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theories which serve to represent and organize bodies of data and evidence. For example, McGrath cites Dmitri Mendeleev's Periodic Table of the Elements. With this kind of organization in view, a certain "beauty" and "coherency" emerges, a kind of simple elegance that can inspire both (subjective) awe and enable further scientific (objective) investigation. It is in fact through these mentally constructed theories that we "see" and make sense of the external world, and these "imaginaries" should aim to engage *both* the intellect and the affect.

In chapter 8, McGrath visits the "first world" of objectivity, with the primary concern to show that, since humans are part of the very cosmos that objective science seeks to explain, there are inherent limits to the reach of a detached, person-neutral, objectivity. McGrath seeks to safeguard against a totalizing scientific reductionism by pointing out that a new natural philosophy will recognize that there are *several* aspects or layers of meaning to any given object of inquiry, and one needs to consider them all to get behind what's really there. He posits neo-Confucianism as one potential example of this kind of engagement with the external world.

Chapter 9 is about the importance of subjective experience, where McGrath seeks to show how aesthetic value and affective engagement are more than arbitrary states of mind. Instead, they often reflect true and proper responses to a world that *really* is pregnant with "beauty and wonder." McGrath then wraps up the book by surveying what he has done and emphasizing the need for a retrieval of natural philosophy, a retrieval that can be enabled through a newfound imaginary or imaginaries.

I will offer two points of praise and two points of criticism. First, McGrath's keen ability to clearly explicate a very complex subject is on full display in this book. McGrath covers an impressive amount of historical ground in the first half of the book in a surprisingly small space (about a hundred pages), complete with explanatory and exploratory footnotes which enable the reader to delve deeper into subtopics. In this way, and like McGrath's many other monographs, the volume is worthwhile if for no other reason than that it acts as a sort of brief yet rich handbook to the subject at hand. Secondly, McGrath's effort is worth considerable praise because he not only seeks to give an intellectual history and critique of the modern epistemic predicament concerning science, but he also delivers up a thought-provoking proposal on what can be done to begin to *address* the problem. His re-conception of Popper's "three worlds" model is, I think, worthy of serious consideration. The broader point, however, is that McGrath is unafraid to wield both a critical acumen and a hopeful positivity regarding this issue, and such constructive attitude from a mind like his is welcome.

On the other hand, in Part 1, McGrath ends his historical survey and critique of natural science with the nineteenth-century secular Darwinists. It is, in fact quite arguably, the horrors and figures of the twentieth century which serve to hammer home the point concerning the consequences of abandoning the disciplinary imaginary for an elevation of (fragmented) scientific knowledge and scientific goals above most everything else. Thus, the first five chapters could have served as a setup for a polemical slam-dunk, but without this survey of the twentieth-century consequences, Part 1 left me with the feeling that McGrath proceeded a bit too prematurely.

Secondly, in Part 2, the way in which McGrath approaches the problem of modern science and his laying out a potential solution gives the impression that he views the issue, fundamentally, as an intellectual one. Is it perhaps more likely, as C.S. Lewis believed, that the problems which plague the modern scientific establishment (including the epistemological problems that stem from fragmentation) are fundamentally *moral*, not intellectual (see *The Abolition of Man*)? On this idea, civilization requires first and foremost a turn back toward God, in repentance. Only then can our institutions—knowledge producing and otherwise—begin to function properly. Moreover, given that our current state of scientific and technological advancement has far outstripped our moral scruples, one is left wondering what a scientific establishment could be capable of with the *wrong* (morally speaking), yet effective, disciplinary imaginary in place. The lesson from the biblical story of the Tower of Babel comes to mind, where an unprecedented attempt at evil was made possible only *because* corrupt humanity enjoyed a cohesive and integrated knowledge base, and the subsequent fragmentation of knowledge through the dispersion of languages acted not only as a divine judgment, but also as a paternal guardrail.

In all, nevertheless, McGrath's contribution to the topic is a timely and welcome addition, one which is sophisticated while remaining accessible, critical while remaining constructive. It is well worth picking up.

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DOI: <https://doi.org/10.56315/PSCF9-23McLeish>

THE POETRY AND MUSIC OF SCIENCE: Comparing Creativity in Science and Art by Tom McLeish. New York: Oxford University Press, 2022. 414 pages. Paperback; \$16.95. ISBN: 9780192845375.

