Boyle Lecture 2021

with Tom McLeish, "The Re-Discovery of Contemplation through Science: Boyle Lecture 2021"; Rowan Williams, "The Re-Discovery of Contemplation through Science: A Response to Tom McLeish"; Fraser Watts, "Discussion of the Boyle Lecture 2021"; and Tom McLeish, "Response to Boyle Lecture 2021 Panel and Participant Discussion."

THE RE-DISCOVERY OF CONTEMPLATION THROUGH SCIENCE

by Tom McLeish

Abstract. Some of the early-modern changes in the social framing of science, while often believed to be essential, are shown to be contingent. They contribute to the flawed public narrative around science today, and especially to the misconceptions around science and religion. Four are examined in detail, each of which contributes to the demise of the contemplative stance that science both requires and offers. They are: (1) a turn from an immersed subject to the pretense of a pure objectivity, (2) a turn from imagination as a legitimate pathway to knowledge, (3) a turn from shared and participative science to a restricted professionalism, and (4) an overprosaic reading of the metaphor of the "Book of Nature." All four, but especially the imperative to consider reading nature as poetry, and a deeper examination of the entanglements between poetry and theoretical science, draw unavoidably on theological ideas, and contribute to a developing "theology of science."

Keywords: citizen science; contemplation; history of science; science and poetry; theology of science

---

One of the great individual sadnesses of 2020, amid the general onslaught of the global pandemic, was the tragic loss of former UK Chief Rabbi, Jonathan Sacks. His successor Rabbi Ephraim Mirvis embedded a marvelous anecdote about him in a few weeks later in a BBC Radio 4 *Thought for the Day* (Mirvis 2020). Rabbi Sacks and George Carey, then Archbishop of Canterbury, had struck up a firm friendship fueled by a mutual support of Arsenal football club. So, when their beloved team suffered a massive home defeat under the very noses of these senior religious leaders, a national newspaper claimed the débacle as final proof that God does not

Tom C. B. McLeish is Professor of Natural Philosophy in the Department of Physics, University of York, York, UK; e-mail: tom.mcleish@york.ac.uk.

exist. "On the contrary," replied Sacks in a letter, "it is direct proof that God *must* exist, it's just that He supports Manchester United." The lesson that this real-life parable holds for the remit of this journal is that, on the question of God and on how events in the world should be interpreted theologically, it is all too easy to follow the newspaper journalist, who had simply been *looking the wrong way*.

Parallels with the question of God and the interpretation of those other real-world events revealed by science are inviting—but if they hold true, the news may be worse for the science-and-religion community than for the newspaper journalist who interpreted the outcome of a football game as evidence against theism. For the pathological narratives of conflict and incompatibility around religion and science that have played out since Robert Boyle's time indicate that much of the discussion might have been "looking the wrong way" on this question for over three centuries.

I want to argue in this article that, in spite of the uncontested glories of science since the time of Boyle and Newton, their crucial century saw some pivotal re-orientations in the interpretation, cultural framing, and practice of science. And I want to suggest that, although these directions seemed inevitable for science to work in the early-modern period, they were contingent, arbitrary, and unnecessary, even damaging to science, and that there are alternative framings, other "directions to look at the field of play," under which science may better serve human flourishing, as well as find its place within a theological purpose and practice, rather than continually negotiate with them the specifics of a sort of truce within, at best, a perpetually suspended conflict.

To be more specific, I propose to explore four such contingent "wrong turns":

(1) A turn from human contemplation of nature as subjects fully immersed in the world, toward an illusion of perfect objectivity.

(2) A turn from the appreciation of imagination as a legitimate pathway to knowledge, in partnership with reason, to an elevation of reason alone.

(3) A turn from science as a shared cultural experience, to a restricted, professional, and institutional expertise.

(4) A profound misreading of the Book of Nature—that traditional metaphor of the natural world and our epistemological relation to it as "God's Second Book." If we are to understand science theologically, I will propose that we should rediscover how to read the world, not as prose, but as poetry.

To unpack and clarify such a densely summarized manifesto requires a preliminary suspension of habit. This is to drop notions of the "boundaries of science"—or indeed "boundaries of theology" for that matter. For

this disciplinary fragmentation—this territorialism—is an aspect of the very early modern wrong turns that I am attempting to isolate and display (McLeish 2019). Our disciplinary boundary-making is, for such a task, as futile as a geological expedition to Antarctica would be that focused on where to erect the political fences. In the past this fixation on frontiers has led, to take just one example, to our assumption that "science and religion" questions must belong to *apologetics* (McLeish 2014). This pigeon-holing entirely misses the point that the *theological consequences* of the ability of humans to do science are profound and beautiful.

Robert Boyle wrote in *The Christian Virtuoso*, (Boyle 1690) that "Being addicted to Experimental Philosophy, one is rather Assisted than Indisposed, to be a good Christian." The title that Boyle eventually chose for his book points to his direction of thought—it is not so much the results of scientific enquiry that he suggests nudge his readers toward the Christian story, but more the practice of it, and especially the devoted (so "virtuous"), trained (so "virtuosic"), open-eyed study of nature. Further evidence lies in the originally intended title of "Religion and Experience" (Hunter 1990).

Boyle's emphasis on scientific *experience* serves as a way in to the first of the four ill-chosen modern re-orientations: that of a pretense that humans can really act as disconnected subjects at a sort of distant "Archimedean point" (Arendt 1998) over and above a distinct physical reality of objects. Boyle knew very well—by experience—that truths about nature emerge from the immersion of observers in the world we seek to understand. Text books may insist on "framing" science—here the art-gallery metaphor is very apposite—as a glazed image of truth before its consumer's gaze. But there are lessons from the practice of science that point to a much stronger coupling that conscious observers have with the objects they observe. The inevitable coupling of observer and observed is by no means limited to Heisenberg's Uncertainty Principle, the unavoidable change of quantum states when these are observed. The immersed and strongly coupled nature of all scientific descriptions of the world emerges ubiquitously in even classical statistical mechanics, for example.

