeks to derive from that [teleological] story a moral impetus to establish further progress thereby overcoming the Darwinian processes of natural selection. Moreover, the establishment of this story is apparently itself a sign of humanity's creative self-knowledge and perfectibility. There is according to this view, something intuitive about wanting to see the organic and inorganic worlds as one, as if we are tapping into some infinite being at the origin of all things that is in fact ourselves. (Hesketh 200)

Alexander von Humboldt was perhaps the progenitor of the genre. His work *Cosmos* heavily influenced English writers in the nineteenth century. It suggested that humanity's recognition of its place in this epic — heralded by the writing of that epic — was the closing of a loop of self-awareness that is inherently pleasurable (Hesketh 203). This intrusion of the author of a text into the narrative of the text is an early precursor to one of the forms of metalepsis seen in the contemporary genre. The nineteenth-century evolutionary epics also looked to the future, occasionally entertaining the idea of humanity achieving even more perfect moral or physical forms (206). Hesketh also notes one author who, in this spirit, enjoined readers to write the final chapter in human existence, a prospect that clearly has "aesthetic appeal" (219). This is a prototypical version of the transhumanist futures suggested

in popular evolutionary texts today, where humans are encouraged to *rewrite* their own genome (Mukherjee 479).

To summarise, here are the key features of the full evolutionary epic that are still present in smaller scale accounts of evolutionary history: anthropocentrism; a fusing of the organic and inorganic; the self-referential inclusion of the writing of the epic as a key event in the epic itself; and the inclusion of the reader in this final phase of self-awareness. All four features are related. The anthropocentrism is boosted by the idea of self-awareness and the inclusion of the teller in the told is a blurring of ontological domains equivalent to the blurring of organic and inorganic. This blurring is achieved through various narrative tools — including several of Dawkins' metaphors and images explored below — most notably metalepsis.

The term metalepsis originally designated a rhetorical trope, but since Gérard Genette it has had a narratological meaning as well. For Genette, metalepsis occurs "when an author (or his reader) introduces himself into the fictive action of the narrative or when a character in that fiction intrudes into the extradiegetic existence of the author or reader, such intrusions *disturb*, to say the least, the distinction between levels" (88, my emphasis). Genette argues that the technique produces an effect of humour or the fantastic, which he illustrates with examples of various Borges stories (87–9). But as Genette's use of the word "disturb" shows, the effect is also one of the sublime, as scales or levels are confounded and conflated. Brian McHale's well-known study of postmodernist fiction brings this into closer focus, calling metalepsis a technique for foregrounding "violations of ontological boundaries" (227) and the "ontological dimension of recursive embedding" (120).

As several other scholars have argued, metalepsis is part of a more general category of strange loops.[64] Beyond merely describing the tangle of levels in a text, metalepsis is increasingly seen as a trope found in other media (see Kukkonen and Klimek) and in other discourses such as logic, computer science, linguistics and the natural sciences (Ryan, *Avatars* 211). With different kinds of metalepsis proliferating, Monika Fludernik usefully distinguishes between real and metaphoric ontological metalepsis, with real metalepsis involving the transgression of actual ontological levels (396). Alice Bell and Jan Alber follow this typology but contend

[64]The phrase is borrowed from Hofstadter. See Bell and Alber, McHale (120), Ryan (*Avatars* 207–11). See also Freestone, "Self-ish Genre" for a fuller discussion of metalepsis, especially in *The Selfish Gene*.

that real ontological metalepsis is impossible because fictive entities cannot physically interact with real ones: metafictional novels addressing the real reader remain metaphorical in their metalepsis (166). But real metalepsis is exactly what the evolutionary epic is supposed to do. The epic does not specifically blur the fictional and nonfictional (as we saw with the MWI interpretation of quantum mechanics in Deutsch's *Beginning of Infinity*, see page 100). Rather, it is the wish to see the organic and inorganic come together and other separate ontological realms reunited, that is a hallmark of the genre — I expand on this in the following sections.

In the case of evolutionary texts, what are the levels that are being mingled? In the first instance, they are widely separated spatial scales: the molecular world of the gene, the macro-scale world of the organism. This provokes the sublime movement in an essentially Kantian way as the reader struggles to reconcile the actions of nanoscale replicators with phenomena visible to the naked eye, such as a forest of trees. But this is the same as the conflation of scales employed by writers in popular cosmology, where the human scale is converted to or juxtaposed with the astronomical, such as the cosmic calendar mentioned in Chapter 1 (see page 139). Note that the cosmic calendar is a temporal scale effect. In evolution the temporal scales are also used to dwarf the human, but the conflation of those scales is more unusual. The daily actions of humans are embroiled with the four billion year history of life. This is where the scale effects in evolutionary biology become more metaleptic and more ontologically sublime than the cosmological case. The spatial and temporal scales — levels of reality — are mingled by way of diegetic levels. The text tells the story of the reader's evolution and makes the reading of that story its climax as well. But this is accomplished with several metaphors that contribute to the strange blurring of real levels (spatial and temporal), diegetic levels (teller and told) and distinct ontological realms (organic and inorganic; subjective and objective).

I will now examine the different metaphors and metaleptic elements in my focal text, Richard Dawkins' *The Selfish Gene: 40th Anniversary Edition*. Dawkins' first book (it was originally published in 1976) has gone through four editions and inaugurated his career as probably the best known contemporary populariser of evolution.[65] The title of the work derives from the argument — novel at the time —

[65] *The Selfish Gene* is one of the most successful popular science books of all time. It has replicated itself very effectively, having gone through four editions. All citations here are for the fortieth anniversary edition from 2016, which handily collects all the prefaces and endnotes from earlier versions and contains a new afterword.

that we should view evolution and the development of living things from the "gene's eye perspective". This means that natural selection operates at the level of the gene rather than at the level of the individual organism, the kinship group, or the species. This is because it is the gene that is the entity that is replicated and subject to variation and therefore the entity on which Darwinian evolution can, strictly speaking, be said to operate.[66] Every organism is really just an uneasy temporary alliance of many self-interested genes who "care" only for their own replication. To argue this, Dawkins personifies the gene, including in the title, but includes frequent disclaimers about not attributing agency or purposiveness to unthinking entities. He is only partly successful in this and indeed critiques of his work over the last 40 years have often focused on this point (Journet; Midgley; Sullivan). In prefaces, endnotes and an epilogue to subsequent editions of *The Selfish Gene* and also in other of his books, Dawkins has sought to clarify the usefulness of personification while also weighing in on arguments over genetic engineering, consciousness and how language works.

The textual metaphor and Richard Dawkins' genetic book of the dead

The most obvious device that contributes to the strange loops and metalepses in the genre, is the extended text-as-genome metaphor. The genome is a *text*, *script*, *code*, or *palimpsest;* genes are *written, proofread, duplicated, copied, transcribed*; biologists *read, decode, interpret* or *edit* the genes; and the genes are said to be *authors* or *writers* of organisms' behaviour, while at the same time those behaviours are *written* into its genome. This is not merely the default metaphor used by science writers as a tool to aid understanding, but the official terminology of biology textbooks.

This pervasive metaphor surely contributes to the urge to see evolutionary sequences as narratives. Other metaphors for genes abound and are well studied. Genes can be maps or instruction manuals (Ceccarelli), blueprints for building organisms (Condit), computer programs that direct embryonic development (Keller,

[66] This view became the orthodoxy, although recent investigations into group selection and other "non-Darwinian" forms of evolution have modified the strict neo-Darwinism of the gene's eye view. Samir Okasha's *Evolution and the Levels of Selection* is a work of philosophy of biology that I found extremely useful for this chapter. Equally useful was a chapter of Peter Godfrey-Smith's *Darwinian Populations and Natural Selection* (129–146).

Refiguring), or timebombs presaging the onset of genetic disease (Gronnvoll and Landau). Of these the only rival to the textual metaphor in terms of popularity or centrality to theorising is the computer program metaphor that figures genes as the *information* or *program* that can *execute* the *instructions* for protein synthesis (Keller, *Refiguring* 18). But the metaphor that dominates not only in popular and technical literature, but that is actually built into the lexicon of biology, is the textual metaphor — and indeed the instruction manual and blueprint metaphors are also suffused with textual language.

The textual metaphor also sets the stage for a blurring of ontological and narratological levels. In *The Selfish Gene*, the main subject — in every sense — is the gene and because genes are described as both texts *and* authors, certain metafictional devices present themselves. This figuring also means that there is a mingling of ontological hierarchies where the macro-level phenomenon of animal behaviour is partly controlled by the molecular world of the genes. These two different sets of mingled levels in turn intermingle in an even more involuted metalepsis when one considers that the story of the discovery of DNA is an almost ubiquitous ingredient in these texts — and that this almost always precedes a reference to future gene manipulation technologies. Thus the human is posited as a reader and writer of the text that authored her and a manipulator of the agencies that created and manipulate her.

In *The Selfish Gene*, the textual metaphor and the ontology it purports to represent, are especially tied together. Dawkins' views about language, perhaps not surprisingly, seem to be informed by his knowledge of how the genetic code works. In *The Selfish Gene* he continually fights to offer a workable but flexible definition of what a gene is, in order to make his larger case for the utility of the gene's eye perspective. The gene is a surprisingly difficult thing to define and Dawkins reminds us that "words are only tools" (23) and that there is "nothing sacred about definitions" (36). And so he opts for a "fading out definition" of the gene (41), one that is indeed "circular" (42). Dawkins is a pragmatist when it comes to definitions for biological terms and this pragmatism may well be informed by the pragmatics of DNA.[67] Genes are only respected as defined units inasmuch as they are a stretch of

[67] Although this attitude does not seem to extend to all discourses. On biblical interpretation, Dawkins is unremittingly literal, even in his earliest work, cavilling over the definition of "virgin" in Matthew 1:23 (*Selfish* 362). He also refuses to change sexist pronouns (*Phenotype* vi–vii) and openly informs readers they are "muddled" in their common-use definitions of the word "robot" (*Selfish* 363).

DNA that happens to replicate and persist. Keller argues that the ambiguity and essentially metaphorical nature of the gene is what gives it immense explanatory usefulness even while it displays none of the "stability nor the clarity expected of the explanatory elements upon which the physical sciences have come to rely" (*Making Sense* 117).

It is possible that this meaning-as-use approach to language is born of the pure pragmatism of the genetic code. It informs not only Dawkins' willingness to extensively use the textual metaphor for practical explanatory reasons, but also to entertain the mutability and contingency of the human genome. In *The Selfish Gene* he does not go into detail about genetic engineering but does include a few hints at the inevitability of a transgenic future (*Selfish* 4, 260, 434). If the genome is a text and if genes — or words — have meaning only in virtue of use, then changing the meaning of the text/gene is simply a matter of using new tools and "there is nothing sacred about definitions". This approach doubtless also contributes to the theory of memes that Dawkins outlines at the end of *The Selfish Gene*; indeed words are for Dawkins only a subset of the larger class of memes, a catchall for cultural productions of any kind.

A related figure is what Dawkins calls "The Genetic Book of the Dead" (*Selfish* 356). Dawkins speculates that a future scientist with advanced knowledge could analyse the genome of an animal to learn of the environment of its ancestors, because its genome should be nothing but a record of genes which survived given certain environmental conditions: "This makes it a kind of negative imprint of those environments" (356). The DNA of a mole "should be eloquent of an underground world" and the DNA of a dromedary "if we but knew how to read it would spell out a coded description of ancient ancestral deserts" (356). This certainly consolidates the textual metaphor, taking it further than any other writer I have encountered.

More striking is how Dawkins deployed the book-of-the-dead metaphor in other works. In *Unweaving the Rainbow* it is not only the animal's genome that is a text to be read, but its body too: "the animal, any animal, *is* a model or description of its own world, or more precisely the world in which its ancestors' genes were naturally selected" (240, italics in original). Using the language of painting, Dawkins claims that sometimes this is literal and representational, as in a stick insect's body or how "a fawn's pelage is a painting of the dappled pattern of sunlight filtered through trees on to the woodland floor" (240). But animals' bodies can render their

world in impressionistic ways too: “An artist seeking a dramatic impression of air speed could hardly do better than the shape of a swift” which “embodies coded facts about the viscosity of the air in which its ancestors flew” (240). Certain parasites are offered as a strong case of being an embodiment of negative information about their hosts’ bodies — which are a parasite’s environment — in the way a key embodies negative information about the lock it fits; and in a similar way a hermit crab’s abdomen represents or mirrors the shape of a mollusc’s shell.

This is an extraordinary conceit. It makes the body, or genome, of an organism a kind of palimpsest. Through a biological hermeneutics, one might reassemble not the ur-text as in the methods of textual criticism or philology, but instead reconstruct the *context* that influenced successive iterations. In *The Selfish Gene*, Dawkins deploys the conceit to score a point about the ongoing relevance of the gene’s eye view. Its recurrent use in his books is a clue to a more entangled view of life, time and environment. Certainly Dawkins would not ally himself to the worldview of Barad, for instance. And yet there is much in his conception of the biological world that hints at an ideology far more amenable to non-anthropocentric views of life, despite the liberalism that underlies his human exceptionalism.

Dawkins may have gotten some of this imagery from the philosopher Daniel Dennett and the two quote each other frequently.[68] In *Darwin’s Dangerous Idea,* which is partly a work of popular science but also philosophy, Dennett writes of a hypothetical Martian biologist interpreting the body of a seagull:

> The wings of a seagull magnificently embody principles of aerodynamic design, and thereby also imply that the creature whose wings these are is excellently adapted for flight in a medium having the specific density and viscosity of the atmosphere within a thousand meters or so of the surface of the Earth. . . If [the Martian scientists] made the fundamental assumption that the wings are functional, and that the function was flight (which might not be as obvious to them as we, who have seen them do it, think), they could

[68] In an earlier piece of writing (1983) Dawkins briefly imagines the thought experiment of an animal on an alien planet having information about its environment embodied in its camouflage patterns (“Universal Darwinism” 410). But it is not developed and is used purely in an argument about the possible inheritance of acquired characteristics. Dawkins does write of the genetic book of the dead in *The Ancestor’s Tale* (21–2, 80). In *The Selfish Gene* the figure is only in the afterword to the 2016 edition. He also recently made it his contribution to an *Edge.org* yearly question (see Dawkins “Genetic Book”): what scientific term or concept ought to be more widely known?

> use this assumption to "read off" the implicit information about an environment for which these wings would be well designed. Suppose they then asked themselves how all this aerodynamic theory came to be implicit in the structure, or, in other words: How did all this information get into these wings? The answer *must* be: By an interaction between the environment and the seagull's ancestors. (197–8, italics in original.)

Again the reading metaphor applies not just to the genome of an organism but its body as well. This is part of Dennett's broader philosophical argument about how meaning is possible within a naturalistic worldview. The image of the Martian reader gleaning knowledge of an organism's environment from its form is a kind of self-reference, with the organism referencing its own ancestors' milieu. The "text" is very much enmeshed in the world. Dennett notes that the environment contributes as much if not more than the genome to the phenotype (the collection of traits expressed by genes). Citing Monod's *Chance and Necessity*, Dennett explains how the basic processes of complex life involve ascending levels of informational richness or meaning. Thus a gene codes for a one-dimensional string of amino acids to be assembled, which in turn folds into a three-dimensional protein structure. There is more information in the protein than was specified by the one-dimensional string. Where does this additional information come from? Just like the wings of the gull or the fawn's pelage, it is from the environment, but in this case the protein's environment is the interior of a cell. Monod has it that the environmental conditions impose "an unequivocal *interpretation* of a potentially equivocal message" (93, italics added). Dennett, after quoting this line from Monod, asks:

> What does this mean? It means — not surprisingly — that the language of DNA and the "readers" of that language have to evolve together; neither can work on its own. When the deconstructionists say that the reader brings something to the text, they are saying something that applies just as surely to DNA as to poetry; the something that the reader brings can be characterised most generally and abstractly as information, and only the combination of information from the code and code-reading environment suffices to create an organism. (196)

Dennett elsewhere confirms that his understanding of deconstruction and — as he terms it — "postmodernism" is tenuous.[69] But to say that the meaning of the protein is a combination of the code of amino acids specified by genes and whatever the environment brings to the reception of that code is similar to the very basic assumption in many schools of contemporary literary theory. Namely, that meaning is a combined product of the symbols in the text and the milieu in which they are read. The lock and key metaphor from Dawkins is a higher-level version of this interactive production of meaning, this time between the bodies of whole organisms and the rich environments that envelop their forms. There is at least a weak affinity here with Barad's intra-action between agents and material-discursive practices; but Dawkins veers off in a different direction.