In this tour-de-force book, British physicist Tom McLeish finally comprehensively argues, in one dense volume, what so many scientists have been claiming

piecemeal for centuries: that doing science often looks and feels like doing art. That is a broad, amorphous statement, of course, and scientists have not done a very good job of fully understanding this idea or selling it to the rest of the world. This carefully crafted volume must be the most exhaustive work in this area, treating the notion that the creative work of scientists and artists is extraordinarily similar, in that they both fundamentally involve an intimate passion for describing and representing the world around us.

This is not a book about beauty or wonder in science, but rather it examines how scientific ideas and theories come to a scientist's mind and find fruition as publishable science. The entire book juxtaposes literature and art with science and mathematics to help understand the creative process. One important impetus for writing the book, according to McLeish, was recent evidence that smart, capable high schoolers in England were choosing not to go into science because they believed it would not be nearly as fulfilling, creatively, when compared to work in the arts or humanities. McLeish, a Christian, succeeds in this book in showing that not only is creative thinking and experimenting necessary and "part of the chase" in science, but that it is also a natural fulfillment of our creative mandate as human beings made in the image of God. McLeish is also careful to give examples of "more-regular" science, rather than relying solely on the popular accounts of the creativity of exceptional geniuses; he tries to show that all scientists participate in this artistic-like creativity no matter what they are studying.

The first two chapters introduce the concepts of creativity and inspiration in science. McLeish begins an interaction with several important works that he draws on throughout the book: William Beveridge's *The Art of Scientific Investigation* from 1950, Henry James's *The Art of the Novel*, and Howard Gardner's 1993 work *Creating Minds* (one of many surveys of particularly creative individuals). Chapter 3, "Seeing the Unseen," is about visual imagination and its role in theory creation, artistic design, and general problem solving. Visual imagination is seeing things in the mind's eye, but it is obviously linked to actual sight and seeing the world, too. Surveying the history of thought in this area, McLeish ranges from Plato to Gregory of Nyssa, to the thirteenth-century polymath Robert Grosseteste, to the Italian painter Giotto, to Einstein, who said his theory creation and problem solving started with visual images in his mind, which often led to his famous *gedanken* experiments. Grosseteste is one of the main interlocutors for McLeish throughout the book, being an exemplar of someone having a broad view of thought and creative exploration, not just compartmentalizing

a premodern understanding of the physical world from his theological and philosophical commitments.

Chapters 4 through 6 sequentially juxtapose each of the three main areas of scientific work (experiment, theory, and mathematics) with their natural counterpart in literature and music. Experimental science is akin to writing a novel (!?) in that both set up artificial worlds that are tested against the real world and help illuminate the real world. Theoretical science is akin to writing poetry, in that both re-imagine the universe within fixed constraints: poetry within a certain shaping but constraining form, and theoretical visions of what goes on "under" the natural world constrained by a necessary conformity to that world. Chapter 6 compares mathematical creativity with composing and listening to music—the two "wordless" human endeavors in the world of the abstract.

The book is ultimately a treatise on creativity, and as such applies not just to science and art, but to all human endeavors that require creativity. In the final two chapters (7 and 8), McLeish develops what he describes as an "Ur-narrative of creative experience." Starting with a four-step creative process taken from Graham Wallas's 1926 work *The Art of Thought*, he adds in three more important stages that emerge from his analyses. The seven steps are: vision, desire, industry, constraint, incubation, illumination, and verification. (McLeish has added in desire, industry, and constraint, along with switching Wallas's *ideation* to *vision*.) Chapter 7 deals with emotion and drive in scientific creation, and chapter 8 ponders the purpose of human creativity, the telos that ultimately drives scientists and artists to such great lengths in pursuing their creative work. McLeish brings the *imago Dei* front and center, drawing on the two great hymns in the Book of Job, "Voice from the Whirlwind" (Job 38–42) and "Hymn to Wisdom" (Job 28), as guides to understanding the creative impulse to understand creation. In this he draws on his previous volume with Oxford, *Faith and Wisdom in Science*.