My own fortunate scientific field of soft matter science (McLeish 2020), where quantum effects are almost never important, is full of illustrations of how much the observer's viewpoint matters. One of the special beauties of soft matter is its delightful ability to distinguish between the familiar and the understood. Of course, we are *familiar* with the ability to stretch a rubber band to four or five times its original length, and to return it perfectly unchanged. But there is no other solid that behaves in remotely similar way. A metal wire may be stretched a little, but will snap before 10% is added to its length. A block of wet clay or nub of silly putty may be deformed to the same extent as the rubber—but it does not recover, like the rubber, its original shape.

The closest analogy to the fascinating physics of rubber is neither metal nor clay, but counterintuitively the elasticity of *air*—the very phenomenon that Boyle described in his momentous 1660 Oxford publication, *New Experiments Physico-Mechanicall, Touching the Spring of the Air* (Boyle 1660). Boyle's famous experiments were guided by the metaphor, and model, of a spring, whose force could be weakened by letting the gas expand, or enhanced by compressing it. He did not attempt a structural explanation of why air acted as a spring, although the atomic hypothesis had been mentioned by Henry Power and others in that connection (Power 1663). But it was Boyle's insight that what we would now call a coarse-grained effective model would be the most fruitful guide of experiment.

The radical effectiveness of coarse-grained theories is as true today in our theories of rubber, as well as gases. For an understanding of why both these systems are elastic requires a careful choice of conceptual distance between subject and object. Understanding observers need mentally to stand back from the detailed knowledge of atomic arrangements and motions of the myriad crosslinked macromolecular chains that comprise a rubber, and to contemplate a wider picture in which the statistical behavior of billions of molecules is conceived of *together*. Alternatively, we might say that the macroscopic properties, such as pressure and temperature, of vast ensembles of molecules, are not simple sums of their component behaviors, but are irreducibly *emergent*.

Standing at too great a mentally proximity to the rubber presents to the scientific imagination millions of polymer chains thrashing around in chaotic, unceasing, thermal motion of overwhelming complexity. Standing back a little, on the other hand, allows the mind's eye to observe that a continually excited string tends to adopt shapes that are somewhat coiled or contorted, for these are far more numerous than the rare, stretched-out ones (McLeish 2020). In Boyle's gases, the analogy is between abundant expanded arrangements of molecules, and more rare condensed ones. Again, blurring out the details of what every component is doing is utterly necessary, but rather inimical, to any comprehension. Here, then, is the rub: it is the carefully chosen *ignorance* (coded in the degree of coarse-graining in the description) of the immersed observer in the world that creates the possibility of *understanding*.

An analogy to this essential choice of the right depth to which one is mentally immersed in a natural system, to do science with it, is the way we contemplate impressionist art. To be sure, Claude Monet made the details of oil paint on canvas worthy of the closest inspection in their own right—this is Clement Greenberg's (1982) defining analysis of the impressionist movement after all—but that is not the best way, to look at his paintings. It is better still to switch between close and distant views to appreciate the limpid *Bridge at Giverny* or the windblown *Pines at Antibes*. I have elsewhere developed this strong methodological analogy between

representational art, especially in the impressionist tradition, and the practice of theoretical physics in the contingent choice of distance between subject and object, and the consequent coarse-graining of a mathematical description of nature (McLeish 2019). Among other aspects, the analogy serves to underline the unavoidably contemplative stage of constructing theoretical models of natural systems, which considers different possible degrees of resolution in the model, before the detailed "paintwork" of construction.

The modern understanding of *entropy* corresponds very closely to this careful choice of distance between object and subject. Entropy is often explained as an intrinsic measure of disorder, but it is better thought of as a measure of our deliberate ignorance of a system, of how many of its detailed components we choose to blur together in our mental, and mathematical, representations of it. This is not a simple choice of interpretation, the case of "colloidal crystallization" is wrongly (anti-)predicted by theories that take entropy as inherent to the system, rather than to the degree of knowledge of the system embedded in theory (Cates and Manoharan 2015). The very concept of entropy ought therefore to teach us that science is a relational exercise. The glorious paradox is that by negotiating our entropic relationship with the world, by formally *knowing less* in this way, we can arrange to *understand more*. Even were Laplace's famous panoptic mind able to *know* everything, and so in Laplace's (mistaken) notion that all future states of the world would lie open to it (Laplace 1814), by the same token, even if true, it would *understand* nothing.

The second, unwitting, turn of early-modern science, debilitating both to the project of science itself as well as to its wider contemplation and enjoyment, is at best the silence, and at worst the outright denial of the role, in science, of *imagination*. Now the English word itself, and its Latin cognate "imagination" (*imaginatio*) has an interesting history. Medieval scholars saw a ladder that starts with *sensation*, then *via imagination* and *memory* leads finally to a renewed and healed *understanding*. Here, for example, is thirteenth-century natural philosopher Robert Grosseteste writing his Christian commentary on Aristotle's *Posterior Analytics* (his theory of scientific method, if you will), outlining a theory of learning that heals fallen human understanding (Grosseteste 1982, trans. Southern 1992):

> Since sense perception, the weakest of all human powers, apprehending only corruptible individual things, survives, imagination stands, memory stands, and finally understanding[1], which is the noblest of human powers capable of apprehending the incorruptible, universal, first essences, stands!

So, "imagination" was, for centuries, that mental place where sense-impressions were first received and curated. It became, of course, central to the process of experimental and observational science. But, as its meaning became subtly extended in the seventeenth century to allow this same

mental locus to receive images and impressions from *within* as well as originally, from *without* through the senses, so through the elevation of rational thought, science slowly forgot its essential debt to creative imagination. By the end of the eighteenth century, William Blake could write of his own task as a poet, in a felt opposition to that of the new science:

> … in the grandeur of Inspiration to cast of Rational Demonstration … to cast off Bacon, Locke and Newton; I will not Reason and Compare—my business is to Create. (Blake 1804)

I suspect that Boyle would have used "speculations" or "suspicions" where we now say "scientific imagination." The subsequent demise of these terms into a shadow-vocabulary of censure points to the same late-modern "turn" to the suppression of imagination. Boyle's series of short books that he termed "Tracts" bears witness to his wisdom that inner imagination must be nurtured if the natural philosopher is to meet experimental observation with inner understanding (Hunter 1990). In the first volume, he argues for as yet "unheeded Relations and Impressions" between bodies and particles that might not be reducible to their shape, size, and motions. Does not that read like an imaginative glimpse of our later notions of fields of force?