In addition to extending the reading metaphor of genetics, and entangling the organism, the environment, the reader and the written, the genetic book of the dead also conflates temporal scales. By recasting an organism's form as embodied time the evolutionist's perspective merges the deep past with the present, as history is incarnated in living plants and animals. Hence the *palimpsest* part of the textual metaphor is used later in that chapter when talking about the genetic book of mice and rats because they are great generalists with many environments in their lineage. This means that "anyone attempting to 'read' their genes may find a confusing palimpsest of ancestral world descriptions" (254). So different time periods are superimposed on one another and even very distant ancestral environments are still utterly present in our own genes, which still replicate themselves and exert some influence on our embryonic development and our physical traits.

This somewhat contradicts other perspectives on how time is portrayed in evolutionary texts. Clayton's thesis on evolution and temporality involves "genome time": a mixture of linear and cyclical, fusing the "personal timescale of everyday life with the immense impersonal timescale of the species" (58). Thus while evolution marches linearly onwards, the genetic code has a synchronic dimension, written in the same four "letters" of nucleobases which eternally recur (58). But this seems to

[69] Sadly, like many philosophers from the analytic tradition, Dennett uses "postmodernism" as a blanket term for a series of caricatured positions on moral relativism, radical feminism, anti-science dogmas and social constructionism. There are several other ways in which Dennett's work resonates with the ideas of Derrida in particular, that cannot be explored here. See Staten for elaboration on this point. I would add that because, on the topic of meaning, Dennett is a follower of the later Wittgenstein and the philosopher of language Paul Grice, he should already have some notion of the "reader brings something to the text".

be less eternal recurrence than duration.[70] Rather than the past repeating itself, the past accumulates, with vestiges of ancestors still present in current day genomes. Clayton repeats Dawkins' eternalism when he, Dawkins, calls genes "immortal replicators" — although at one point he admits it is only "potential" immortality (*Selfish* 44–5). And apart from anything else, RNA may have been the forerunner to DNA and contains one different nucleobase, that is one of the supposedly eternally recurrent "letters". Dawkins' own text is a better model of the way meaning accumulates in a genome or book than Clayton's notion genome time. The latest edition of *The Selfish Gene*, with its caveats, revisions, contradictions and extensions, is truly palimpsestic.

The extended phenotype

Another way that ontological boundaries are transgressed in *The Selfish Gene* is with the theory of the extended phenotype.[71] An organism's genotype is its collection of genes; its phenotype is the set of characteristics resulting from that genotype. Traditionally, the phenotype was seen as identical to the organism's body: genes produce bodily characteristics so the effects of the genes end at the boundary of the body. But Dawkins questions how arbitrary this boundary is from the gene's point of view. There should be no biological reason why the influence of a gene cannot extend beyond the edge of an organism's body into other objects in the distal environment. Dawkins suggests that a phenotype should encompass anything that bears on the natural selection of the genotype, regardless of its proximity to the genes. Artefacts such as beavers' dams and spiders' webs demonstrate that genes that somehow contribute to building better dams or webs — and here "better" means they increase the gene's rate of replication — are in principle no different from genes that contribute to more aerodynamic wings, more adept eyes, or sharper teeth. The organism's phenotype bleeds into the world, and the things it makes or does in that world are as much tools used by genes as the organs with which it makes them. The organism is no longer circumscribed, distinct from the environment in which it lives.

[70] Some recent feminist philosophers have offered a more interesting view of temporality in evolution — especially Elizabeth Grosz and Luciana Parisi — which I detail elsewhere (Freestone, "Evolution").
[71] Dawkins second book, *The Extended Phenotype*, explains the ideas in detail. But he also added a chapter summarising the hypothesis to the second edition of *The Selfish Gene*.

The selfish gene remains a locus of identity, but now one whose influence extends out arbitrarily far.

Like the genetic book of the dead, I think this is a startling doctrine from the point of view of contemporary theory. I have not found any scholars who have engaged with this aspect of Dawkins' work, or any other popular writer's work on the same concept; although it does slightly resemble Deleuze and Gauttari's discussion of the intertwined relationship of some wasps to orchids and their mutual "becoming" (10). The idea of the extended phenotype seems to complicate the demarcation of the subject and the object or at least the organism and the environment. The entanglement between genes, organism and environment proposed by the extended phenotype is reminiscent of Barad's insistence on the intra-action that occurs between all "objects". Genes cannot exist without affecting their environment and the environment is constitutive of the genes. Barad tells us to read diffractively: she reads the social and the natural *through* one another (30). Perhaps Dawkins' imagined scientist of the future will not try and read *off* the genome but try and read the genome and the environment *through* one another.

Tellingly, "Action at a Distance" is what Dawkins calls the crucial chapter of *The Extended Phenotype*, in which he outlines the "long reach" of genes beyond their bodies. This is an allusion to the phrase in physics first used to describe gravity, later electromagnetism and eventually quantum entanglement. Einstein's well-known variation to describe quantum entanglement was "spooky action at a distance". The quotation is a cliché in popular physics books, but it conveys the strangeness which non-local phenomena always evoke. The action at a distance of genes is not as inexplicable as quantum entanglement where the influence appears to be propagating faster than light. But the idea is still unsettling and not only because of the parasitic element: the genes of a parasitic worm influence the behaviour of their host shrimp, just to get eaten by a duck, because the duck's digestive tract is the breeding ground for the worm (*Phenotype* 216). For the worm, "the environment" consists not just in the water immediately around it, but also the eventual viscera of a shrimp, and then, further away, a duck's intestines. And because the worm has evolved to thrive within the phenotype of two other genomes, there is a blurring of what counts as environment, as against the organism itself. Coupled with the cellular self and microbiome considered in Chapter 3, these ideas begin to accumulate into a worldview that is not at all conducive to the staid materialism and liberal humanism

that is science's public face. They unsettle, I think, because they imply a more entangled ontology where seemingly separate entities are actually part of *phenomena* (in Barad's usage of the term) without obvious boundaries or isolated properties (Barad 333–4).

The personification of genes

I have argued for the narrativity of *The Selfish Gene* and that agency is perhaps the *sine qua non* of narrative. In trying to identify the agents within the story told in *The Selfish Gene* there are two prime candidates: the personified gene of the title and the liberal humanist subject who seems to reappear at the end of the narrative to rescue humans from the fate of other organisms who remain mere vehicles. In evolutionary epics it is always the rational human who is able to inaugurate the final chapter of the epic by writing or reading it. But once we look further into the figure of the selfish gene, a more nuanced idea of agency is at least suggested, even if it belies Dawkins' own politics. This kind of agency is uncertain and provisional, nothing like the ideology that led Katherine Hayles to sum up *The Selfish Gene* like this:

> Dawkins's gene is the ultimate individual, the triumphant product of that brand of Anglo-American ideology that ignores the complexities of social and economic contexts and declares success or failure to be solely the result of individual initiative. ("Agency" 150)

That is indeed Dawkins' rhetoric. But we can read past the rhetoric and look at the extended phenotype of *The Selfish Gene*, because its long reach does not stop at the arbitrary boundary of the main body of the text. In Dawkins' endnotes he adds nuances, contradicts himself and settles scores with critical reviewers. Several of his notes rebut charges that he is personifying genes — and also the opposite: that he is de-personifying humans.

The philosopher Mary Midgley opened a critical review of *The Selfish Gene* by stating that, "Genes cannot be selfish or unselfish, any more than atoms can be jealous, elephants abstract or biscuits teleological" (439). The language of intent that is often used to describe genes and evolution by natural selection is a contentious topic in the scientific and popular literature. Some biologists worry even at the use of

the term *selection*, because it implies a selector rather than a disinterested filtering process (Coyne 127). As early as 1866, Alfred Wallace, co-developer of the theory of evolution, wrote to Darwin to dissuade him from using the term *selection*, suggesting "survival of the fittest" instead (Richards 402). Dawkins is happy to use the language of purposiveness in describing selfish genes and the evolutionary imperatives of organisms trying to reproduce. He is aware of the danger of doing so and, as usual, pugnacious in response to critics: "Personification is sometimes a useful device, and for critics to accuse us of taking it literally is almost as stupid as taking it literally in the first place" (*Unweaving* 235).

In what sense are Dawkins' selfish replicators selfish or unselfish? Dawkins is quite clear. Selfish genes "act" in their own interests, but this only means that they successfully replicate and therefore "become more numerous" (*Selfish* 57) or "survive in the gene pool" (*Selfish* 112). Dawkins calls phrases like these the "respectable terms" of "gene language" rather than the "sloppy language" of metaphor (*Selfish* 114). Dawkins is able to oscillate between these registers, using metaphor to carry the narrative and using "respectable terms" to reiterate the mindlessness of natural selection. But if narratives need agents and one wants to popularise evolution then the conventions of the genre all but mandate the personification of genes. In other genres personification is less fraught. Popular neuroscience texts personify people. Popular physics can personify stars, light, or atoms. Natalie Angier, for example, can safely write the following without incurring charges of misleading anthropomorphism: "The electron, with a designated minus sign tattooed on its forehead, finds the positive proton terribly attractive, and wants to spend its time somewhere in the vicinity of one". Likewise the technical language of *attraction* and *repulsion* is not considered purposive when referring to particles or larger quantities of matter, so long as the frame of the discussion is physics. In biology, though, even *natural selection* has been under scrutiny since the time of Darwin. Evolutionary texts are bound to draw criticism because they deal with a cast of "characters" that span a wide range of degrees of agency. They include putative full agents — humans — and quasi-agential entities such as genes or simple organisms, all in the same text. Popular physics books, meanwhile, generally do not blur the boundaries between human and nonhuman and so provisional agency is unproblematically granted to atoms and it seems to be received as plainly metaphorical.

There are explanatory advantages to at least weakly personifying genes. The philosopher of biology Peter Godfrey-Smith, even while arguing the case for moving beyond a gene's eye view, concedes that focusing on quasi-agential entities like genes aids in understanding evolution. Echoing Abbott's two levels of evolution, he notes that the gene's eye view moves the focus away from a "sea of transients" that feature in the statistical view of evolution as changing frequencies of characters in a population (*Darwinian* 37–8). Instead the focus can be on: "a set of hidden, coherent, and persisting things that can be the locus of attributions of agency. These attributions impart a kind of order and comprehensibility on the evolutionary process" (38). Godfrey-Smith also suggests that we intuitively think about evolution in agentive terms because we naturally apply certain "conceptual tools" to thinking about living things, including causality, teleological thinking and agency (142–3). This claim is based on work in "folk biology" (12) that I find compelling, especially the view that: "This mode of thinking [the agentive perspective] engages a particular set of concepts and habits: our cognitive tools for navigating the social world" (10).

In addition to the cognitive pull of agentive language and the explanatory or narrative benefits that no doubt accrue to popularisers who employ it, such language may simply be inescapable. Keller, discussing the metaphor of the genetic computer program, hits upon what I think is a crucial point. She notes the ambiguity around the grammatical case to which *genetic* refers and asks, "Are genes to be understood as the subject or as the object of the genetic program?" She observes that genes simultaneously *activate*, are *activated* and are *acted upon* (*Making Sense* 136–7). Debra Journet makes a similar point. Drawing on Kenneth Burke's rhetorical and tropic analysis of *Origin of Species* (Burke 152–8), she calls attention to the difference between *action* which is purposive and redolent of human agency and *motion* which is passive and associated with unthinking phenomena (Journet 217). Natural selection should be a clear case of motion and yet Darwin used action terms — the language of selection — to describe the motion of evolutionary phenomena. For Burke this was simply another example of the pathetic fallacy (153) but Journet convincingly argues that this ambiguity over the locus of agency is actually central to theorising about evolution. She further argues (echoing Keller's earlier work on metaphor) that ambiguous metaphors in science — including selfishness in Dawkins — "stand in for a part of the argument that is still to be developed" and allow scientists to theorize beyond what is currently known (224). In considering the dual

claimants to agency in evolutionary theory (gene and organism), "the rhetorical ambiguity of agent rhetoric. . . provides a discursive space where thinking can occur" (Journet 225). Godfrey-Smith, Keller and Journet all concur that some measure of personification is explanatorily useful.

But a larger reason for this ambiguity is that Dawkins and his colleagues are unable to find a grammatical category to match the selfish gene, because no such category exists in a language based on subject and object constituents. Dawkins makes the jump from passive object to active subject fairly explicit in *The Selfish Gene* when he uses the language of inert matter to describe primordial replicators in a plausible origin of life scenario: "If a group of atoms in the presence of energy falls into a stable pattern it will tend to stay that way. The earliest form of natural selection was simply a selection of stable forms and a rejection of unstable ones. There is no mystery about this. It had to happen by definition" (17). In any explanation of how agency came about — *i.e.* an evolutionary narrative that runs the gamut from simple life to humans — there will necessarily be a disputed zone where agency is ambiguous. Dawkins must alternate between the "respectable" language of action and the metaphorical language of motion, the language of a passive object and an active subject. He cannot compromise and use quasi-passive or -active language because it is not available to him in English. Dawkins is hamstrung and has to use agential language to describe something that is not yet agential if he is to explain in roughly narrative terms (because narratives need agents) how full agency evolved. The selfish gene is best thought of as this compromise, as an only self-ish entity.

The criticisms of Dawkins strike me as similarly ironic to the criticisms of the Anthropocene from Chapter 3. Midgley chides Dawkins for attributing human qualities to nonhuman things. But concealed in her argument is human exceptionalism *par excellence*. Clearly even Midgley does not object to humans being personified; so can *only* humans be described using agential language and personification? There seems to be an assumed ladder or chain of being with humans at the top, so any violation of this hierarchy with agency being granted to nonhuman things, even in the ambiguous terms of the self-ish gene, is bound to provoke criticism. We do not know if Midgley would also object to other mammals, or even primates, or even our hominin ancestors being personified too. She does not need to declare her opinion on where real agency begins: the point at which personification (which is an anthropocentric term) is unproblematic.

But although I do think Dawkins is unfairly criticised for using personification that is largely inescapable, his own position on the use of metaphor in conveying types of agency is totally inconsistent. Although the self-ish gene is used as a way to find the germ of human agency in our replicator ancestors, in the next section I show how Dawkins de-personifies humans in an attempt to achieve another rhetorical win. Both effects, personification of nonhumans and de-personification of humans, suggest a kind of self-effacement that is the first half of the Kantian movement, before the final act of the evolutionary epic restores the reader (and more so the scientist) to the place of ultimate agency.