I believe that listing all the scientific works that McLeish describes in detail with regard to the creative elements behind the works is a good way to convey the magisterial scope of this intellectually rich book. Topics that get 2–10 pages each of description include Feynman's theory of beta decay, McLeish's own considerable contribution to viscous flow in branched polymer melts and his idea of entropically based allostery in biology, Belgian scientist Jan Vermant's work in mesoscale properties of "living matter" (which involves cellular-based material science), "collective phenomenon" and its original invocation by Pierre Weiss in 1907 to explain ferromagnetism, the centuries-long premodern

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controversy over the nature of sight (*intromissive* vs. *extramissive*, etc.), the recent evidence of a star being destroyed by a black hole, Boyle's contributions to the founding of modern experimental science, Alexander von Humboldt's important contributions to the value of a wholistic, multilevel vision of nature and science, Emmy Noether's astonishing discovery of the theoretical origin of conservation laws in physics, the discovery of the all-important fluctuation-dissipation theorem over 30 years (inaugurated by Einstein in 1905, applied to electrical noise by Nyquist in 1928, and fully generalized by Callen and Welton in 1951), the recent development at Caltech of a jet fuel polymer additive that greatly inhibits explosions of jet fuel (motivated in part by the horror of the fuel explosions on 9/11), and finally the full discovery of what causes rainbows by Theodoric in ca. 1310. The descriptions of these historic achievements are each fascinating in their own right and very readable—they alone, for me, would justify an investment in this book. When they are paired with a similar creative work from art, poetry, or fiction, the juxtaposition is extremely fruitful, though the philosophical/psychological analyses get much denser.

Many other discoveries are given much shorter treatment (less than one page), including Andrew Wile's solution to Fermat's Last Theorem, Dirac's mathematical discovery of spin and anti-matter, Poincaré's discovery of a new class of Fuchsian functions, Royer's recent proof of the Gaussian Correlation Inequality in statistics, and Heisenberg on discovering quantum matrix mechanics. The explorations into artistic and literary creativity are typically much shorter, but are nearly as numerous; they include a painting conceptually representing a string-quartet performance by English artist Graeme Willson, Virginia Woolf's *To the Lighthouse*, Robert Schumann's orchestral work *Konzertstück*, and Picasso's masterpiece *Guernica*.

At nearly four hundred pages, this is not light reading and takes some patience and time to get through. It is written at a very high level of sophistication, and therefore one is often "bogged down" trying to make complete sense of what one is reading. (However, if one is not writing a review of the book, one need not spend quite so much time disentangling every dense sentence to get the main gist of the passages.) Also difficult are the many references to previous parts of the book. While these references are entirely appropriate, they are quite demanding of the reader given the sheer number of names and amount of material covered. I had to do quite a bit of flipping back and forth, checking the index to remember exactly what so-and-so said that is now being referenced 100 pages later. In other words, this is a thoroughly academic text.

This is a revised edition of the book, which was first published in 2019. The overwhelming positive response, according to the new preface, prompted the author to immediately answer some of the initial reviews and friendly critiques, which I believe made the book quite a bit better (initially there was not nearly as much about poetry; the comparison of poetry with theoretical science now became a separate chapter, enabling McLeish to more logically and thoroughly cover the territory he had staked out). McLeish sadly died very recently (February 2023) at age 60, while holding the newly created chair in Natural Philosophy at University of York. He was a lay preacher in the Anglican Church and a Fellow of the Royal Society.

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DOI: <https://doi.org/10.56315/PSCF9-23Bishop2>

EMERGENCE IN CONTEXT: A Treatise in Twenty-First Century Natural Philosophy by Robert C. Bishop, Michael Silberstein, and Mark Pexton. Oxford, UK: Oxford University Press, 2022. 363 pages. Hardcover; \$103.65. ISBN: 9780192849786.

Reductionists dream of a day when all scientific truths can be derived from fundamental physics. Bishop, Silberstein, and Paxton show that dream is now dead, or at least it's quite ill. But what will replace it? One answer is "emergence," although that term is ambiguous. In its weak sense, it merely expresses pessimism about our ability to fully understand how microphysics produces all other phenomena. In its strong sense, it means that some entities have a kind of autonomy from physics, with their own "causal powers," including downward causation. Bishop et al. seek to replace strong and weak emergence with "contextual emergence."

Let's start with an example (sec 2.4). Rayleigh-Bénard convection occurs when a fluid is trapped between a heating plate below and a cooler one above. Convection cells emerge as warmer fluid rises toward the top and cooled fluid sinks. While molecular interactions play a part in this, sustained convection is impossible without the macroscopic plates. This behavior is not wholly determined by the fluid's constituent parts but rather by the context in which the fluid exists.

What this and scores of other examples show is that phenomena at a given scale often depend on a host of "stability conditions" at other scales—sometimes higher, sometimes lower. *Contra* the reductionist, the authors argue that the behavior of entities, properties, and processes at a given level is never wholly determined by events at a lower level. Macroscopic conditions (among other things) play an essential and ineliminable