Yet this essential free-reign of imagination in science is never the officially sanctioned story. Thomas Sprat's (1667) *History of the Royal Society* (really of course, and after only four years of its existence, the Society's informal manifesto) urged its readers to "separate the knowledge of Nature from the ideas of Rhetoric, the devices of Fancy or the delightful deceit of Fables." There is a direct line from Sprat to my own repeated and soul-destroying experiences of meeting bright high-school pupils who have given up science because, in their words, they perceived "no role for imagination" in it.

The unofficial, lived, story of science is quite different. Even Karl Popper—though if one blinks while reading it is missed—admits in the introduction to *Conjectures and Refutations* (Popper 1962) that there is *no* method for generating scientific hypothesis in the first place. My own experience in science is utterly unexceptional in relying on the unplannable moments of half-conscious contemplation where scientific ideas are born. When, for example, a mental image of a giant protein molecule started to dance in a particular way, partway through a lecture that I was attempting to follow, that I later found could be described mathematically, and which led to careful lab experiments that others (not I) were capable of executing—and which in turn allowed us to see how noise, in the form of chaotic random molecular motion, might serve as a carrier of biological information, not as its suppressor. The chemist Kékulé's famous half-dreamed benzene molecule in the glowing embers, seen biting its own tail in his semi-slumber (Read 1957), should not attract the exceptional, mythical, singular status that it continues to enjoy. Such experiences need to be

normal, if all too infrequent. Their other joy is that they can and should be widely shared. Yet scientists tend to be embarrassed to talk about them.

Occasionally, perceptive thinkers and writers have glimpsed this truth. A surprising example is that highly original fantasy-writer and poet, George MacDonald, mentor to Lewis Carroll and a huge influence on the fictional writing of C.S. Lewis and J.R.R. Tolkien. MacDonald's 1867 essay *The Imagination, its Function and its Culture* (MacDonald 1893) begins with an imagined dialogue with the same Thomas Sprat of the early Royal Society we met a moment ago. Sprat first:

> But the facts of Nature are to be discovered only by observation and experiment.
>
> True. But how does the scientist come to think of the experiments? … the heart must open the door to the understanding. It is the far-seeing imagination which beholds what might be a form of things, and says to the intellect: 'Try whether that may not be the form of these things.'

Such fundamental role of imagination in the conception of both experiment and theory is even more essential in those larger shifts to which Thomas Kuhn famously drew our attention [in his *The Structure of Scientific Revolutions* (Kuhn 1966)]. It is all too easy to forget, for example, that the very rise of experimental method in Boyle's century is itself a hugely counterintuitive work of imagination. It is only with the benefit of hindsight after all that it is understood how anything as oversimplified and artificial as an experiment might teach us anything about the interconnected and supremely complex real world. This was Boyle's contemporary Margaret Cavendish's (1668) insightful objection to the new "experimental philosophy." Cavendish had a point. As historian Peter Harrison (2007) has shown, the driving imaginative energy for this counterintuitive leap derived largely from a Christian theology of Fall and a consequent *faith* in the God-given potential to restore human sense and intellect—a reformed account, if you will, of that medieval "ladder of understanding" that we met earlier. An underlying and counterintuitive belief overcomes a rational (but mistaken) assessment of the unlikely effectiveness of the simplification and isolation that is implied by the experimental method. The argument is not over today, but can be found in the tension between advocates of *in vivo* versus *in vitro* approaches to cell biology (Lorian 1988).

Arrival at the Reformation reminds moves the discussion on to the third "wrong turn" of early modern science—the turn from a universal, shared scientific contemplation and practice to one that is now all too exclusive, professional, and closed. This is perhaps the saddest of the misshapen aspects of science that we suffer from in the late modern period. It also lies behind the reason those bright young students gave me for dropping all science subjects—that they saw no room there for their *own* creativity or

imagination. Science seems strangely exceptional: for not being a professional musician, for example, is no bar to creative amateur performance or to critical engagement with those who are; yet having no professional scientific credentials all too often limits experience of science at best to the passive reception of TV nature documentaries (and at worst, perhaps, to science denial). It is as if a ladder between elementary and amateur access, and the professional community in music has, in science, had several rungs removed (McLeish 2014).

To understand how this has happened, some material from the fourth theme is required, in advance of its full argument, in a consideration of the effect of the Reformation on the reading of God's "first and second book"—the books of scripture and nature. To oversimplify an account of the transformation of the "first book": the Reformation propelled a shift in Bible reading from the practice of an exclusive clerical elite, educated in Latin, to an inclusive lay participation through its translation into the vernacular, and toward a daily practice of bible-reading as an act of personal piety (Provan 2017). The question arises, with this move in mind, as to its corollary within that most persistent of religious metaphors for Nature—as God's "second book." From Augustine in the fourth century to Galileo in the sixteenth, *via* Hugh of St. Victor in the thirteenth, the metaphor of nature as second work of sacred writing, which demands similar tasks of translation and interpretation as the first book, has guided and perhaps misguided our theologies of science (Kosso 1992). But if the Reformation took the reading of God's first book from priestly and scholarly exclusiveness to a lay and daily piety, would a cultural historian not expect, in the hands of devout, reformed, early-modern scientists to see a similar transformation in the reading of God's second book?