The de-personification of humans

According to the gene's eye view, any organism, even a large one like a human, is merely a *vehicle* for the success of the replicators it carries. These replicators arose as free floating self-replicating molecules in some primordial environment, probably the ocean, but have since developed elaborate vehicles to aid their propagation:

> Four thousand million years on, what was to be the fate of the ancient replicators? They did not die out, for they are past masters of the survival arts. But do not look for them floating loose in the sea; they gave up that cavalier freedom long ago. Now they swarm in huge colonies, safe inside gigantic lumbering robots, sealed off from the outside world, communicating with it by tortuous indirect routes, manipulating it by remote control. They are in you and me; they created us, body and mind; and their preservation is the ultimate rationale for our existence. They have come a long way, those replicators. Now they go by the name of genes, and we are their survival machines. (*Selfish* 25)

In an endnote for the second edition (and all editions thereafter) Dawkins admits this is a "purple passage" and also laments its misquotation by people arguing against strict genetic determinism (363). The image relegates or obliterates the notion of a coherent, integral self. Our bodies are refashioned as technologies for self-ish genes. As emergent, seemingly expendable prostheses for tiny chemical replicators, we vehicles are nonetheless clearly entangled with the world inside our cells, the same one that dictates our embryonic development, that shaped our

ancestors' forms and that curated the set of genes we now have. As robots animated by entities that we cannot see without advanced microscopes, we are convolved with a tiny ontological scale and authored by those entities' self-interest; indeed they arguably constitute our self: "they created us, body and mind; and their preservation is the ultimate rationale for our existence". This imagery is similar to that found in invisible biology when the human body is decomposed into semi-autonomous cells made up of micromachines or nanobots. And again, a kind of sublime terror is evoked by the comparison of humans to inorganic machines. But Dawkins' gene/vehicle distinction is not unusual (although it was in 1976). It is the epitome of the neo-Darwinian view of living things and in many ways the background assumption that drives the explanations found in popular evolutionary texts published since *The Selfish Gene*.

Indeed, the robots passage is "infamous" according to Broks, who uses it as an example of how to critically read a popular science text (136–7). He offers three levels on which to read the passage: the level of raw content (information on genes), the level of framing (the imagery used by Dawkins) and the critical level: "at a critical level we could explore how the language of 'robots' could be *seen* as an attack on our own sense of self and relate this to wider discussions about free will and identity" (137, italics in original). I do not want to confuse those levels with the narrative or ontological levels mentioned above. But Broks' point is relevant in showing how the topics of genes and evolutionary biology are particularly liable to interweave human concerns with descriptions of non-human physical processes. He also recognises the obvious affront to human agency. Broks also includes Dawkins' endnote wherein he responds to criticisms of the passage. Dawkins regrets the "purple passage" but says the negative reaction is owing to the public's "erroneous" associations with the word robot (363). Broks compares Dawkins to Humpty Dumpty in trying to control words even though, once they're in the public sphere, an idea's meaning is "up for grabs" (Broks 148–9).

In another response to criticism, in his second book, *The Extended Phenotype*, Dawkins makes the point that the word *robot* is likely to experience some semantic drift as robots themselves become more intelligent. After summarising some then recent feats of artificial intelligence he predicts:

> From being synonymous in the popular mind with a moronically undeviating, jerky-limbed zombie, 'robot' will one day become a byword for flexibility and rapid intelligence. Unfortunately I jumped the gun a little in the passage quoted. When I wrote it I had just returned from an eye-opening and mind-boggling conference on the state of the art of artificial intelligence programming, and I genuinely and innocently in my enthusiasm forgot that robots are popularly supposed to be inflexible idiots. (16–7)

He goes on to apologise for the covers to the German and French editions of *The Selfish Gene* which are illustrated with human marionettes and wind-up people, respectively. And he admits: "No doubt I was partly to blame for the original misunderstanding, but I can only urge now that we put aside the preconceptions derived from common usage and actually go and read some of the fascinating modern literature on robotics and computer intelligence" (17). Dawkins protests too much. He has contradicted his meaning-as-use approach, which he used to defend the definition of *gene* and his use of personification.

More importantly, we see the influence of artificial intelligence on the understanding of organic intelligence (a hint here of the fusing of the organic and inorganic advertised by the evolutionary epic). Dawkins is more bullish on this point in the endnotes to *The Selfish Gene*: "People who think that robots are more 'deterministic' than human beings are muddled. . . What on earth do you think you are, if not a robot, albeit a very complicated one?" (363). The problem for Dawkins is therefore not that people (such as the German and French publishers) have taken the "lumbering robots" metaphor too literally, but that they have not taken it literally at all, because they misapprehend the nature of computers and robots. Whereas puppets and wind-up toys are connotative of a complete lack of agency, robots and computers are for Dawkins pre-programmed, but potentially able to make decisions based on feedback from real-world situations. Likewise humans are "pre-programmed" by evolution, but pre-programmed to be able to act agilely in an uncertain world. In this way the language of artificial intelligence is not a series of anthropomorphisms or misplaced personification, but an actual explanation of how complex organisms like humans can self-determine. Thus although the advent of robots post-dates the evolution of humans, robots are now (for Dawkins) the

explanatory metaphor for humans rather than the other way around.[72] Dawkins wants to have it that rather than robots being an AI project of the future, the stuff of science fiction, they are in fact the self-reflective product of purely selfish, more primitive components, namely genes. Dawkins is a sort of pre-posthumanist: rather than emphasising the future of genetic engineering and cyborg technology, he presents the evolution of complex life as a process of non-teleological research and development that includes the non-artificial intelligence of humans.

Although this is a de-personification of humans and although it betrays Dawkins' inconsistent views on language and metaphor, it is also complementary to the personification of the selfish gene. A narrative of evolution that includes the advent of agency must adhere to the gradualist logic of evolution: more agency than usual is granted to genes (who are selfish) and less agency than usual is attributed to humans (who are robots). Again, Dawkins' critics might pause to consider why this is objectionable. Although it is not Dawkins' explicit point, the de-personification of humans is hard to avoid in a narrative of evolution. Would critics object to hominins being described as robots? And if not, then perhaps apes, other mammals, insects, single-celled organisms, or genes? Somewhere in the full sequence there will be a liminal zone where one thinks the entity in question is robotic — according either to Dawkins' usage or common usage.

Dawkins' problem is reminiscent of the notion of the uncanny valley. In films, computer games and robotics, an unambiguously nonhuman robot, cyborg, or animated figure seems to be unremarkable. Likewise with a perfect human replica. But a figure who is nearly human is unsettling, even sublime, as it straddles habitual frames of thought. Dawkins' robotified human is such a figure. Once again he is hamstrung. Dawkins is trying to narrate the evolution of agency over billions of years. In the condensed form of a popular science book, this can only be achieved by a crude promotion of unthinking genes to self-ish genes and a crude demotion of humans to vehicles or robots. Calling humans robots — even if the appellation will "one day become a byword for flexibility and rapid intelligence" as Dawkins hopes — is a rendering of the human as slightly less animated, slightly dehumanised and so trespasses on the uncanny valley.

[72] In a similar fashion computer viruses have become the best explanatory metaphors for biological viruses, reversing the order in which they appeared in the language.

Another keen critic of Dawkins is Alexis Harley. Her *Autobiologies: Charles Darwin and the Natural History of the Self* recognises the interplay between the narration of evolutionary history and the Bildungsroman, where. the selfish gene develops increasingly elaborate strategies for propagation, culminating in humans who are able to understand this process and countermand it: "We, alone on earth, can rebel against the tyranny of the selfish replicators" (*Selfish* 260). Harley puts it like this:

> The rhetorical conferral of intentionality, a point of view, and even selfishness upon the gene transfers the attributes of the free-willed humanist subject onto the biological code that is understood to circumscribe human free-will. Dawkins optimistically allows that human biology has given rise to a self-awareness that permits an occasional rising above the determinations of the gene and he notes the fallacy of supposing "that genetically inherited traits are by definition fixed and unmodifiable," [Dawkins *Selfish* 4] and yet the abiding tenor of his work — and of much popular writing about the gene — invests agency in the gene and takes it away from the organism. Unless, that is, the organism is the scientist, "playing God" with "nature". (Harley 190–1)

The abiding tenor of the work is certainly as Harley characterises it. Dawkins wants to emphasise the rightness of the gene's eye perspective, and to uphold a vision of science as noble and the scientist as able to transcend base instincts. But a stranger vision of life leaks out from behind Dawkins' cheerleading for the humanist subject, as Hayles and Harley identify it.

If we were to stop the analysis here I would say we have the same kind of ontological sublime illustrated by the invisible biology texts in Chapter 3. They dismantled the self into its component cells and also interweaved those cells and the organism into an ancient, global superorganism. Dawkins' robot imagery, his extended phenotype and the genetic book of the dead *might* have been the path to a similarly entangled way of being-with the nonhuman. In the final section, however, I will explore how Dawkins fulfils instead the goals of the evolutionary epic, which have not evolved much since the Victorian era. He provides an ontological sublime that fuses together not merely ontological levels (widely separated spatial and temporal scales) but separate metaphysical domains too: the material and the

immaterial, the organic and inorganic, the world of the teller and the told. He does so by encompassing even consciousness and culture into the exiguous framework of selfish gene theory and neo-Darwinism.

Scale, consciousness, memes and reaffirmation

The Selfish Gene can be read as a Bildungsroman. As a coming of age story of the selfish gene, it is poignant that the protagonist does not finally come of age even with the appearance of *Homo sapiens*. The arrival of the full agency able to transcend the imperative for replication and make its own ends is coded as a particular male liberal humanist subject: the scientist able to understand the scientific account of his own becoming. *The Selfish Gene* offers the genesis of this self. Unlike the environmental or ecological sublimes from last chapter, the scientific self reaffirmed by Dawkins and others in the evolutionary epic genre, is the result of a sublime vision of the world that unites ontological categories rather than undermining or destabilising them. With the framework of Darwinian evolution in place, Dawkins uses it not only to explain the ultimate rationale of all organisms' behaviour, but also of cultural transmission, technology, language and concepts. Dawkins coined the word *meme* in the first edition of *The Selfish Gene* as a way to extend the logic of replicators and vehicles to human social and cultural phenomena. He devotes only a scanty chapter to the idea and was not the first to propose a cultural equivalent of biological evolution. Nor does he claim the meme is a grand theory: "my designs on human culture were modest almost to vanishing point" (*Selfish* 423). Although that is a defensive endnote, here it is in the body of the text: "When we die there are two things we can leave behind us: genes and memes (258)". And merely by proffering this method to subsume the social sciences into a neo-Darwinian analysis of natural selection, he mounts an immense grab in the colonisation of other disciplines.

The sublime that attends this confidence does not terminate in self-annihilation, though it starts there. By transcending so many levels of influence, a new kind of horror is presented, unlike the *horror vacui* of quantum physics or microbiology. In those cases the world or the subject itself is dissipated into tiny parts and the baselessness of things exposed. But the horror of the evolutionary metalepsis is that the tiny entities that make up the subject also *control* the subject. Even when describing other species and their genetic determinism, the human

subject is threatened by implication. Just like the cellular self from Chapter 3, Dawkins' image of the lumbering robots as unwitting vehicles for tiny replicators, suggests the vertiginous view of reducing humans to agglomerations of tiny constituents; but it includes a new threat to self-affirmation in the form of the loss of agency. This loss of agency is peculiar because it comes from below. Reversing the usual top-down extra-agential causality of god or fate or chance, the lumbering robot and the extended phenotype are difficult to accommodate because they violate the usual order of control.

But even amid this confusion of scales, a pseudo-Kantian sublime takes shape. We are able to alter the very foundations of our recently co-opted agency: "We are built as gene machines and cultured as meme machines, but we have the power to turn against our creators. We, alone on earth, can rebel against the tyranny of the selfish replicators" (*Selfish* 260). These are the last words of the first edition of *The Selfish Gene* (later editions have additional chapters), and they serve as a peroration that undermines the meaning of the title. *The Selfish Gene* mirrors the Kantian movement by at first disrupting the subject — we are "lumbering robots" (25) — thrown into a welter of discussion of selfish genes, game theory, parasites and manipulation, but then restored to sovereignty by the end of the book — we alone can rebel (260) — but our ontological rather than epistemological categories are confounded. The epistemological ground of *The Selfish Gene* is never in doubt: Dawkins is an advocate for the enduring efficacy of Darwin's theory. But ontological reassurance is a more difficult task for Dawkins. And yet he attempts that suture as well.

Note the alliteration in the quotation above: *meme machines*. With a single phrase Dawkins subsumes language, culture, technology and ideas into the same minimalist neo-Darwinian evolutionary framework that he has used to simplify the unpresentable diversity, complexity and contingency of the world of species. Recall Lynn Margulis, from the previous chapter: "Nature has a certain subsuming wisdom; our aptitudes must remain meagre in comparison to the biosphere of which we form relatively tiny parts" (152). Dawkins does the opposite. Nature and culture are not in a strict dichotomy but both are incorporated into scientific understanding.

Even human consciousness is presumed to be explainable in this manner. In another endnote, Dawkins glosses two theories of consciousness, simultaneously collapsing the realm of mental life into the gene-centred perspective and reaffirming

his human exceptionalism. One of the theories is from Dennett and the other from the psychologist Nicholas Humphrey (who will be encountered in Chapter 5). The latter includes the hypothesis that consciousness — a seemingly extravagant addition to unconscious thinking, from the point of view of evolution — evolved to help simulate other social beings' motives (*Selfish* 374–5). In other words, human consciousness evolved in a world of non-conscious proto-humans by them misattributing a certain level of reflective agency to others. This ability had survival advantages because it afforded better predictions of others' behaviour. The most effective way to model others' reflective agency was to eventually become conscious at which point others really were conscious as well: a bootstrapping process. There is an irony here. Dawkins is suggesting that the very sin he is accused of committing in *The Selfish Gene*, misplaced personification, actually drove the selection pressure for the evolution of human consciousness.

Dennett's theory of consciousness is similar. The brain creates a kind of "user friendly" illusion of a stream of consciousness, so that on top of the *parallel* processing undertaken by the unconscious mind, humans evolved to have a *serial* processor as well (*Selfish* 373–4). Note that this is Dennett via Dawkins and Dennett's ideas are more complicated and will feature in the next chapter. Importantly, Dennett too is a committed neo-Darwinian, an advocate of meme theory, and supposes that consciousness, culture, norms, meaning and language can all be explained by the underlying logic of replicators, mutation, heritability and selection (Dennett, *Darwin's* 64–7, 200–7, 335–69, 401–27).

Both Dennett and Humphrey are proponents of what is now called *illusionism* in the philosophy of mind: the seeming first-person phenomenal properties of consciousness are an illusion, with various evolutionary explanations put forward as to why the brain creates such an illusion (see Frankish). As I will explore next chapter, such a theory is the ultimate extension of the ontological sublime informed by modern science and is a frontal attack on not merely the liberal humanist subject but any kind of implied reader, or any subject who would have an experience of the sublime.

In *The Selfish Gene*, Dawkins merely adumbrates a *plausible* way in which a hard to explain phenomenon — consciousness — can in principle be pulled into a neo-Darwinian worldview. In the section of the main text to which the above endnotes refer, he says it like this:

> Whatever the philosophical problems raised by consciousness, for the purpose of this story it can be thought of as the culmination of an evolutionary trend towards the emancipation of survival machines as executive decision-takers from their ultimate masters, the genes. Not only are brains in charge of the day-to-day running of survival machines affairs, they have also acquired the ability to predict the future and act accordingly. They even have the power to rebel against the dictates of the genes, for instance in refusing to have as many children as they are able to. But in this respect man is a very special case, as we shall see. (Dawkins, *Selfish* 77)

Human (and more, male) exceptionalism, gigantic philosophical problems swept aside, organisms reduced to vehicles: these are themes discussed so far. The quotation also typifies the miniature form of the evolutionary epic contained in *The Selfish Gene*. This is a "story" with a "culmination" and a "trend towards emancipation". As Hesketh noted, evolutionary epics belie their Darwinian underpinnings in the almost unavoidable language of teleology, especially when it comes to the culmination of the epic: the understanding of the epic itself.

As a final point, I want to emphasise how Dawkins also attempts the fusing of the organic and inorganic: the other common feature of evolutionary epics. Since the *The Selfish Gene* he has become if anything more overt on this point. In *The Ancestor's Tale*, Dawkins emphasises what Hesketh has called "the relationship between the observer who can comprehend nature's vast sublimity and the natural world itself" (Hesketh 203). Compare Dawkins: "Not only did evolution happen: it eventually led to beings capable of comprehending the process, and even comprehending the process by which they comprehend it. This pilgrimage has been a trip, not just in the literal sense" (Dawkins and Wong 699–700). Dawkins staunchly abjures all teleological thinking — he chose to move the narrative of *The Ancestor's Tale* backwards in time to avoid anthropocentric conclusions. Yet he is impressed with the seeming self-apotheosis that is fostered by this perspective, precisely because of the contingency involved in evolution and human survival:

> Not only is life on this planet amazing, and deeply satisfying, to all whose senses have not become dulled by familiarity: the very fact that we have

> evolved the brain power to understand our evolutionary genesis redoubles the amazement and compounds the satisfaction. (700)

Note the language of layering or involution: *redouble*, *compound* and the adjective *very* in the sense of self-reference. And both the quoted passages use a colon to introduce the self-referential layer of meaning, as if to signpost the profundity of the forthcoming sentiment. The parenthetical clause "and deeply satisfying" tells us that Dawkins will not brook any negative *evaluative* judgement of the epic, let alone a scientific one. The fact–value distinction is collapsed.

Finally, Dawkins explicitly evokes nature's sublimity to make a favourite point: "My objection to supernatural beliefs is that they fail to do justice to the sublime grandeur of the real world" (700). This is Dawkins on a familiar anti-religious streak, but this is also the quiddity of the scientific sublime, rarely made explicit in popular texts. In the case of the evolutionary subgenre, Dawkins is very willing to explore the strange enfoldedness of ontological layers and the "trip" that it entails as it confounds habitual thinking. These quotations from *The Ancestor's Tale* are in some ways more hackneyed than the examples from his earlier texts, because they are largely recapitulating the nineteenth-century genre's trademarks. But when read in the context of the metaleptic ideas previously put forward by Dawkins they seem less derivative and hint at a potentially radical set of ideas that Dawkins himself has stopped short of exploring. At a minimum they attempt to extract an aesthetic or moral value from the scientific, non-teleological account of evolutionary history.

The epic is supposed to provide not only an explanation for how all the complexity of the world came about, but also to offer an account of where (as memes) concepts, narratives, norms, agency, consciousness and culture came from and finally to be an example of a meme worthy of admiration. Dennett has elaborated a philosophical justification of this worldview. In *Darwin's Dangerous Idea*, Dennett summarises the promise of Darwinian evolution, not merely as an explanation of speciation and other biological phenomena, but of much else in science and even in other domains usually thought to be ontologically distinct: "In a single stroke, the idea of evolution by natural selection unifies the realm of life, meaning, and purpose with the realm of space and time, cause and effect, mechanism and physical law" (21). *Is* and *ought*, along with facts and values, are fused together, finally, in the epic of evolution. This vision is sublime as it does disrupt habitual ways of thinking about

the world and dissolves ontological boundaries. Although it does not explore the potentially more radical implications of such dissolution — unlike some of the texts in invisible biology — this vision is nonetheless another example of the soaring metaphysical ambitions of popular science.

CHAPTER 5: Cognitive science and the lucid sublime

> Kant's theory of the sublime (however awkwardly he presents it) is based on a cognitive structure that is basic to us as finite embodied beings. It consists in the fact that phenomenally or psychologically overwhelming phenomena can make the extraordinary scope of rational comprehension vivid to the senses. This can be instantiated differently under different historical conditions — there are, in other words, different modes of the sublime — but it is the same cognitive structure that is at issue in each of them. (Crowther 166n3)

The ontological sublime is an experience that calls into question the coherence of the subject having that sublime experience. Popular books about the brain (by neuroscientists and cognitive scientists) produce the most intense version of the ontological sublime because the object of their study is the experiencing subject.[73] In this chapter I try and answer three questions. First I investigate (1) whether or not there is a distinct *neural sublime* — as proposed by Alan Richardson — sufficiently different from other versions of the sublime already discussed. But in answering this — which I do by extending the neural sublime beyond Richardson's work — I hope also to suggest answers to two questions dogging previous theories of the sublime and running through the earlier chapters of this thesis: (2) whether the sublime is usefully thought of as a cognitive effect and (3) whether the experience of the sublime is ultimately self-abnegating or self-affirming.

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[73] I read Diane Ackerman's *An Alchemy of Mind*, Lisa Feldman Barrett's *How Emotions are Made*, *Meme Machine* and *Consciousness: An Introduction* by Susan Blackmore, *My Stroke of Insight* by Jill Bolte-Taylor, Nick Chater's *The Mind is Flat*, Patricia Churchland's *Touching a Nerve*, Stanislas Dehaene's *Consciousness and the Brain*, *Self Comes to Mind* and *The Feeling of What Happens* by Antonio Damasio, David Eaglemann's *Incognito: The Secret Lives of the Brain*, Gerald Edelman's *Wider Than the Sky*, Peter Godfrey-Smith's *Other Minds*, Michael Graziano's *Consciousness and the Social Brain*, *A Day in the Life of a Brain* and *The Private Life of the Brain* by Susan Greenfield, Nicholas Humphrey's *Seeing Red*, Michio Kaku's *The Future of the Mind*, Steven Pinker's *How the Mind Works*, V.S. Ramachandran's *The Tell-Tale Brain*, *The Man Who Mistook His Wife for a Hat* and *The River of Consciousness* by Oliver Sacks, Carl Sagan's *Dragons of Eden*, Sebastian Seung's *Connectome* and Mario Sigman's *The Secret Life of the Brain*. I also examined several works of the philosophy of mind or cognitive science that were to aid understanding of the science within the popular genre: *The Centred Mind* by Peter Carruthers, *What Makes is Think* by Jean-Pierre Changeux and Paul Ricœur, Andy Clark's *Surfing Uncertainty*, Daniel Dennett's *Consciousness Explained*, *Illusionism* by Keith Frankish (ed.), *I am A Strange Loop* by Douglas Hofstadter, *Being No One* and *The Ego Tunnel* by Thomas Metzinger, Alva Noë's *Thinking Outside the Head*, Murray Shanahan's *Embodiment and the Inner Life* and Michael Tomasello's *A Natural History of Human Thinking*.

In brief, I argue that the sublime experience in general can indeed be usefully explained in *partly* cognitive terms with the aid of contemporary neuroscience. But characterising it as a *merely* cognitive effect betrays certain preconceptions about what cognition is and overlooks the more sophisticated ideas about so-called 4E (enacted, embodied, extended, embedded) cognition currently favoured by a growing number of scholars in the humanities. As mentioned in Chapter 3 (see page 143), Barad's concept of entanglement also extends and embeds the subject into material phenomena. So I would add *entangled* to the 4E model and emphasise the degree to which even well described brain-based processes are enmeshed in other parts of the world and across time. Consequently I also argue that the self is (n)either affirmed (n)or negated by the nature of the sublime, given an entangled and distributed thoroughly post-Kantian notion of the subject is adopted. Such a notion is supported, rather than undermined, by the most seemingly alienating ideas of modern science, as discussed in previous chapters. The cellular nature of humans, our semi-autonomous microbiomes, the evolutionary history of life and the many worlds interpretations of quantum physics, all suggest that a stranger but more radical version of subjectivity and selfhood is warranted. It is plainly different from the self or subject involved in Kantian formulations of the sublime, and so the question posed — about the cognitive nature of the sublime — on that basis is now inapplicable or at least anachronistic: a case of (n)either/(n)or.

The limit and the void seep into popular science texts. But openly challenging the integrity of the reading subject is a very different rhetorical exercise from merely appealing to their sense of wonder. It is unsurprising that most popular science authors refrain from doing so. A few are willing to call into question the liberal humanist subject of the implied reader. Ed Yong, for example (examined in Chapter 3), pushes for a more entangled, multiple idea of the self. Some authors, influenced by Buddhism, Taoism, or Vedic traditions, call for a dissolution of the egocentric model of the self in light of the holistic and vast nature of the cosmos; the physicists Fritjof Capra and Alan Lightman are two examples. But in the main, popular science texts provide material that *implies* the undermining of the Kantian or pre-Kantian subject, while they nonetheless announce that scientific research is good, the results awesome and our ability to comprehend them wonderful.

Some commentators on popular science (Gross, Sideris, Curtis White) have recognised such rhetoric, but have missed the subversive potential of the latent

messages in the text. What makes popular neuroscience especially interesting is that very recently a sub-subgenre has emerged that happily foregrounds the attack on the liberal humanist subject, explicitly undermining the reader's coherence and consciousness.[74] This is a standard move in modernist or postmodernist novels, or texts that explain psychoanalysis. But for a popular nonfiction genre, one allied so closely to the liberal technocratic system in which almost all its authors and readers reside, it is remarkable.

Richardson's neural sublime, however, is still rooted in a Kantian heritage and draws on popular neuroscience texts that do the same. But communicated latently — one might say subliminally — in those texts and overtly in the newer texts which I examine, is a much more extended version of the neural sublime that I call the *lucid sublime*. Richardson locates his neural sublime in any text that demonstrates the neural- or brain-based self. By this he means any textual reminder that neural machinery is working away underneath habitual cognition. He points to the use of optical illusions in popular neuroscience texts as exemplars of the neural sublime (17–22). Such triggers of the neural sublime contain their mix of initial disruption followed by a sense of pleasure, he argues, in what is essentially a Kantian movement of the sublime. And although he sides with Hitt — who proposed the ecological sublime — in claiming self-abnegation as the preferred outcome of the sublime, this is only advocated because it tempers human exceptionalism (Richardson 35), not because of a more thoroughgoing disruption.

Richardson stops at visual illusions and the disjuncture between how things seem and how they are: assuredly a staple message of popular neuroscience and a process of defamiliarisation of the previously familiar (21). But the edgier results of cognitive neuroscience go far beyond optical illusions.[75] In the popular texts examined here, all aspects of experience are defamiliarised and in addition to a

[74] Specifically, the sub-subgenre comprises texts by Barrett, Chater, Dehaene, Godfrey-Smith (*Other Minds*), Graziano, Humphrey and Metzinger (*Ego Tunnel*). Blackmore's *The Meme Machine*, Dennett's *Consciousness Explained*, Hofstadter's *I Am a Strange Loop* and Marvin Minsky's *Society of Mind* were popular forerunners.

[75] A brief note on terminology. *Neuroscience* developed out of neurophysiology and neurobiology and is concerned with the workings of the brain at various levels of magnification. *Cognitive science* is a more interdisciplinary field comprising influences from artificial intelligence research, linguistics, developmental psychology and philosophy among others. *Cognitive neuroscience* is the branch of neuroscience that is most closely aligned with cognitive science, dealing as it does with cognition, behaviour and consciousness. It is a fair generalisation to say that the authors in the popular genre that are more willing to comment on consciousness tend to be from the cognitive science field. Neuroscientists tend to be charier about issues that overlap with philosophy.

disjuncture between appearance and reality there is interposed a further one between the appearance of appearance and the reality of appearance. That is to say people's intuitions about how the world seems are upended, but so are our intuitions about those intuitions; and we are shown to be wrong not only about how the world is, but wrong about how it seems to us as well. Simultaneously, this pervasive defamiliarisation also lays the ground for a kind of awareness that depends on this lack of access. In Lyotardian terms, the unpresentable (the neuronal basis of cognition and the lack of access to most perception) is the condition of possibility for any presentation (conscious awareness). In Žižekian terms — and he addresses this precise point, with reference to popular neuroscience (*Nothing* 721–3)— the subject is created when it fails to articulate itself in a signifying chain: its revealed void or negativity is a positive feature. This appreciation of limitations and their necessity engenders an awareness of the conditions of possibility for a seemingly paradoxical subject. I call triggers of this awareness the lucid sublime.

This chapter begins with a quick preliminary note on consciousness, the most contested concept in both popular and academic neuroscience texts alike. I then examine primary texts by Nick Chater and Sarah Feldman Barrett. These authors evince the lucid sublime: they defamiliarise normal cognition to such an extent that they totally undermine consciousness as a whole and the nature of subjective experience. Because this chapter is about a scientific discipline that claims to explain subjectivity and give a scientific account of different experiences, some reflexivity is in order. As such I briefly survey the recent work on the neuroscience of sublime experiences and related experiences of awe, wonder and astonishment. That work is theoretically limited and provides more insight into the epistemological sublime than the ontological sublime. And so, in the final two sections, I look to the work of Hayles and Žižek for perspectives on recent cognitive science and consciousness. Following Hayles (and Barad) I offer the notion of distributed cognition as a more defensible way of investigating subjectivity in light of modern neuroscience. And following Žižek, I suggest that the illusionist theories of consciousness found in popular neuroscience texts can be used to offer a theory of the sublime. The lucid sublime incorporates an updated notion of the subject that has that sublime experience.

A note on consciousness

Consciousness is an infamous topic for philosophers, commentators and neuroscientists. Even the last ten years appears to have represented a major shift towards much more confident accounts of consciousness, as seen in popular science books and attendant commentary and philosophy. The works I examine closely are all from within the last decade, and all of them refrain from issuing the standard caveats and disavowals typical of texts from the preceding twenty years. For a time it was seen as foolish to study consciousness, or it was simply a case of straying beyond one's disciplinary boundary — "a career limiting move" according to Susan Greenfield (*Day in the Life* xi). There is no shortage of cultural commentators who lambast neuroscientists for exactly this sin.[76] And there is no shortage of naive interpretations of neuroscientific findings, or simplistic mappings of one specific part of the brain to a specific feature of consciousness. But the authors examined here have clearly done some wider reading.

Whereas consciousness had often been described in the subgenre as something beyond the comprehension of the conscious mind (Pinker 561), or something about which no one has the slightest idea (Fodor 5), some latter authors do not see it that way. Two solutions to the problem of studying consciousness have recently appeared. First, a lot of credible work has happened in tackling the evolution of consciousness: why and in what sequence this apparently superfluous and perhaps unique (to *Homo sapiens*) ability evolved (see Tomasello for the vanguard in the field). Second, new experimental techniques allowed researchers to go well beyond the one-to-one mappings of naive investigators.[77]

As a consequence of these — and other developments no doubt — the metaphors describing consciousness have also shifted. New metaphors in science do a huge amount of explanatory work and allow scientists to proceed more quickly over territory that is not yet fully understood (Keller, *Refiguring* 114–21). I think the new

[76] Gross, Midgley, Sideris and Curtis White as already mentioned, but see also John Gray.

[77] Especially important was the advent not only of functional magnetic resonance imaging (fMRI) technology, which provides a high resolution "snapshot" of the brain, but also voltage-sensitive dye imaging (VSDI) which allows for monitoring of activity over a timescale relevant to conscious activity; and further, the development of functional electrical impedance tomography by evoke response (fEITER) provides an even finer temporal resolution (Greenfield, *Day in the Life* 42–50). Critics of simplistic neuroscience tend to overlook these newer techniques and focus on the limitations of fMRI, which can only register activity that endures for several seconds, akin to a Victorian daguerreotype. VSDI captures brain events lasting as little as 8 milliseconds (a millisecond is a thousandth of a second) and fEITER can distinguish as finely as 500 microseconds (a microsecond is a millionth of a second).

metaphors for consciousness have helped neuroscientists go beyond naive representationalist accounts. Consciousness is figured as a virtual reality, an immersive simulation, a lucid dream, an hallucination, a hoax, a *feeling* or *happening* rather than as a projection, a film, a procession, a show, a tapestry. The latter are either static or passive media whereas the former are both experiential and processual.