The tentative expectation proves to have been correct. Once again, it is through the writing and advocacy of Robert Boyle that the appearance of such a reformed reading of nature in the early modern period can be deduced. His 1665 *Occasional Reflections upon Several Subjects* contributed to an all too brief flowering of a new lay science. The movement of "Occasional Meditation" encouraged the lay practice of observations, reflection, and recording: the colors and forms of flowers, the ripples on a lake, the fall of leaves. It also encouraged a lay interpretation of nature. Historian J. Paul Hunter (1990) writes of Boyle's commitment to "the universal priesthood of all observers and interpreters."

However, in contrast to its ecclesiastical counterpart, the analogous counter-reformation against this presumptuous lay *science* of personal contemplation and piety, was by the mid-eighteenth century, complete and utter. Occasional Meditation as an early form of "citizen science" suffered early strangulation by the growing institutionalization and professionalization of science. The Royal Society of London, the Académie des Sciences de Paris, and their cognates, soon ensured by competitive and self-selected

membership, by establishment of exclusive forms of scientific writing and more, that the reading, translation, and interpretation of Nature would henceforth remain the preserve of an elected and professional elite.

Blame cannot be laid entirely at the feet of the new scientific priesthood—Jonathan Swift (2003) was merciless in his lampooning of Occasional Meditation, for example, in *Gulliver's Travels*. Yet when the metaphor of priesthood is used of science in our own times, it is always decidedly unreformed. Here is broadcaster and theologian Angela Tilby (1992) writing in her book *Science and the Soul*:

> Like priests in a former age, scientists seem to guard the key to knowledge, to have access to transcendent truths which the rest of us could never hope to understand. Many people feel that what they do is cut off from everyday life, that it is irrelevant and rather frightening, a form of magic.

If the current pandemic has perhaps moderated the charge of irrelevancy, it has not done much else to restore a sense of shared possession of the beautiful human ability to re-imagine nature. But I am delighted that the newly appointed head of the science-funding organization, UK Research and Innovation, plant geneticist Dame Ottoline Leyser has announced as a goal the recovery of a shared participation in science: "Science needs to be a normal part of cultural life," she said in an interview for the *Times Higher* recently (Leyser 2020), "rather than seen as an elite and alien world inhabited by boffins." If we wish for a sporting analogy, she added, we need to shift science from its current position as the equivalent of polo to that of the soccer field—the metaphor with which this article began.

Its analysis to this point has implied the recommendation, in correction of the first three contingent "wrong turns" of early modern science: (1) a re-immersion of a falsely aloof objectivity, (2) a renewed valuing of imagination and contemplation in science, (3) a re-discovery of a broad lay community of confidence, contemplation, enjoyment. However, the misorientations in need of reversal in these ways, all spring, I propose, from a deeper, theological, turn. By this I do not intend the invented and tawdry "conflict narrative" of science and religion, the mistaken claim that science is inimical to belief, or the false history that religion has always suppressed science. This narrative is now understood as a polemic, not a history, and originating in a nineteenth-century interdenominational invective (Ungureanu 2019). On the contrary, we need now to tell a new story of science as a gift and vocation with a purpose, within an Abrahamic, Christian, and wider theological narrative, to restore a fruitful human relationship with Nature (McLeish 2014).

Our underlying problem in getting there, I want to suggest, lies deeper: within a modern misreading of nature, and of our relationship to it, as co-created beings who carry a unique image of its Creator. An experimental attempt to explain what I mean by this begins once more with the old

metaphor of the Book of Nature. One of the problems with metaphors is that they are slaved to times and cultures. If nature is God's second book, then what happens to our reading of nature when books start to appear in the vernacular rather than in clerical Latin? What happens to the Book of Nature when written books begin to be printed and widely distributed rather than lovingly copied, and rare? And is this Book one that we read only? Or may we also write in it? Rather than drop the metaphor in the face of such complexity, I suggest taking the Book of Nature idea in a different direction, and to ask what form of text it really is, if it is to be understood as a text at all. This is not an entirely new proposal; Maxwell, for example, suggested that the "Book of Nature" should really be thought of as a magazine-compilation of independent instalments, as its divisions were not arranged in diachronic sequence (Harman 2001). The question of whether if we are indeed to think of nature as a book, it is better to think of it as poetry than of prose, will take us into the underexplored territory that lies in the overlap of science, theology, and poetry.

To clarify, "Poetry" here stands for much more than "poems," for the same reason that the Newcastle philosopher Mary Midgely (2001) entitled her powerful critique of reductionism, *Science and Poetry*. "Our visions," Midgley writes, "—our ways of imaging the world—determine the direction of our thoughts, as well as being the source of our poetry." She interprets Shelley's (1840) claim that poets "are the unacknowledged legislators of the world" to mean that they are modern-day *prophets*. Of course, there is a painful tradition of poets, from Blake to Keats and Poe, who see in science only harmful "reasonings like vast serpents," (Blake in *Visions of Albion*) or "unweavings of the rainbow," (Keats in *Lamia*) but Midgley helps us see these shrieks as prophetic words, not against science as such, but against a framing of science that had already forgotten a deep kinship with poetry. Form, concept, imaginative energy—these poetic ideas pervade all of science too. And without the rhetoric of metaphor, science would possess neither its raw material, nor the possibility of communication, so that, in George Steiner's words, it might meet the deep human need to "wake into some measure of communicability, the sheer inhuman otherness of matter." And, notably, Steiner was thinking about the purpose of art when he wrote that teleological analysis for human representational craft (Steiner 1989).

Wordsworth and Coleridge were more optimistic than Keats about the intercommunication of science and poetry: "The remotest discoveries of the Chemist, the Botanist or Mineralogist, will be as proper objects to the Poet's art as any upon which it can be employed," runs the preface to the third edition of their *Lyrical Ballads* (Wordsworth 1802)—but their vision is conditional—*if*, they write, "the time should ever come when these things should be familiar to us … as enjoying and suffering beings." For science had even then become sequestered within the locked safe of the experts: "Science," they continue, "is a personal and individual

acquisition, … The Poet, in contrast, … rejoices in the presence of truth as our visible friend and hourly companion." Wordsworth was not alone in identifying a hidden, and contingent, fraternity between poetry and science, while admitting that the two had parted company for a while. An almost contemporary analysis from Goethe (1827) in *On Morphology* likewise envisions a time when such "forgotten" connections might be re-established:

> Nowhere would anyone grant that science and poetry can be united. They forgot that science arose from poetry, and failed to see that a change of times might beneficently reunite the two as friends, at a higher level and to mutual advantage.