Critics of the whole enterprise counter by saying we cannot in principle ever be *conscious of* the way consciousness works, because of cognitive limitations, and so a scientific or philosophical explanation of consciousness will remain a chimera (Pinker 561–5). But although it may be impossible in practice for various reasons, I do not see why this in-principle objection applies only to theories *of* consciousness. According to this standard, could we ever be *conscious of* an explanation of any of the highly counterintuitive and unpresentable phenomena discussed in earlier chapters (*e.g*. dark matter, extra-dimensions, the microbiome)? It prompts the question as to what counts as being *conscious* of any knowledge at all. But that leaves cognitive neuroscientists precisely at the point they started from: trying to explain consciousness. Against the backdrop of these kinds of explanatory impasses, I have followed a different tradition and contend that consciousness can be talked about and operationalised, if not ever fully or intuitively understood, even while other texts deny this can be done. Consciousness is thus a parallel to the experience of the sublime itself: an intimation of something beyond easy comprehension, a presentation of the unpresentable. As the void in the centre of all popular neuroscience books, consciousness is on the same plane as similarly challenging phenomena from earlier chapters. However, the peculiar relation that consciousness and subjectivity hold with the experience of the sublime — triggered by any phenomenon — is inescapable. The status of the conscious subject must help inform what the status of the sublime is if the sublime is an experience the conscious subject has. And so the sublime of this chapter is something of a meta-sublime and that is why I make it the final chapter.

The neural sublime

Richardson's *The Neural Sublime* is a study of British Romanticism, utilising some of the theories prominent in the cognitive humanities movement.[78] For Richardson, instances of the neural sublime in prose, poetry, or images "dishabituate our habitual relation to perception and our own thinking process, defamiliarising ordinary cognition" (21). But although the study is of Romantic literature, Richardson introduces the theoretical basis of the book with reference to a strategy common to many popular neuroscience texts:[79]

> Books written for a general intellectual audience — in particular cognitive neuroscientific "crossover" books — frequently enlist the reader as coexperimenter. They ask the reader to perform a series of self-experiments, often involving visual illusions or like forms of cognitive bewilderment (17).

Such experiments generally take the form of visual or optical illusions, such as a diagram that demonstrates the blind spot, provided the reader closes one eye and holds the page at a certain distance from their face. Other well-known illusions cited by Richardson include the duck-rabbit, the Necker cube and the Kanizsa triangle. The ensuing "cognitive bewilderment" and "defamiliarisation" described by Richardson are completely in line with the sublime discussed in earlier chapters: a rendering of the limits of comprehension, in this case via *ostranenie* involving a familiar object, rather than confounding via an exotic or vast object.

Richardson also recognises that the neural sublime may say something about the sublime in general, from Longinus up to the present. The "oh wow" response of people exposed to the visual illusions is evidence of a rhetorical success by authors of popular neuroscience and overlaps with the rhetoric of the sublime (22). In response to Sircello's claim that the sublime represents an impossible effect because it is predicated on access to epistemologically inaccessible objects, Richardson rightly argues that there are ways to gain knowledge of a lack of knowledge, or indeed to become indirectly aware of something beyond direct awareness. The blind spot is an obvious analogy for, and a concrete example of, the difficult and *seemingly*

[78] See *The Cognitive Humanities* by Garratt (ed.) and *Cognitive Literary Science* by Burke and Troscianko (eds) for representative collections.
[79] Richardson draws on Churchland, Dennett, Edelman and Ramachandran, all included in my study.

paradoxical experience of the sublime. One can be made aware of the existence of the blind spot without ever being able to see it because it is a gap in what is seen.

As to whether this experience of the neural sublime has a cognitive component, Richardson of course says that it does (23). But he adds that this is "in disagreement with more recent accounts that would limit the sublime to a purely linguistic, rhetorical, or textual phenomenon" (23). Here Richardson under-theorises the neural sublime and the foregoing quotation is a clue as to why. There is no sharp dividing line between "cognitive experience" and "purely linguistic" (or rhetorical or textual) phenomena. Some of the very same sources cited by Richardson to explain the cognitive bewilderment typical of the neural sublime actually go much further than he suggests and defamiliarise not only habitual cognition but all cognition; they render strange not just visual perception, but all conscious experience; and they complicate the interrelations of language, cognition, representation and the unconscious.

Richardson understands — or at least characterises — consciousness as a *medium* and the brain as a kind of generator of this medium. In a word, this is representationalism. Following Barad (46–50) and a long list of philosophers in both the continental and analytic traditions, I share a suspicion of the representationalist approach to science, language and consciousness. Barad decries the "asymmetrical faith we place in our access to representations over things" as "simply a Cartesian habit of mind" (49). She notes how "representations are presumed to have a mediating function between independently existing entities" (47). Richardson betrays this Cartesian habit of mind in differentiating what he takes as the representational functions of language, rhetoric and text and the separable processes of cognition. And yet this leaves cognition in a representational mode also, as it is responsible for containing or showcasing elements from language or text, or, if "emptied" of those, the contents of perception (37). Richardson offers as the ultimate neural sublime an experience of the "'brain's eye view' of the world" that is stripped "of the usual overlay of conceptual and linguistic categories, an unfiltered and unedited encounter with the real" (37). The assumption is that once the contents are emptied out of the medium of consciousness, what is left is a pure medium, no longer sullied with representations. This positions the representations as the way we normally gain access to things. But that is already to posit a distinction between things and representations and also implies that a consciousness emptied of

representations is something like the unfiltered image or lossless recording of the real world — an idea that, we will see, is utterly unsupported by modern neuroscience. In Barad's worldview, representations cannot passively or perfectly *reflect* the things they represent. Instead, in all these domains of thought a more performative or processual metaphysics is warranted.

Regarding consciousness in particular, Dennett is another staunch critic of representationalism (although he does not use that term). Dennett's *Consciousness Explained* is part philosophical tract part popular science book and is the very work from which Richardson quotes the blind spot diagram. One of the rhetorical goals of *Consciousness Explained* is to expose the untenable but intuitive idea of consciousness as a kind of "Cartesian theatre" in which the "presentation" or "projection" of consciousness plays out or is viewed in sequence as on a stage (107). The metaphor of the theatre leads to the well-known homunculus fallacy: the positing of a miniature version of the self, inside the brain, observing the "show" of consciousness, which only removes to another step the problem of explaining consciousness because the homunculus itself must have a mind where consciousness happens, and that mind must have a homunculus inside it, and so on. More generally, any notion of consciousness as a medium or stage on which the contents of consciousness are represented in an analogous fashion to representational media like cinema or landscape paintings, has no basis outside of our intuition. Dennett calls this and other inherited intuitions about how the mind works "folk psychology" (303).

Dennett breaks down the inflated view of consciousness as a cinematically rich representation of reality by use of the blind spot and other optical illusions — instances of the neural sublime (322–4, 355–6). The presence of a blind spot in the middle of the visual field, that we cannot detect without an experiment, and never see, is evidence that we *suppose* conscious experience — at least of the visual field — is more coherent than it is. Another example he gives is that we cannot perceive colour at the edges of our vision, only in a small area in the centre (54). This seems implausible and, like the blind spot, can only be indirectly presented by demonstration. Dennett takes these and other examples to much more radical territory than Richardson. Dennett notes that this opens up a gap between our first-person reports of conscious experience and the reality of that experience. He elaborates to other aspects of consciousness — auditory, linguistic, emotional — and

argues that in those domains as well we can be wrong about how things *seem* to us on top of being wrong about how things are (see especially 362–6).

Richardson, however, concludes that the visual illusions "demonstrate how the conscious mind is fed a mere simulacrum" (22). He thereby invokes the Cartesian theatre by implying that our conscious mind *receives* or *views* a kind of representation of the scene in front of us. Richardson concedes that the "simulacrum" is "a sketchy one at that, filled in here, edited there, of an only apparently stable and clearly outlined object world" (22). He takes the visual illusions to be evidence of the unreliability of the world or our image of it, not our own reports of consciousness.

Curiously, in another passage Richardson does acknowledge the suspect nature of our experience of consciousness: "By discrediting conscious introspection, revealing its literal as well as figurative blind spots, such illusions leave us open to the counterclaims of cognitive and neuroscientific theory" (21). But the claims he refers to are of the hidden contributions of "unconscious processing" and our "disturbingly alien brain" (21). The neural sublime is chiefly about how the brain contributes more than we realise to our everyday habitual cognition. This is no doubt a shock because our habitual cognition is precisely when we are not thinking about how we are thinking. But it is an underwhelming conclusion to take away from demonstrations of how mistaken we are about even the basics of conscious experience. Of course the brain contributes more to habitual cognition than we are aware of. It could not be otherwise. But if that was the extent of the idea it would make Freud the originator of the neural sublime.

The philosophical implications of visual and other illusions are, for Dennett, nothing less than a re-*writing* of how we should consider consciousness. The self is "a centre of narrative gravity" (427–30), conscious experience is framed as "multiple drafts" of awareness that overlap in time (111–43) and consciousness *is* the contents of conscious thought rather than the medium (354), their richness only possible because of the richness of sense data from the world (408). He is one of the most well-known philosophers of mind and his ideas are much more compatible with work in continental philosophy (see Staten) than other well-known philosophers of mind such as David Chalmers, Thomas Nagel and John Searle all of whom adhere to varieties of representationalism. I dwell on Dennett's ideas because the more recent popular authors that I focus on here all acknowledge his influence. This influence

doubtless contributes to the much more radical defamiliarisations in their texts. They go far beyond merely dishabituating the reader from habitual cognition and reminding them of the unconscious workings of the brain, as in Richardson's neural sublime. They also call attention to the strangeness of becoming aware of the limitations on awareness.

Indeed they make strange what we take to be awareness as such. Just ten years earlier most popular authors avoided the "hard problem" of consciousness (Chalmers' phrase). The nature of "phenomenal consciousness", the "raw feels", "what it is like to be" something was generally seen as an ineffable aspect of experience and indeed as a part of the world qualitatively different from the physical world described by science. But authors like Chater, Dehaene, Graziano and Greenfield are much more willing to try and explain phenomenal consciousness, even to explain it away. In doing so they attempt not only to defamiliarise but to re-familiarise something standardly seen as alien or ineffable.

A way for many authors to do this is to explore semi-conscious states. Churchland, Greenfield, Metzinger and Sigman all make much of the surprising cognitive capacities of sleepers. *Parasomnias* — sleep disorders — include sleep-talking, -walking, -cooking, -driving and -molesting. Such activities do not correlate with REM sleep, meaning that people exhibiting parasomnias are not acting out their dreams; they may not be aware of anything at all. And yet they can complete complex motor tasks and even maintain one side of a pseudo-plausible conversation. And yet the legal system and most scientists do not consider the sleepers to have volition, agency or awareness of their actions. They are humans performing actions but lacking the conferral of subjectivity. What is the remainder once the substantial capacities of the somnambulist are subtracted from a waking, volitional, legal person? The question is complicated by the bridging phenomenon of lucid dreaming. This experience seems to entail the awareness and self-reflexivity of waking life but without the ability to perform bodily actions. Communication with the waking world is possible via the use of pre-arranged coded eye-movements, eye muscles being the one part of the body still under control of a sleeping subject (Metzinger, *Ego* 144). The lucid dreamer is aware they are in a simulated world courtesy of their own brain and aware that there is a world beyond the simulation they are experiencing. They seem to themselves to be conscious and can report the fact to others. And yet there is clearly *something* lacking from the experience. We can take this as a metaphor for

how waking experience is framed by the authors who go beyond the neural sublime. Typically they attempt to *awaken* the reader to the conditions of their perhaps not fully or phenomenally conscious state: in that way the authors attempt to make the reader aware of their provisional and simulated awareness, that *something* is lacking. For that reason I call these instances of the more radical *lucid sublime*.

Nick Chater's grand illusion

The gap-filled, sketchy, papered-over nature of our visual experience has been called "the Grand Illusion" (Noë iv, 113–5). Echoing the allusion to stage magic, a recent movement in cognitive science and the philosophy of mind has coalesced around the name *illusionism* which claims that all conscious experience is illusory in its apparent richness.[80] The illusion extends beyond visual experience to encompass emotions, multitasking, the subconscious, memory, higher order thinking and the sense of self. Chater, in *The Mind is Flat*, puts forward the boldest version of illusionism. All aspects of mental life, which seems to be detailed, deep, coherent and profound are "flatter" than they appear, just as visual experience does not hold up to scrutiny when interrogated by cognitive neuroscience.

Chater starts with visual perception, which is easily demonstrated with instances of the neural sublime identified by Richardson (Chater 40–2), and moves "inward" from there:

> Without the hoax, our subjective experience would be strange indeed: we would be tormented by the sense of the world as undergoing remarkable changes as we scan our eyes across it. Objects would suddenly snap into colourful focus, while others would, just as rapidly, be drained of detail and colour. This would, of course, be hugely misleading. Our experience would suggest exuberant flux even as we scan and examine an utterly still page of text, painting or scene. (58–9)

[80] See *Illusionism: As a Theory of Consciousness* (edited by Frankish), based on a special issue of *Journal of Consciousness Studies* including articles by Blackmore, Dennett, Gazzaniga, Graziano and Humphrey, authors mentioned here.

The "hoax" is Chater's metaphor for the illusion that helps us navigate the world. Yet the hoax is produced to give a more accurate picture of reality. Without it perception would have too much fidelity to what the eyes see, rather than what is probably in front of us. Compare to *The Neural Sublime* where Richardson assumes that an unfiltered awareness would be more faithful to reality. Again, this figures everyday conscious experience as a kind of filter added on to a more sublime and raw experience of the "naked brain". But in Chater, the term *hoax* at least removes one layer of distanciation between the Thing-in-itself and the maculate representation of it to consciousness. A hoax is real in the sense that it is not immaterial or imaginary, but is false inasmuch as is made to deceive.

The deception is not a high-level edited version of the visual scene with lower-level, unredacted versions somehow accessible if we could strip away the layers of interpretation, as in Richardson's characterisation. Instead, in Chater's view, there is no raw and unfiltered sensory "read-out" for the mind to use. The raw physical information that bombards the retina is not part of mental life, which Chater contends does not contain levels or layers in this way: "The mind is flat: our mental 'surface', the momentary thoughts, explanations and sensory experiences that make up our stream of consciousness is all there is to mental life. The illusion of mental depth is much more pervasive than it appears at first sight" (31). He goes on to claim that Western philosophy has striven so unsuccessfully for insights into "the nature of objects and events, mind and body, knowledge, belief or causality" because of the misguided and gap-filled intuitions about such things (31). The flatness of the mind and its tendency to confabulate or improvise rather than scientifically or philosophically *theorise* has meant we have had an illusory sense of depth about most of our philosophical ideas (32). One of the things the flat mind obscures is its own lack of depth.

Even philosophising is flatter than it appears. Higher order consciousness, including thinking about our thoughts or the ability to abstract "up" to higher levels of thinking about lower levels, is another faculty we are deceived into having, according to Chater. Rather, we only experience a stream of consciousness that focuses attention on certain sensory information, at a surface level, without the ability to multitask:

> We have no subjective experience of "deep" concepts of mathematics, the inner workings of our minds, or, indeed, consciousness itself. We can talk and write about these things; we can express them in symbols and sketches. But we are conscious only of the perceptual properties of these words, symbols and pictures, not of the supposedly shadowy abstract realms themselves. In short, we consciously experience the sensory information, broadly construed (including images generated by our own minds; sensations from inside our bodies, such as pain, feelings of exhaustion or hunger; and crucially from inner speech). But there is nothing more. (Chater 185)

These claims are based on laboratory experiments on people performing mathematical operations, feats of mental imagery, and metacognitive thought. Chater obviously does not deny the possibility of advanced reasoning, complex ideas, or serious intellectual labours such as writing books. But writing, talking and other media give the appearance of more thought happening inside one's head than Chater thinks is possible. The effortless everyday use of various representations lures us into thinking in representationalist terms or thinking that consciousness is a representational medium.