Although the English romantics point to a future hope for a remarriage of science and poetry, Goethe insists on their common ancestry. His notion that their felt separation is a form of forgetfulness is fascinating. It patterns that similar cultural forgetfulness that obscured a cousinly relationship between literature and experimental science (McLeish 2019). Such agreement between early nineteenth-century poets in both German and English traditions might suggest that, if they saw poetry as the eventual healing of division between science and art, or in more historically faithful language, between reason and imagination, then the falling-out might have begun with poetry in the first place. This amnesia of the imagination not only shrouded the powerful kinship of imaginative creation of alternative worlds and the creation of experimental abstractions from ours, but also made science appear, to these poets, as a force of disenchantment, as replacing colour with grayness, and as preying on wonder.

Nearly two centuries later, biologist and science-writer Peter Medawar (1984) voices in almost identical terms to Wordsworth's on the conditionality of the common contemplation of science, writing in *Pluto's Republic*, "no-one questions the inspirational character of musical or poetic invention because … something *travels*; [but] scientific discovery is a private event and the delight that accompanies it does not travel." Happily, there is more than pure optimism to Wordsworth's conviction that someday science might, like poetry, "travel" in this way. For, as Steiner and Midgley both glimpsed, science and poetry share a deeper place in the human psyche than even aesthetic delight. Listen to Shakespeare's Theseus at the close of *A Midsummer Night's Dream* (Act V scene 1):

> The poet's eye, in fine frenzy rolling,
> Doth glance from heaven to earth, from earth to heaven
> And as the imagination bodies forth
> The forms of things unknown, the poet's pen
> Turns them into shapes and gives to airy nothing
> A local habitation and a name.

As Malcolm Guite has observed (2012), there are strong resonances here with Christian notions of incarnation, of Word made Flesh, as unknown and transcendent Materiality is made Word. The scientist likewise cannot help but recognize our own encountered experience in Shakespeare's sequence of observation, imagination, formation, and naming, that the bard allots to poetry. Tellingly, both the theatrical framing of this act of making the unknown known, as well as its subject matter, constitute public acts of rhetoric. Although not a discipline that now excites strong scientific resonance today, its late antique and medieval accompaniment to the mathematical disciplines, in the tradition of the liberal arts, leaves traces in the practice of oral presentation and persuasion within the research community today (Gasper et al. 2019; McLeish 2019). It also constitutes another hidden theological strand to the narrative framing of science.

A current writer especially attuned to the persistence of the rhetorical throughout human participation in creation, is the American orthodox theologian David Bentley Hart. Discussing the theme of "Creation" in his response to post-modernism *The Beauty of the Infinite*, Hart (2003) points out that the created "other" (other, i.e., than either God or human) is "known *as other* not in the silence of immediacy or identity, nor in the darkness of infinite alterity but in the free and boundlessly beautiful rhetoric of a shared infinite." He continues: "The rhetoric of the other *evokes my representations*." This seems to capture my personal experience as a scientist in words I could never have found for myself. I think I know the "in-betweenness" of a "representation of the other" evoked, in my case, in the terms of theoretical physics, by nature's "infinite and beautiful rhetoric." Admittedly, we are describing a *very* good day in the lab here, but it is more than a philosophical articulation, but a description of the experience of science that I am trying to explore as truly theological.

If taking verbal analogies for science from poetry, rather than prose, is still surprising, we might turn for assistance once more to Coleridge, a poet who, after all, also spent years conducting experiments at the Royal Institution under the informal tutelage of Humphry Davy. He writes of the aim of the *Lyrical Ballads*:

> by awakening the mind's attention to the lethargy of custom, and directing it to the loveliness and the wonders of the world before us; an inexhaustible treasure, but for which, in consequence of the film of familiarity and selfish solicitude, we have eyes, yet see not, ears that hear not, and hearts that neither feel nor understand.

Malcolm Guite's (2012) comment on Coleridge at this point is absolutely on-target: "the poet, as much as the philosopher, or the scientist, is concerned with helping us to look beyond surfaces at what is really there." It is the continually fruitful, rhetorical gift of the poetic that enables this giving to Shakespeare's airy nothing, be it, in our own time, dark matter,

Higgs bosons, or the COVID-19 spike protein, "a local habitation and a name."

A final thread of evidence that advances a case for poetry an appropriate analogical form of a reading of nature conducive to a "theology of science," is the way that Biblical nature-poetry itself works in both shaping theology and science. Berkeley Hebrew scholar Robert Alter writes of the poetic content of the Psalms, Prophets, and Writings:

> Poetry … is not just a set of techniques for saying impressively what could be said otherwise. Rather, it is a particular way of imagining the world—it has its own logic, its own ways of making connections and engendering implications, … its distinctive semantic thrusts that follow the momentum of its formal dispositions and habits of expression. (Alter 2011)

This passage, summarizing as it does a scholar's lifetime acquaintance with the Biblical material, can be experimented with replacing "poetry" with "science." The resulting, transported, text is remarkable in its faithfulness to the structure of *theory* in the role it plays within the scientific project. A significant early-modern adoption of the classical use of *theoria* for priestly religious observance occurs in Thomas Browne's "true theory of death" on contemplating a skull in his *Religio Medici* (Browne 1643). A first glance seems to perceive a yawning conceptual chasm between such poetic, priestly, imaginative writing, and current scientific usage of "theory," as in the "theory of evolution," "quantum theory," or "theoretical polymer physics," especially when these adopt mathematical forms. Yet, urged to examine the juxtaposition closer by the material already encountered, from ancient Hebrew to nineteenth-century poetry, the structural similarities outweigh the initially contrasting content.

First, all theory is representation. Originally the description of ancient priestly rights, theoria later becomes the studied mediation exemplified by Browne's skull, with its powerful signifiers of emptiness, sterility, void, and lost life, beyond the object of gaze. Later still "theory" conceives immense schemes of interrelation and explanation within the material world, such as the "tree of life" that Darwin sketched for his Origin of Species—itself a representation in abstract and graphical form of the vast temporal branches of living species on Earth; the idea crystallized in his mind over decades.

Second, the long history over which any great, framing scientific concept takes shape, such as Darwin's grand idea in biology, or the expanding universe of cosmology, illuminates the language chosen as the title for this article (and also deployed by Browne in his testimony of theory), and a second common thread linking poetic and scientific theory—that of "contemplation" itself. All theory emerges from slow reflection, the mental examination of an object from different perspectives, and the experience of a slowly cohering representation.

Finally, the dynamic of poetry—poesis, as of theory, is directed from the inner imagination outward toward the world. For Plato, poiesis described the creative act that brought nature into being;[2] for Aristotle, it referred to the human re-imagining of nature. This is the sense in which theory is the reciprocal partner of observation, creating and expressing by representing the world from within, rather than receiving it from without.

Such a dynamic of expressive, even rhetorical re-creation of the world appears repeatedly in the reflections of poets themselves. Philip Larkin could write of poetry, "as a guiding principle, I believe that every poem must be its own freshly-created universe" (Motion 1993), and T.S. Eliot frequently mused over the way that poetry moves from particular instances to general truths, writing in his Poetry and Drama:

> It is ultimately the function of art, in imposing a credible order upon ordinary reality, and thereby eliciting some perception of an order in reality, to bring us to a condition of serenity, stillness and reconciliation; and then leave us, as Virgil left Dante, to proceed toward a region where that guide can avail us no farther. (Eliott 1951)

The inductive and extrapolative "procession to further regions" is the function of theory in science; an experiment can illuminate and report on a specific set of events. But, on its own, this is not sufficient to reimagine a cosmos. Scholar David Withun (2017) writes of Eliot's discussion of the purpose of poetry that it

> … is able to grant the reader the ability to perceive that reality, in spite of its often chaotic and random appearance, has some underlying unity by which it is bound together. This insight, in turn, provides the terms by which one may make peace with the world.

echoing once again George Steiner's "rendering into some measure of communicability the inhuman otherness of matter." There seem, therefore, to be two levels on which poetry and science in its theoretical mode may entangle. Not only is there the possibility of mutual inspiration—of scientific discoveries providing material for creative writing, and of imaginative writing inspiring scientific imagination—but at a deeper level there are structural patterns of correspondence to be explored, including the act of sustained contemplation, the exercise of imaginative *poiesis*, and a recurrent teleological thread: to make peace between the human mind and the world.

Returning to the most ancient source material adduced in this argument, it is precisely this human gift, both poetic and scientific, of mental "sight beyond the surface of the world" that lies at the explosive core of the best poetry in all the Hebrew Bible (best according to Robert Alter 2011). The *Book of Job* is surely Biblical Wisdom literature's most excruciating and most lovely rhetorical expression of (Wordsworth's) "enjoying

and suffering being" facing (Steiner's) "inhuman otherness of matter." At the peak of Job's pain, a new Voice takes him, in stunning poetic form, down a mine (this is Job 28:1):

> Surely there is a mine for silver; and a place where gold is refined …
> The Earth from which food comes forth is underneath changed as if by fire
> Its rocks are the source of lapis, with its flecks of gold.

Not even the hawk with her sharp eyes sees what humans see, the poem continues, beneath the surface of the world, by their art, and by their imagination. Job, like modern science, needs a re-orientation in his *relationship* to an apparently chaotic cosmos more than he needs anything else. So, when the Voice from the Whirlwind finally answers his complaints and demands for vindication, in the highest Hebrew poetry of all, the re-directing questions of the Lord's Answer (in chapters 38–40) peal out in over 160 registers of the untamed quarters of the natural world, for example:

> Where is the realm of the dwelling of light?
> Have you entered the storehouses of the snow?
> Can you bind the cluster of the Pleiades?

In the long question-form poem, Yahweh points Job to his co-creating imaginative task to reach behind the surface of the world, into the ice, out to the star-clusters, onward to light itself. It remains a great pity that mainstream scholarship has tended to interpret this most healing and affirmative of texts as a form of petty divine put-down. The Hebrew rhetorical tradition of question is pedagogical, prophetic, affirmative, eliciting "thoughtful engagement, contemplation and possible counter-answers" (Adams 2020), but never bullying or diminishing. Within a comprehensive textual analysis of the book as a whole, the Lord's Answer's long nature-poem in question-form both takes up the theme of how to interpret the "Book of Nature" that pervades the earlier discourses (McLeish 2014), as well as responding specifically to Job's original lament in chapter 3, which also calls on nature metaphors and the creation-narrative of Genesis, in particular (Alter 2011). Finally, the Answer discourse points Job, as it points the readers of the Book, toward a re-orientation similar to that Rabbi Sachs urged, albeit on a cosmic, rather than a football, playing field. The textual encounter of *Job*, where the Creator, a human image of that Creator, and created nature meet, feeds our task to fashion a theologically conceived framing of science. Surprisingly to those attuned to the old "natural theology," this re-orientation is entirely opposite to that tradition. It urges us not to look *on* the natural world for signs of God, nor *through* it as a window onto some dim divine image, but to learn to look on nature with God's eyes, aligning our servant gaze *with*, not *at*, the divine.[3] The same searching look of creative power and insight, of love,

with which God participates in his created nature is to be the direction, if only in image, of our participation also. Coleridge puts it this way:

> The primary IMAGINATION I hold to be the living power and prime Agent of all human Perception, as a repetition in the finite mind of the eternal act of creation in the infinite I AM.

Malcolm Guite (2012) comments, "it is as though the creative word that speaks the cosmos into being echoes back to God from minds made in his image." This is the place where scientific contemplation nourishes the task of re-creation, in image, which is the calling of science itself, a first step on the pathway to caring for, and mutually flourishing within, the primary creation.