The distributed nature of much of our cognition — distributed across time and space in the form of media — is a recurrent point for Chater and also for scholars working in the 4E tradition and the illusionism tradition. When Chater admits that "we can write and talk about these things" and yet "have no subjective experience" of them, he is pointing to the excess of cognition, of thinking, that takes place outside of brains (185). With the aid of language, more can be expressed than thought. This is an inversion of Schiller's epigram for what the experience of the sublime provides us: "We can think more than we know" (24). Working in a Kantian context Schiller saw the sublime as disclosing a faculty of reason that can grapple with objects beyond the lesser faculty of imagination. Reason is the unshakable foundation underneath imaginative thought. But Chater's lucid sublime suggests there is less of a foundation or maybe no foundation. Sophisticated reasoning is not something the subject can really experience, other than by building out into the richer information processing afforded by language. We can become lucid of sophisticated ideas — even the idea of our limited consciousness which is communicated, after all, in Chater's book. But

language is colouring our experiences with a degree of complexity that cannot inhere in our minds, but is not therefore less real: this is the basic illusionist perspective.

Such an idea is perhaps not too shocking to literary scholars. This kind of forthright attack on the unity of the subject is commonplace in contemporary theory. But commentators on the popular science genre have overlooked its presence there. Katherine Hayles is an exception and her latest book *Unthought: The Power of the Cognitive Nonconscious* takes seriously the ideas in contemporary popular neuroscience, although it is not primarily a study of the subgenre. I discuss her work at more length below, but here I note that she too recognises the distributed nature of cognition and — echoing Barad — the distributed or extended nature of agency (2, 83, 105, 117–9). She also strikes a balance between the enthusiasm for the "return to ontology" represented by new materialism and object oriented ontology on the one hand (65–7) and a continued recognition of the textual and the linguistic (219n3).

In previous chapters I noted how the various popular science subgenres make strong ontological claims, often more radical than their authors may realise. In popular neuroscience we find the authors putting forward ideas about consciousness that are in some ways reminiscent of the work of Lacan and Žižek. Chater and others are even happy to directly address the reader in their act of reading to illustrate her flat mind: "your eye directs the fovea onto the word it is currently attempting to read" (Chater 41) but any perception of other words on the page is an illusion because we can see "roughly, one word at a time" (43). The repeated insistence that neither the reader nor Chater himself (the scientist) can be thinking anywhere near as much as they suppose is an advance on the rational subject conjured in, say, popular cosmology. Again, rather than the caricature of science writers as naive realists or unreflective positivists, I find ample evidence — especially in this subgenre — of radical, decentring ideas.

Lisa Feldman Barrett's simulations

Lisa Feldman Barrett is another cognitive scientist happy to make big philosophical claims in her work. *How Emotions Are Made: The Secret Life of the Brain* investigates the constructed rather than essential nature of emotions. In doing so she offers up an entire theory of how the mind works, which again plays down the nature of phenomenal consciousness and plays up the role of language in enriching thought.

Emotions were one example Chater used to illustrate the flatness of the mind. He and Barrett point to research (much of it by Barrett) that suggests emotions are concepts that the brain constructs based on a population of past instances of similar but not identical experiences. That means that emotions do not have some cross-cultural, neural, or bodily fingerprint. Instead, one's social history and how one is taught to classify and talk about emotions (including the mere addition of increasingly precise emotion words to one's vocabulary) determine how an affective response is interpreted (Barrett 9–12). In experimental conditions, people can be induced to interpret the same physiological response (a raised heart rate owing to adrenaline injection) as either anger, fear, or sexual arousal depending on contextual cues (34). Barrett's claim is that even something as seemingly internal and essential as emotion is largely externally produced; although such findings do as much to break down the internal–external division as to reverse it.

Where Chater calls the construction a hoax Barrett terms it an "hallucination" (26). She also begins with visual illusions as a way to initiate the reader into unfamiliar territory. An image of a bee created by negative or white space is offered as an example of how the brain constructs a meaningful interpretation based on past experience and often very little current evidence (25). The reader is enjoined to look at the image first, at which point it looks like meaningless blobs; then an explanation is given of what it represents (a bee) so the reader can return to the image and cannot help but interpret it:

> Your past experiences — from direct encounters, from photos, from movies and books — give meaning to your present sensations. Additionally, the entire process of construction is invisible to you. No matter how hard you try, you cannot observe yourself or experience yourself constructing the image. We needed a specially designed example to unmask the fact that construction is occurring. You consciously experienced the shift from unknown to known because you saw [the image of the bee] both before and after you had the relevant knowledge to draw on. The process of construction is so habitual that you might never again see this figure as formless shapes, even if you try hard to un-see it and recapture experiential blindness. (26)

Barrett creates a micro-narrative that makes use of an effect equivalent to *anagnorisis* in fiction: the revelation of information that recasts the meaning of earlier plot points. Here we have information given later in the text that prompts a "rereading" of the earlier part, in this case an image. This example is ironic as it is using defamiliarisation — of the earlier information — to explain how the brain achieves familiarisation in everyday activity. The way Barrett has presented it, the anagnorisis rewrites earlier experience, because the text is obviously written in a linear sequence. This is the equivalent of a twist ending that makes us go back, via either memory or rereading, to earlier details of a story. We return to look at the image in Barrett's text and no longer see it the way we did upon first reading. But the target of this explanation is the opposite phenomenon: how the brain uses *past* experience to make predictions about the future that are either confirmed or disconfirmed in the present.[81]

It is also ironic in light of Richardson's point that defamiliarisation is the mode of the neural sublime. In the example of the bee, Barrett is habituating the reader to the process by which the brain renders something unfamiliar as familiar. And yet it is true that the bee demonstration is nonetheless an example of exactly what Richardson is writing about. It is an optical illusion that illuminates the ordinarily secret workings of the brain, or "the secret life of the brain" as in Barrett's subtitle. This marks the difference between the neural sublime and the lucid sublime. The neural sublime, triggered by something like the Necker Cube illusion, dishabituates us from habitual cognition providing a "frisson" of delight. The lucid sublime, however, as invoked by the bee demonstration, renders strange even the process by which an item passes from the familiar to the unfamiliar, or vice versa. Is there an equivalent frisson with the lucid sublime? In the specific case of the bee image, there does happen to be. But *that* frisson and indeed the emotion of awe can also be explained by the framework Barrett offers for studying emotions (Barrett 94, 194, 320; discussed below). The momentary experience of the neural sublime gives way to a slower, more enduring effect which is the realisation that all experiences — including those of defamiliarisation and visual perception — are constructed by the unseen processes of cognition. Crucially, one cannot escape that process to achieve a private, mental appreciation of the limitations of, say, visual perception.

[81] Barrett is drawing on the paradigm of Bayesian predictive coding (381n51) currently sweeping cognitive science. See Clark's *Surfing Uncertainty* for a thorough review.

Richardson's neural sublime is something like an attempt at that: the conscious subject becoming aware of one aspect of cognition being constructed by neural machinery. But in the lucid sublime this conscious subject can only become aware of the conditions that provide for cognition of any kind, including that same awareness. According to Barrett, cognition is an ongoing, unfolding process which hallucinates an experience, including emotions, and including a frisson at having an aspect of cognition revealed.

What Barrett calls the "emotion concept of awe" (194) is what I am calling the epistemological sublime. It is on the whole a positive experience of the limitations of understanding. Ditto for the neural sublime and its attendant frisson in Richardson's work. The lucid sublime, however, is more like a set of conditions and their limits, the knowledge of which cannot familiarise or defamiliarise because these conditions disclose the interplay of past and present that shapes the hallucination. That it *is* a hallucination is able to be disclosed, such as in these popular neuroscience texts. But this only happens when the Cartesian and Kantian subject is deflated and diffused into the more distributed and extended processes of cognition, involving not only the subject's individual brain but systems of knowledge, the text, language, context, *etc*. It is also clear that this process relies on underlying mechanisms that cannot be conscious. They need to be not only unconscious, but also incomplete or heuristic to be intelligible or useful for the conscious subject (Barrett 163). And so the conditions of knowledge are in a sense *ontologised* not only by being explained by brain-based mechanisms as in any neuroscience text, but also by being embedded in networks of events and processes. The core of subjectivity is stretched out to an ongoing physical process rather than being some essence or core.

It is also worth noting that Barrett is working at the level of large scale brain networks, rather than merely discrete brain regions or smaller circuits of neurons. Networks involve several distributed brain regions activating in a highly correlated manner, better thought of as events rather than parts. The two networks principally responsible for monitoring a person's own state — including conscious thought — are the *default mode network* and the *salience network* (Barrett 68). Roughly speaking, the default mode network is in operation through most waking life, but it is interrupted by the salience network when a novel or dangerous object or event draws one's attention. What is interesting about the default mode network is that although it is a reasonable stand-in for Richardson's "habitual cognition", it is *simulation-*

based (Barrett 318), where a simulation is not a passive representation but an immersive, dynamic experience. Just as the default mode network is not a brain region, but a series of connections between clusters of neurons that activates over an interval of time, simulations are constantly running and re-running — even overlapping and revising — rather than being snapshots or images. Hence it avoids some of the pitfalls of representationalism.

Barrett emphasises a processual and performative model of cognition and consciousness. This is best illustrated by a passage where Barrett comments on another popular science subgenre and the counterintuitive ideas it presents. She mentions how baffled she was about the physicist's notion of expanding space, until she read Greene's *The Fabric of the Cosmos* and experienced the emotion of awe:

> A concept is not a "thing" that is in the brain, any more than "space" is a physical thing that the universe expands into. "Concept" and "space" are ideas. It is a verbal convenience to talk about "a" concept. Really you have a conceptual system. When I write "you have a concept for awe" this translates as "you have many instances that you have categorized, o*r that have been categorized for you*, as awe, and each can be reconstituted as a pattern in your brain". The "concept" refers to all the knowledge you construct about awe in your conceptual system in a given moment. *Your brain is not a vessel* that "contains" concepts. It *enacts* them as a computational moment *over some period of time*. When you use a concept, you are really constructing an instance of that concept on the spot. You don't have little packets of knowledge called "concepts" stored in your brain, any more than you have little packets called "memories" stored in your brain. *Concepts have no existence separate from the process that creates them*. (320, italics added)

This passage does four things. It emphasises processes over things. It also construes cognition as an enacted event rather than a passive or static situation. The container metaphor of knowledge — key to representationalism — is also dispensed with and, finally, the experience of awe is seen to be part of a lineage of prior experiences, partly made meaningful by others. Here again we have an example of an author discussing the conditions of what should go into a classical sublime experience — or,

as here, its rough cognate, awe — but actually outlining something more radical: the conditions of the lucid sublime.

Barrett discredits the intuitive sense of how emotions and concepts in general work. But she also maintains that we can use this knowledge to take an active part in constructing ourselves, even as we are forced to concede that we have no inner essence and that we are at the mercy of our contexts. Yet Barrett entreats us to "train the rider" (264). In so doing she gestures towards something that should be impossible given a thoroughly estranged view of the self: self-control. But in accepting a view of the brain that is embodied and embedded in a social context, there is the potential for a recognition of the limits of self-knowledge and how those limits can be manipulated or worked with to achieve a kind of self-knowledge nonetheless. Barrett presents a detailed theory of subjectivity, especially emotions. She thereby enacts not only a scientific sublime — by presenting the reader with counterintuitive imagery and ideas — but also implicates the nature of subjectivity in that sublime. The reader themselves and their experience are the object of study in this subgenre where reading and identity are defamiliarised in an ontological sublime.

The neuroscience of the sublime

In examining texts that purport to explain how consciousness, intelligence, experience and emotions work, it is fitting to reflect on the cognitive status of the experience of the sublime itself. This question has already been raised in earlier chapters, where I suggested that calling the sublime "*merely* a cognitive effect" is problematic on two points. First, it assumes that cognition is a remote or passive process, somehow divorced from the world in which it takes place. Second, even if cognition were like that, the sublime is never proposed as having a completely arbitrary trigger. Instead, there is some feature of the trigger — whether linguistic, rhetorical, natural, mathematical, technological, *etc.* — that overwhelms or confounds the subject. Admittedly critics are divided on whether it is some capacity of the subject that is overwhelmed (imagination, cognition, self-image) or rather the subject becoming aware of their already compromised status, by having the sublime disclose the void, excess, or unpresentable that always exceeds self and self-representation. These are the epistemological and ontological versions of the sublime

I outlined in Chapter 2 and developed in Chapters 3 and 4. I have argued that the ontological version is the more prominent version in contemporary scientific discourse, with the epistemological version more accurately associated with the concepts *wonder* and *awe*. But in either case, it is some non-arbitrary experience that is supposed to trigger these results. Certainly it may be that the sublime object is itself illusory: a mirage, an hallucination, a false idea; but the experience is taken as accurately exposing the limitations of representation, imagination and so on, or indeed of subjectivity itself. But whatever the trigger, the experience of the sublime must have some brain-based component, although trying to restrict it to the neural would be foolish.

Other scholars have had this idea. The best summary of recent research into the neuroscience of the sublime or awe is by Elizabeth Oldfather, in a contribution to *Contemporary Visual Culture and the Sublime*. Most studies in this area, she points out, have focused on awe or frisson, although Tomohiro Ishizu and Semir Zeki's well-known work did call the same phenomenon the sublime (Oldfather 120). Oldfather focuses on the most influential model of awe in this subfield, that of Dacher Keltner and Jonathan Haidt. They utilise the theory of cognitive schemata: "mental models, formed by experience, that allow us to efficiently process new encounters through categorisation rather than needing to attend to every detail individually" (121). These schemata are roughly synonymous with Barrett's concepts. When encountering something that cannot simply be assimilated into the subject's schema, a cognitive *accommodation* must be performed. Awe is theorised as being an accommodation of a schema resulting from an experience of something vast; *vast* is taken metaphorically and can involve an overwhelming of a schema of any dimension, including spiritual, mathematical and metaphysical (Keltner and Haidt 304). This can result in either a triumphal feeling, if the existing schema is simply expanded and made more capacious by the new experience, or alienating, if the accommodation is unsuccessful (Oldfather 122). But both feelings or effects happening, simultaneously, was not an outcome included in the experimental framework. So although delight/horror is one of the crucial features of even the pre-Kantian sublime that I have argued is closer to simply being awe or wonder, the triumph/alienation duo cannot be investigated within the Keltner–Haidt theory of awe.

Another study highlighted by Oldfather, by Luke Harrison and Psyche Loui, comes from musicology. Harrison and Loui's work on frisson in people listening to

music is notable because the music in question was purely instrumental and had been chosen because, theoretically, it is divorced from personal associations. Hence the test subjects would be responding to the aural qualities and structure of the music itself, rather than the semantic content of the lyrics. (It is not clear that this removes *all* associations the listener might have from previous engagements with similar music, but it does at least focus in on the structural effects of the music.) The common factor that the researchers found in music that produced frisson was a pattern of violated expectation, such as sudden shifts in volume or unusual chord progressions (Park and Loui 3). Similar results about violation of expectations have been found in frisson research in dance studies (Oldfather 125). These results are not so surprising. But they do corroborate a general theory of the sublime as having a cognitive component that involves a confrontation with violations of expectations, in any medium, dimension, or modality.

A tantalising idea included by Oldfather comes from the science fiction scholar Istvan Csicsery-Ronay. Theoretically, when readers enter a fictional world their cognitive schemata necessarily perform some accommodations, mild ones in the case of realistic narratives (Oldfather 123). But in science fiction, claims Csicsery-Ronay, the world encountered is often so counterintuitive and counterfactual that they "surpass the accustomed and habitual" (Csicsery-Ronay 71). In the popular science genre, the world entered by the reader certainly surpasses the accustomed and habitual, but is being presented not as fictional but as the reader's actual world. And in popular neuroscience texts that offer an illusionist perspective, the intuitive view of reality is held to be fictional.

This leads me to the most pertinent argument in Oldfather's work, where she distinguishes between the cognitive effect of awe and the sublime. Comparing the effects of two fictions, James Joyce's story "The Dead" and M. Night Shyamalan's film *The Sixth Sense*, she notes that the trick ending in the latter certainly entails the violated expectation of the cognitive model of awe proposed by Keltner and Haidt. But Joyce's use of imagery of natural vastness and the undermining of the main character's selfhood, as well as the violation of a moral schema, achieves a more enduring feeling of "recentring" because it has implications for the reader's self: it is "personally cognitively real" (Oldfather 123–5). *The Sixth Sense* provokes a kind of epiphany that is only context dependent, because, in Oldfather's words, "I am not a ghost" (125) and so the revelation in the denouement that the main character is a

ghost does not bear on the extra-textual world of the reader. In popular science texts, the world of the text *is* nominally the reader's extra-textual world. And threat to selfhood instigated by vastness and the undermining of existing schemata, is enduring because it is not merely context dependent — although the experience fades as one withdraws from the text. Popular science could be seen as containing a combination of science fiction's surpassing of the habitual, and sublime narrative fiction's attention to the personally cognitively real.

Studies in the neuroscience of awe tend to equate awe, frisson and the sublime, if they mention the sublime at all. But the results are noteworthy at least as far as they show neural states that are unequivocally distinct from simple enjoyment and which are triggered by physical or metaphorical vastness and expectation violation (120, 125). These neural states have not yet been clearly sub-divided into positive and negative affect (triumph versus alienation), nor has there been any research on mixed or ambivalent affective states; nor has there been any cross-cultural comparisons of differences in awe, frisson, or sublime experiences. But there is a consensus that the violation of expectations, *i.e.* the exceeding of habitual frames of reference along any of multiple dimensions, produces an effect that has cognitive and neural signatures. Oldfather interprets this consensus as aligning the sublime not with "fear, transcendence, or alienation, but rather to the simpler practical delight of learning" (127). But again, this ignores the alienating version of awe noted by Keltner and Haidt, as well as the prospect of a more confusing or irreconcilable sublime experience that confounds learning.

The question, in light of modern neuroscience, is whether there is a cognitive component to the experience of the sublime, whether epistemological or ontological. Clearly the answer has to be yes, in a trivial sense. But the results summarised by Oldfather, combined with the implications of the neuroscientific perspectives that give rise to the lucid sublime, consolidate a two-level theory of the sublime. The first, epistemological level, is nowadays better termed awe or wonder, even though in retrospect it does well capture the Burkean sublime and roughly the Kantian sublime (provided one settles on the final, positive affective state in the Kantian movement). It is a real experience for the subject, triggered by any object that disrupts habitual cognition, as in Richardson's neural sublime or the cosmological sublime from Chapter 1. And it is *generally* associated with a positive affect. Then the more interesting and radical ontological sublime is triggered by an intimation of something

not merely exceeding one's knowledge or imagination, but exceeding or dissolving one's desire for a coherent or unified subjectivity (in a way that resists the Kantian movement of the sublime which allegedly ends in reassurance and self-affirmation). It is "personally cognitively real" in Oldfather's terms and resists accommodation. That is not to say it is a purely negative affective state. Rather it is an awareness — albeit dim, paradoxical, or unstable — of some lack, void, or aporia that inheres not within a limitation of our understanding, but in what it is we seek to understand, or the ground of understanding itself.

Entangled or distributed cognition

The dispersal of cognition and even consciousness beyond the confines of the skull is a key tenet of 4E approaches to cognition and to what I am calling the lucid sublime. And once conscious experience no longer depends on the strictures of an inside/outside binary, the experience of the sublime follows, *i.e.* it is no longer assumed to be an experience of self-affirmation by a bounded, autonomous, liberal subject. Moreover, the revelation of the apparently alien idea that cognition also happens outside the head, is a trigger of the ontological sublime that complicates the ground of subjectivity. Distributed — or extended — cognition is another point in favour of an ontology of entanglement. And as to the question of whether the sublime is ultimately self-affirming or self-abnegating, it must be that the self assumed in that question is now inapplicable based on cognitive science (and much twentieth century theory).

Hayles' approach to distributed cognition is to offer the notion of *cognitive assemblages*. These are technologies that perform cognition that is too fast for *conscious* humans and allow humans to thereby carry out cognitive tasks that would otherwise exceed their abilities (*Unthought* 11). Because of these features, Hayles likens cognitive assemblages to our very own unconscious brains: "Their emergence represents the exteriorisation of cognitive abilities, once resident only in biological organisms" (11). For her, cognition is "a process that interprets information within contexts that connect it with meaning" (22), regardless of where it happens. Clark and Noë even go on to explicitly include language, mathematics and tools as part of these distributed cognitive assemblages. Hayles draws on the work of the physicist Edward Fredkin, for whom, "The meaning of information is given by the processes

that interpret it" (Fredkin qtd. in Hayles 23); she notes that because processes occur within contexts, the meaning of information must clearly be context-dependent. All of this leads in the direction of a more distributed model of cognition, understanding and subjectivity. More broadly, it speaks to the metaphysics of entanglement advocated by Barad and which underlies much science that appears at first glance to be representationalist.

We can extend Hayles' work here by noting the surprising temporal aspect to cognition. The unconscious brain is fast; the conscious brain is slower. Hence the title of Daniel Kahneman's *Thinking Fast and* Slow, a very popular summary of his and Amos Tversky's work in the psychology of decision making. That book popularised two terms from cognitive science: System 1 (roughly instinctual, unconscious, fast cognition) and System 2 (roughly deliberate, conscious, slow cognition). In outline, we can say that Kahneman's metaphors of System 1 and System 2 can be expanded to something like a System 3: including parts of the body other than the brain, such as the microbiome in the gut, along with the immune system and the endocrine system, as seen in Chapter 3. And we can add the distributed cognition that utilises media, language and the Systems 1 and 2 of others and what Hayles calls cognitive assemblages. This idea of System 3 thinking is in keeping with the thrust of the 4E movement. Indeed it should also be noted that even Systems 1 and 2 should be thought of as extending beyond the confines of the brain to include other parts of the embodied subject. And, as the analogy should suggest, I think that System 3 is potentially even slower than System 2. Admittedly, Hayles points out the parallels between a data crunching computer that is not conscious but is thinking fast and our own brain's fast unconscious processes. But even more striking, I feel, is the drawn-out, enduring temporality entailed by processes that take place over years or even generations, in terms of the cognition carried out in institutions, languages, inventions and culture. And it is this aspect of System 3 that allows for a cognition markedly different from the unconscious fast processing of System 1. Even one of Hayles' cognitive assemblages, for instance, can be seen as a node in a larger and slower network of thinking that takes place on the Internet. And if the meaning of information is given by the processes that interpret it — *à la* Hayles and Fredkin — then System 3 clearly produces meaning over an extended time period, in the form of cultural and institutional knowledge, above and beyond individuals' thinking.

Distributed cognition is the cognitive component of a more radical version of the sublime, one that is compatible with more modern notions of subjectivity and one that helps explain the notion that, despite having "flat" minds, we can know more than we think — the inversion of Schiller mentioned above. It is an advance on Richardson's neural sublime and emphasises the ontology of cognition and where it happens. For Richardson, the neural sublime is simply about brain power. He quotes Emily Dickinson: the brain is wider than the sky (Dehaene also uses the quotation as hisbook's epigraph). This is almost a form of neuro-idealism:

> I contend that the neural sublime does not, as in Kant, trigger in the beholder the apprehension of a higher Reason but rather, as in the neuroscientific demonstrations recounted above, yields up a disturbing but compulsive glimpse into the ordinarily secret workings of the brain. (Richardson 25)

Richardson is right to dissent from Kant's idea of a higher Reason. But this attempt to uncover hidden aspects of cognition within the brain can never be more than the epistemological sublime that seeks to uncover the previously obscured. In fact this is something of a trend in the titles of popular neuroscience books: Sigman's is *The Secret Life of the Brain*; one of Greenfield's works is *The Private Life of the Brain*; Barrett's is *How Emotions are Made: The Secret Life of the Brain*; and Eaglemann's book is called *Incognito: The Secret Lives of the Brain*. It is worth questioning from whom it is hidden. If these secrets are hidden from the armchair philosopher performing introspection, then it is again a trivial result of there being unconscious brain processes. The lucid sublime is much more radical, undercutting the nature of *conscious* awareness, that which is not hidden and yet still somehow illusory.

Similarly, the "wider than the sky" trope is undercut by most popular authors' insistence — the ones examined in this chapter are exceptions — that the brain cannot understand the brain or consciousness and certainly the unaided brain cannot do so. Another irony of popular science is that in its reportage of complicated experiments — often pooling resources among dozens of researchers, utilising supercomputers and billions of dollars' worth of infrastructure, and building on decades of accumulated insights and practices and scientific cultures — it simultaneously aims for humility or self-undermining. In Chapter 3 I noted the irony of using extensive, unprecedented scientific methods to try to disprove human

exceptionalism. Something similar occurs in authors' denials of our ability to understand consciousness and the brain. Yet it is weirder still because the argument of popularisers and critics like Edelman and Richardson is that the brain, including the unconscious, *can* understand more than the conscious subject. Were this meant as a comment on the superiority of System 1 compared to System 2, there would be some argument to make. But this still ignores System 3: the offsite, external, distributed cognition that Hayles locates in places such as computers and also cultural practices. Any neuroscience experiment utilises resources from System 3 and in effect allows System 2 to think more than it knows; or, evidently, based on Edelman's, Richardson's and others' comments, to know more than it thinks. The lesson implied by the popular authors such as Barrett and Chater is that representationalist ideas of consciousness are insufficient. The comfortable image of a mind that mirrors or represents an external reality is untenable if the cognitive processes are not even clearly delineable into internal and external. And of course even the metaphorical Systems 1, 2 and 3 bleed into one another.[82]

The lucid sublime is the experience of knowing more than we can think, as we are presented with the unpresentable of consciousness. The hidden workings of the brain *and* the hidden workings of other brains, as well as the displaced cognition of language and other cognitive aids is "where" presentation would happen. The apparent fact of lucidity in general — awareness of being in the world — is a presentation that relies on the distributed and non-local unpresentable processes of cognition. Contra Richardson, popular neuroscience does not render the brain wider than the sky so much as it renders the subject wider than the brain. And in a final blow to representationalism, one is left to consider not only where the presentation would occur, but to whom or what it would be presented. Without a Cartesian theatre and with distributed cognition, *presentation* as such gives way to a more processual notion of enaction or entanglement. This is the ultimate paradox of consciousness as it is discussed in contemporary texts that take an illusionist approach. The only place or event at which a subject, the I, can be situated is in the very failure of its articulation or location.

[82] The best way to illustrate their graded difference is in terms of time. Kahneman notes that System 1 is for fast thinking and System 2 can be for slow deliberation. System 3 is potentially even slower, in that it allows thinking to take place over a much longer timeframe than conscious thought, even indeed across years or generations with the aid of print material, databases and so forth. I think a useful parallel is with three kinds of memory: short term, long term and cultural.

Reading, Žižek and the lucid sublime

The sublime is not a purely cognitive effect and neither is it simply self-affirming or self-negating. Contemporary neuroscience — particularly from those authors who hail from the cognitive science disciplines — offers new perspectives on the sublime and a sublime of its own. The model of predictive coding advocated by Barrett and others suggests that waking cognition, as an adult, is an ongoing process of generating expectations. Moment to moment these expectations are usually confirmed by feedback (or at least not disconfirmed), as in habitual or default cognition. Otherwise they are contradicted, necessitating closer attention and increased cognitive work. This clearly jibes with the violated-expectations model of awe from Keltner and Haidt given above. It establishes the underlying conditions of possibility for a sublime experience with a cognitive component. One way in which expectations are violated is by a trigger that exceeds our usual frames of reference and threatens either our sense of intelligibility or knowledge (the epistemological sublime, awe) or threatens the integrity of the self or world (the ontological sublime). There are many other ways of characterising this basic dynamic using different vocabularies from different branches of cognitive science: System 2 being invoked by a failure of System 1 (Kahneman); the default network giving way to the salience network (Barrett); semantic mismatch requiring resolution by coercion (Bergs 283); unconscious processing failing and requiring conscious processing (Dehaene).

This rhythm of default and salience, of violated expectations and attempted accommodation, is part of the larger rhetorical ploy of defamiliarisation found across the entire popular science genre. It is certainly the basic rhythm of all the texts studied in this chapter. In a given section or even a given paragraph, an author will oscillate between ideas that seem intuitive and familiar and then undermine or complicate them with surprising neuroscientific results. Where this dynamic becomes interesting is when it is reapplied to cognition itself. That is, when popular authors employ this violation of expectations, for rhetorical effect, precisely in a discussion of this feature of cognition. Here is an example from Barrett:

> Consider this sentence:

> Once upon a time, in a magical kingdom far beyond the most distant mountain, there lived a beautiful princess who bled to death.
>
> Did you find the last three words unexpected? That's because your brain predicted incorrectly based on its stored knowledge of fairy tales — it made a *prediction error* — and then adjusted its prediction in the blink of an eye based on the final words (62, italics in original)

This is defamiliarisation used to explain defamiliarisation. Unlike authors in the other subgenres from Chapters 1 to 4, Barrett and her fellow neuroscientists are not only in the business of rendering unfamiliar the previously familiar and thereby engaging the reader with the standard rhetoric of wonder and the epistemological sublime. As Richardson noted they also "enlist the reader as co-experimenter" (17) with demonstrations of the reader's own habitual and non-habitual cognition. Furthermore, in a parallel to Oldfather's analysis of the violated expectations in the fantastical *The Sixth Sense* versus the realistic "The Dead", we can see that the sting in the tail of Barrett's vignette above is more like *The Sixth Sense*, relating as it does to a purely fictional world of a fairy tale. And yet the real sting in the tail comes in Barrett's *explanation* of prediction error. Just like "The Dead", the explanation is more "personally cognitively real" — Oldfather's phrase — given that it is used to characterise the reader's basic experience not only of reading but of reality:

> You might think that your perceptions of the world are driven by events in the world, but really, they are anchored in your predictions, which are then tested against those little skipping stones of incoming sensory input. Through prediction and correction, your brain continually creates and revises your mental model of the world. It's a huge, ongoing simulation that constructs everything you perceive while determining how you act. (Barrett 62)

To me this expresses the ironic, ambiguous rhetoric of recent popular science. It at once openly signals that it is demystifying and disenchanting while at the same time it directs us in a more oblique way to something resistant to demystification.

The neuroscience of the sublime and awe gives us a reasonable model for violations of expectations having certain cognitive effects. And Barrett's use of

anagnorisis enacts those violations even as it explains them, somehow domesticating the process of estrangement. Yet in that same passage above, Barrett casually, in a style typical of the subgenre, refers to both "your brain" and "you" in a way that clearly indicates they have markedly different referents. Far from self-annihilation, the reader thereby has two self-like entities attributed to them. This contributes to a potentially richer conception of subjectivity than earlier popular neuroscience books which might try and convey the identity thesis: that you simply are your brain with no remainder. But underneath this apparent surfeit of identity or presence there lurks an absence. The prediction error is the only thing that can prompt awareness of something new. It is in the default mode when everything is as it should be that there is least awareness. Awareness arises only because of the fact of error or mismatch in prediction. The simulation can only learn when it is wrong and can only be improved by recalcitrant reality when it stumbles in its simulation. And just when one *feels* most uncontroversially in touch with the world, one is in the default mode, experiencing a simulation that is in Metzinger's words "transparent": it is characterised precisely by the fact that it cannot be seen as a simulation (*Ego* 7–8).