More is therefore true: reflect that a good poem results from the expansive energy of imagination meeting with the creative constraint of form (passion meets the sonnet). Now ask yourself, "what greater imaginative energy could be conceived than that required to re-imagine the universe? And what could constitute a tighter form than that universe as we observe it? From this regard science and poetry are metaphors for each other from their first stanzas to their last." The framing narrative of "creativity within constraint" summarizes the many parallels between poetry and the theoretical imperative within science, that the fourth early-modern misorientation obscured.

Personal, methodological, and aesthetic comparison of poetry and science can perhaps be best testified to by those who are both scientists and poets. Examples are by no means as rare as the mistaken narrative of nonoverlap would suggest. A recent biographical collection, by Sam Illingworth (2019) of scientist-poets offers a first glimpse of a fraction of even those who publish (I suspect that there are many more scientists who write poetry privately in the course of reflecting on their experience—I know of some). To earth this discussion in an example of contemporary science-poetry in dialogue with ideas at the extremity of scientific knowledge imagination, one can do no better than to turn to a short poem, *Dark Matter*, by poet-astronomer Rebecca Elson (2018):

> Above a pond,
> An unseen filament
> Of spider's floss
> Suspends a slowly
> Spinning leaf.

It is not possible to detect dark matter directly, but only to infer its existence, and even its form, by its gravitational effect on visible stars and galaxies. Elson, who tragically died in 1999 of non-Hodgkin lymphoma at the age of 39, is best known for her work on the luminosity and structure of rich star clusters in our Milky Way galaxy and its satellites, much of

it making use of data from the (then newly deployed) Hubble Space Telescope (Elson 1998). She wrote poetry throughout her scientific life, but not infrequently faced criticism from colleagues that this "side interest" was a waste of time, and also frequently suffered from the debilitating sexism still endemic to academia today. Undeterred, she continued to write wonderful poetry, convinced that it contributed to her professional development and curiosity. The metaphorical link between intergalactic dark matter filaments and spider silk is an instructive example—fresh potential forms for dark matter leap into question. After reading her work one is left with the impression that here is a human being for whom the questions, "why do you write poetry?" or "why do you do science?" could only be answered by admitting that they were both ineradicable and interconnected parts of her make-up. Elson's poems certainly reveal and articulate the inside of her science thinking and feeling in much the same way, but also reach out and entwine around other, distant, ideas, bringing them close as if through the optics of a giant telescope. Her posthumous anthology, *A Responsibility to Awe* (Elson 2018), edited by her husband and close friends, contains complete poems, but also unfinished work from her notebooks.

I can, therefore, end on an optimistic note. There are many recent and current examples of real signs of turns toward a more contemplative and shared way to think about science, in addition to Dame Ottoline's recent public call. Former science journalist Tim Radford confesses that he found the political events of 2016 so troubling that his search for solace took him, in imagination, to those most distant human artifacts—the deep-space probes of the *Voyager* mission now travelling beyond the solar system in their fifth decade. The resulting 2018 book, titled after Boethius, *The Consolations of Physics* (Radford 2019) takes the contemplative power, in current language and idiom, into the shared commons that Boyle imagined would mark a reformed and renewed public science.

With regard to the deep connections of science and poetry, there are signs that these are breaking surface in new and exciting ways. An annual celebration of science and poetry, *Universe in Verse*, has been broadcast on Maria Popova's "Brainpickings"[4] webpage from its Brooklyn venue since 2017 (Popova 2019). The year 2020 saw the foundation, by Sam Illingworth, of the online journal *Consilience*,[5] the first dedicated to science and poetry.

Turning 180° about is not easy. We call it, after all, "conversion." But consider—every Christian is familiar with just such radical re-orientation: away from self and toward Jesus, and this as both an initial calling to discipleship and as a daily discipline. Re-orienting science from the idolization of pure objectivity to a duality with immersed, incarnate subjectivity; from a false notion of pure rationality to a recognition of the partnership reason has always enjoyed with imagination; from an exclusive expertise to a

shared participation, contemplation and joy; and from a convergent and prosaic narrative of the material world to an open, poetic and infinitely beautiful one—all this constitutes a huge task, but a task it seems is gifted, and wonderfully trusted to those daughters and sons of Adam, each made in the image of God.

Notes

1. This may be an abbreviation of a five-step "ladder of intelligence" detailed by Isaac of Stella in his Sermon 4 on the Feast of All Saints (tr. B. McGinn Cistercian Press 1977): "For the soul too, while on pilgrimage in the world of its body, there are five steps toward wisdom: sense-perception, imagination, reason, intelligence, and understanding."
2. See Diotema's proposal in Plato's *Symposium. The Internet Classics Archive: Symposium by Plato*, translated by Benjamin Jowett
3. I am indebted to Prof. Celia Deane-Drummond for pointing out this contrast.
4. https://www.brainpickings.org
5. https://www.consilience-journal.com

References

Adams, Jim W. 2020. *The Performative Dimensions of Rhetorical Questions in the Hebrew Bible*. London: T&T Clarke.

Alter, Robert. 2011. *The Art of Biblical Poetry*. Philadelphia: Basic Books.

Arendt, Hannah 1998. *The Human Condition*, 2nd ed. Chicago: Chicago University Press.

Blake, William. 1804. *Milton Book 2*, pl. 41; in Bindman, David. 2001. *William Blake*: *The Complete Illuminated Books*. London: Thames & Hudson.

Boyle, Robert. 1660. *New Experiments Physico-Mechanicall, Touching the Spring of the Air*. Oxford: H. Hall, Printer to the University, for T. Robinson.

Boyle, Robert. 1690. *The Christian Virtuoso*, 1st ed. London: John Taylor. https://archive.org/details/christianvirtu00boyluoft/page/n7/mode/2up.

Browne, Thomas. 1643. *Religio Medici*. Ed. Alisdair MacNoravaich (2018). Dumfries and Galloway, UK: Anodos Books.