In the works of scientists like Barrett and cognitive science inclined philosophers like Metzinger, the effect is not the same as the self-annihilation of peak experiences they often describe. If one starts from a post-Kantian perspective, the annihilation of self — mentioned by Metzinger (*Ego* 75ff), Miall (69–70), or Pollan (291ff) — is not even surprising. The experiences listed are clearly profound: out of body experiences, religious experiences of oneness or infinity, Tantric sexual practices, transcendent musical experiences, flow, LSD trips, *etc.* But, against Miall, annihilation of an already discredited self is not a useful definition of the sublime in this moment. The more difficult to reconcile effect is on the reading subject, one who is already in a scientific, post-Kantian and postmodern epoch. The lucid sublime, as I have termed it, is hard to articulate and that difficulty is wrapped up in the effect. It is not self-annihilation but an awareness, somehow, on the part of the subject — who is not a naive Enlightenment Kantian subject or a Cartesian ego — of her own limitations and the strange or paradoxical nature of this subjectivity.

In the defamiliarisation of an everyday cognitive activity such as reading, or the unusual experiences of "self-annihilation", something remains that is resistant to defamiliarisation. In the popular neuroscience subgenre, that remainder is the problem of an ostensibly conscious subject, complicated by non-, pre-, un-, or sub-

conscious processes that undermine that conscious status, while these very underminings make one aware of another form of subjectivity, one that is defined by limits and absences: what I call lucidity.

I close with a lengthy quotation from Žižek because it ties in several threads from this chapter and the thesis as a whole. Žižek is here responding to Metzinger's formulation of the phenomenal self-model, his illusionistic theory of consciousness, whereby the self is likened to the red arrow on a subway map that says, "you are here":

> What Metzinger misses is that, in contrast to ordinary signs, which are "place-holders for something else," the "red arrow" which stands in for the Self is a place-holder for *nothing* (the nothing which "is" the subject itself). Here one should correct the standard notion of the I as a set of features in which I (the subject) recognize myself: I by definition experience myself as absent, as an emptiness towards which my stand-ins point, I never directly identify myself with my stand-ins or with my self-model. It is here that the (otherwise fashionable and much misused) reference to Gödel's theorem acquires a precise meaning: in the same way that, for Gödel, the lack of proof of the "undecidable" proposition is a direct consequence of its truth, the very failure of the subject's representation is a proof that we are dealing with the dimension of subjectivity. This brings as back to one of our formal definitions of the subject: a subject tries to articulate ("express") itself in a signifying chain, this articulation fails, and *by means and through this failure, the subject emerges*: the subject is the failure of its signifying representation. . . In this precise sense, the subject is a non-provable presupposition, something whose existence is not to be demonstrated but only inferred through the failure of its direct demonstration. (*Nothing* 730, italics in original)

The existence of something inferred via the failure of its demonstration recalls the dark matter and other exotic objects from Chapter 1: sublime objects to which we can have only limited epistemological access. Further than that, Žižek claims that subjectivity emerges via a kind of epistemological failure. But unlike an eighteenth-century conception of the sublime, this process does not simply end in a positive

affective state of awe or wonderment. This is something much more systemic and it emerges from the very act of positing subjectivity.

Žižek is not talking about the sublime in the above quotation, but he has written extensively on both ontological incompleteness and the sublime.[83] His definition of the subject is heavily influenced by Lacan, but I think is roughly compatible with what we have seen in contemporary neuroscience. Clearly Žižek would agree — although he was writing in 2011, just prior to the publication of the clutch of recent works that follow the same agenda as Metzinger, whose work he does find useful.[84] The reflective subject is the subject that experiences itself as an absence or failure, the one who has investigated the void that seems to undergird it. Clearly that can be the subject of Lacanian psychoanalysis, but also of illusionism. In both cases subjectivity is unrecognisable from the triumphalist, self-affirmation of the Kantian sublime. Now it is ironic: unable to be directly demonstrated, only inferred, as Žižek says, through a failure of this demonstration.

The reader of popular neuroscience books such as Barrett's and Chater's is presented with information about the workings of the brain and evidence that conscious experience is radically unlike how it seems, even how it seems to consciousness experience. This can only be shown negatively, via failure. Like dark matter, the blind spot is a good metaphor for the sublime. The optical illusions that provoke what Richardson called the neural sublime undermine awareness from within awareness. The blind spot cannot be seen; it is the absence of sight. But it can be inferred by a demonstration of this failure. In illusionism-inspired texts, all conscious experience is said to be similarly gap-filled. And so the reader confronts a barrage of examples that undermine the coherence of conscious experience — sometimes including reading — all while they are reading and feeling as though they are conscious of the ideas in the text. This process, of somehow gaining an insight into the lack or void in conscious experience, is a kind of awareness that is like the lucid dream: an awareness of one's lack of consciousness.

This notion of lucidity founded on what is unpresentable, leads us to another irony, not of the popular science genre this time, but of the sublime. The whole discourse of the sublime is a *discourse of the ineffable*: so many words spoken about

[83] See for instance *The Sublime Object of Ideology* (202–7), *Tarrying With the Negative* (37–8) and *For They Know Not What They Do* (144).
[84] And his section devoted to cognitive science is also writing in response to Hofstadter's *I am a Strange Loop* (*Nothing* 717–37), another precursor to illusionist works.

what is unspeakable. As Chater noted, in reference to abstract thought, "we can write and talk about these things" and yet "have no subjective experience" of them (185). But doing so achieves a kind of abstract thought nonetheless. Like the attempts to deny human exceptionalism in critiques of the Anthropocene and like the subject's emergence in failures to articulate itself, the sublime is also an effect of its own cause's denial. The lucid subject is presented with evidence of the flatness or thinness of its nature, its diffusal across language, time, and other subjects and even evidence that it cannot be conscious of many of the things it thinks it is. And yet the process — unfolding over time, entangled with distributed cognition — that led to this presentation of evidence is a kind of oblique awareness that constitutes genuinely new knowledge. This is why I think the sublime is naturally allied to scientific discovery but not necessarily produced by it. If science produces knowledge it must also invoke the possibility of further knowledge not yet produced. In a very Derridean way the mere assertion of a known summons an unknown: presence cannot banish absence. For some, the demonstrations of the limits or gaps of consciousness are demonstrations of our ignorance; not only the ignorance of current neuroscience but also the subject's ignorance of her own subjectivity. Yet for others, any demonstration of ignorance is itself an instance of new hard-won knowledge. I fall down on the latter side and contend that this is the logic of the scientific sublime and the sublime in general. Far from being epistemologically overwhelming, the sublime encountered in much of popular science — in accessible mass-market books — is ontological in that it discloses voids in the reader's subjectivity, not simply gaps in their knowledge.

This chapter began with a quotation from one of the foremost experts on the aesthetics of Kant, Paul Crowther. He encapsulates the sublime as an experience in which,

> phenomenally or psychologically overwhelming phenomena can make the extraordinary scope of rational comprehension vivid to the senses. This can be instantiated differently under different historical conditions — there are, in other words, different modes of the sublime — but it is the same cognitive structure that is at issue in each of them. (166n3)

That is just about the sublime in a nutshell, except for one thing. “Rational comprehension” is not what it used to be. In the postmodern epoch, in this contemporary scientific moment, evidence for the subject’s lack of rational comprehension is itself one of those overwhelming phenomena. The ontological sublime, illustrated by the radical implications of modern science, *is* this demonstration of the lack or absence that generates reality and generates, not the rational subject, but the lucid subject.

CONCLUSION

The sublime in popular science is both epistemological and ontological. In the first mode, it fits neatly with eighteenth-century claims about the sublime: a mingled experience of fright and delight brought on by some vast aspect of nature or lofty rhetoric. Science writers love to bombard the reader with examples of dark matter, both literal and figurative: huge objects that exceed our imagination, intimidate us initially, but which are domesticated by the reach of the scientific explanation that reins them in. The lofty rhetoric serves to inspire confidence in the scientific enterprise and the liberal humanist subject — often a scientific hero in a hagiographic sketch — who is the protagonist in that enterprise.

But sometimes the revelations of modern science are more threatening even than dark matter. Sometimes they confound not only our imagination, but our basic categories about what is real and who we are. These ontological challenges are not as easy to fold into the standard rhetorical goals of popular science. Ironically, the drive to extend the frontiers of knowledge, to increase the scope of what the rational scientific subject can bring into their domain, tends to expose those ontological gaps and glitches which undermine that same subject.

The ontological sublime is dealt with differently in different subgenres. In cosmology it is only hinted at. Cosmology has, since the 1990s, been an extremely successful discipline in terms of experimental results and funding. Cosmologists happily advertise the limits of their knowledge and these limits provide the epistemologically sublime imagery for their texts. The edge of the observable universe, the unpresentable extra dimensions of spacetime, the obscure interior of black holes and the vagaries of the Planck scale are all exciting and counterintuitive phenomena that play with the notions of boundaries and representation. Often the nature of these objects can only be inferred or described negatively. But as I suggested in Chapter 1, even this awe-inspiring imagery — which is remote from human interests — presents a glimpse of the more threatening ontological sublime. Greene's discussion of space and time suggests that they are emergent phenomena, not fundamental in the way Kant supposed. The Kantian subject, who is at first rocked by the sublime object but recovers as they are made aware of a supersensible faculty of pure Reason, is subtly undermined by this dethroning of what Kant took to be innate conditions for the representation of any phenomena.

In Chapter 2 I followed the investigation of the most basic nature of reality into the quantum physics subgenre. The double-slit experiments expose an explanatory gap in what is otherwise the most successful theory in natural science. This gap concerns the putative collapse of the wavefunction. Most authors writing books about quantum physics avoid any interpretation of this puzzling phenomenon. The "shut up and calculate" attitude — an artefact of Cold War exigencies — still dominates popular accounts that merely allude to quantum "weirdness". The increasingly popular solution to the awkward metaphysical problems posed by double-slit experiments, the MWI, proposes its own bizarre ontology. Deutsch and Tegmark are two of the more ontologically intrepid authors and at least tacitly accede to MWI implying the literal existence of countless parallel universes, complete with near copies and exact doppelgängers of ourselves. The alternative is to admit that measurement plays a constitutive role in producing reality. Žižek's formulation of the sublime has it that a fundamental lack or void is necessary for any positive articulation of the subject; that is, the subject is actually produced negatively, inasmuch as it comes about by its moment of failure as it attempts to articulate itself. Reality too is produced via a kind of failure: "the lack that we take as an effect of our limited knowledge of reality is part of reality . . . what appears as the limitation of our knowledge is the feature of reality itself" (Žižek, *Nothing* 925). This is the ontological sublime and it is far more paradoxical and radical than mere awe or wonder.

Invisible biology also undermines the liberal humanist subject assumed by most popular science writing. Unlike quantum physics, it does so from within the existing ontological categories. Authors like Margulis and Yong do not propose vacua in the heart of reality or parallel worlds. Instead they greatly expand what is meant by *nature*, by emphasising life at the scale of microbes and at the scale of the planet. The human subject is somewhere in between these scales and is blurred out in both directions: decomposed into trillions of semi-autonomous cells powered by cellular machinery and subsumed into a planetary superorganism that acts as a giant network for trading elements. This is still the epistemological sublime of incomprehensible scales, but it does not simply dwarf the reader as in the sublime of the eighteenth century or cosmology. It also compromises the subject by shifting the balance of life away from the human towards the nonhuman, locating value beyond any human enterprise. The Anthropocene could be taken as a kind of species-level Kantian sublime, whereby humanity is first shaken by the enormity of its effect on

the planet and then restored as it is made aware of its agency in tackling climate change; this is the human exceptionalism entailed by the term Anthropocene. But in the sublime of invisible life, agency is distributed throughout nonhuman nature too and the human (*anthropos*) that would be the subject of that species-level sublime experience, is re-visioned as a subject that is already entangled with microbial and planetary scales.

The exact opposite approach is taken in evolutionary biology, where the grand narrative of evolution is said to culminate in human understanding of this self-same narrative. As writer, reader and protagonist the modern scientifically informed subject — preferably an actual scientist, such as Dawkins himself — is able to find self-apotheosis in this metaleptic effect. The world of the teller and told is fused and so too are the organic and inorganic realms, the domain of facts and the domain of values, in an all-encompassing neo-Darwinian account of genes and memes. This is a missed opportunity because buried in *The Selfish Gene*'s palimpsestic text are ideas that mesh with Barad's worldview of entanglement. The extended phenotype tangles the scale of the gene with the environment visible to the naked eye and the genetic book of the dead invokes notions of temporality and intra-action between organism and environment more redolent of invisible biology. The sublime here is ontological but it reprises the Kantian sublime's final movement of self-affirmation for the rational subject. Although *The Selfish Gene* is not a full-scale evolutionary epic, its ambitions are to provide an account of the evolution of strategy, agency, self-ish things called *genes*, fully agential things called *robots* and even human consciousness.

In Chapter 5 books about consciousness present the most overt challenge to the traditional model of subjectivity assumed in most popular science writing and most pre-twentieth-century theories of the sublime. Only in the last decade, works of popular neuroscience have advanced illusionist theories of consciousness. Consciousness used to be the gap in explanation in this subgenre, but in Barrett's work and Chater's even more so, the conscious subject, the one reading the book, is directly challenged as to their coherence, even in the act of reading itself. With consciousness relegated to the status of hoax, hallucination, or illusion a more nuanced form of subjective experience is offered that I call lucidity. The lucid sublime is the experience of becoming aware of the shocking limitations and discontinuities in awareness. Again, Žižek provides a model for this seemingly

paradoxical relation. When the subject encounters this error, often by way of demonstration with an optical illusion — Richardson's under-theorised neural sublime — they may take it as a breakdown in the field of representation. But Žižek suggests that this kind of breakdown is really an insight into what positively makes up the subject: "the very failure of the subject's representation is a proof that we are dealing with the dimension of subjectivity" (*Nothing* 730).

But apart from a few exceptions from the neuroscience subgenre, popular science authors shrink from anything so *weird* — to use a term favoured by both Žižek and the authors in quantum physics who avoid confronting such weirdness. Popular science authors generally offer the imagery of remote scales and the achievements of scientific heroes, while unacknowledged ontological gaps creep into their texts. By showcasing epistemological limits and triumphs they inadvertently disclose ontological challenges to subjectivity and reality. Although popular science texts are largely unadventurous in terms of style, their content is potentially subversive. Ironically, it subverts exactly the kind of subjectivity that is conjured by the assumptions embedded in the scientific hero myths and the claim to objectivity in most science communication. Also ironic is the use of epistemologically sublime imagery to enlist the reader as an ally of science. This goal of impressing the reader with confounding ideas and the success of modern science actually opens up the possibility of an ontological sublime that challenges the integrity of that very reader. Underneath the scientistic rhetoric of this popular genre are radical ontological implications.

The sublime is just one way into this field of texts, a field that is more daring than rhetorical approaches might suggest. Scholars in literary studies, philosophy and cultural studies can mine this genre for the knotty ideas folded into their otherwise exoteric presentations. Some of the imagery detailed in this thesis may constitute well-worn tropes in science fiction and some aspects of the sublime engendered may be unremarkable to scholars in aesthetics. But this is a popular genre with broad appeal and the claims made are about the reader's world. Furthermore, scholars in the humanities, novelists and scientists themselves appear to get their science from popular science books. Although the influence of the genre is hard to quantify, its attempted reach, its metaphysical ambitions, are clear.

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