Cates, Michael E., and Vinothan N. Manoharan. 2015. "Celebrating Soft Matter's 10th Anniversary: Testing the Foundations of Classical Entropy: Colloid Experiments." *Soft Matter* 11:6538–46.

Cavendish, Margaret. 1668. *Observations upon Experimental Philosophy*, 2nd ed. London: Anne Maxwell.

Eliot, Thomas Sternes. 1951. *Poetry and Drama*. Scholar's Select. New York.

Elson, Rebecca A. W. 1998. "The Binary Star Population of the Young Cluster NGC 1818 in the Large Magellanic Cloud." *Monthly Notices of the Royal Astronomical Society* 300 (3): 857–62.

——— 2018. *A Responsibility to Awe*. Manchester: Carcanet Press Ltd.

Gasper, Giles E. M., Cecilia Panti, Tom C. B. McLeish, and Hannah E. Smithson, eds. 2019. *The Scientific Works of Robert Grosseteste, Vol. 1: Knowing and Speaking: Robert Grosseteste's De artibus liberalibus 'On the Liberal Arts' and De generatione sonorum 'On the Generation of Sounds.'* Oxford: Oxford University Press.

Goethe, Johann Wolfgang von. 1827. "On Morphology," In *Hamburger Ausgabe: Werke Hamburger Ausgabe in 14 Bänden*, edited by Erich Trunz, 1948–60. Hamburg: Chr. Wegner (Reprinted, C. H. Beck, 1981).

Greenberg, Clement. 1982. *Modernist Painting*. London: Harper-Row in association with the Open University.

Grosseteste, Robert. 1982. *Commentarius in Posteriorum Analyticorum libros*. Edited by Pietro Rossi. Florence: The Catholic University of America Press.

Guite, Malcolm. 2012. *Faith, Hope and Poetry*. Oxford: Ashgate.

Harman, Peter. 2001. *The Natural Philosophy of James Clerk Maxwell*. Cambridge: Cambridge University Press.

Harrison, Peter. 2007. *The Fall of Man and the Foundations of Science*. Cambridge: Cambridge University Press.
Hart, David Bentley. 2003. *The Beauty of the Infinite*. Grand Rapids, MI: Eerdmans.
Hunter, J. Paul. 1990. "Robert Boyle and the Epistemology of the Novel." *Eighteenth-Century Fiction* 2:275–92.
Illingworth, Sam. 2019. *A Sonnet to Science*. Manchester: Manchester University Press.
Kosso, Peter. 1992. *Reading the Book of Nature: An Introduction to the Philosophy of Science*. Cambridge: Cambridge University Press.
Kuhn, Thomas. 1966. *The Structure of Scientific Revolutions*. Chicago: Chicago University Press.
Marquis de Laplace, Pierre Simon 1814. *A Philosophical Essay on Probabilities*. Translated from 6th French ed. by F. W. Truscott and F. L. Emory (1902). New York: John Wiley and sons.
Leyser, Ottoline 2020. Interview in Times Higher Education Supplement. https://www.timeshighereducation.com/news/ottoline-leyser-im-not-going-pussyfoot-about.
Lorian, Victor. 1988. "Differences between In Vitro and In Vivo Studies." *Antimicrobial Agents and Chemotherapy* 32:1600–1601.
MacDonald, George. 1893. "The Imagination, its Function and its Culture." In *A Dish of Orts*. Lexington: Editora Griffo (2015).
McLeish, Tom. 2014. *Faith and Wisdom of Science*. Oxford: Oxford University Press.
———. 2019. *The Poetry and Music of Science*. Oxford: Oxford University Press.
———. 2020. *Soft Matter: A Very Short Introduction*. Oxford: Oxford University Press.
Medawar, Peter. 1984. *Pluto's Republic*. Oxford: Oxford University Press.
Midgley, Mary. 2001. *Science and Poetry*. Abingdon, UK: Routledge.
Mirvis, Ephrahim. 2020. BBC's Thought for the Day, 9 November 2021. Available at https://www.bbc.co.uk/sounds/play/p08xvfh1.
Motion, Andrew. 1993. *Philip Larkin: A Writer's Life*. London: Faber.
Popova, Maria. 2019. *Figuring*. New York: Pantheon Books.
Popper, Karl. 1962. *Conjectures and Refutations*. London: Routledge and Kegan Paul.
Power, Henry. 1663. *Experimental Philosophy, in Three Books*. London: T. Roycroft, for John Martin and James Allestry.
Provan, Iain. 2017. *The Reformation and the Right Reading of Scripture*. Waco, TX: Baylor University Press.
Radford, Tim. 2019. *The Consolation of Physics*. London: Scepter Books.
Read, John. 1957. *Through Alchemy to Chemistry*. London: G. Bell.
Shelley, Percy Bysshe. [1839] 1840. *Essays, Letters from Abroad, Translations and Fragments*. In two volumes. Edited by Mary Shelley. London: Edward Moxon.
Southern, Richard W. 1992. *Robert Grosseteste; the Growth of an English Mind in Medieval Europe*. Oxford: Clarendon Press.
Sprat, Thomas. 1667. *History of the Royal Society of London, for the Improving of Natural Knowledge*. London: The Royal Society.
Steiner, George. 1989. *Real Presences*. Edited by Robert J. DeMaria. London: Faber and Faber.
Swift, Jonathan. 2003. *Gulliver's Travels*. London: Penguin.
Tilby, Angela. 1992. *Science and the Soul*. London: SPCK.
Ungureanu, James. 2019. *Science, Religion, and the Protestant Tradition: Retracing the Origins of Conflict*. Pittsburg: Pittsburg University Press.
Withun, David. 2017. *Making Peace with the World: T. S. Eliot & the Purpose of Poetry*. https://theimaginativeconservative.org/2017/08/poetry-ts-eliot-david-withun.html.
Wordsworth, William. 1802. *Lyrical Ballads with Pastoral and Other Poems*, 3rd ed. London: Printed for T.N. Longman and O. Rees.