Opinion Page: Creativity and Constraint in Science and the Arts, Tom McLeish, University of York

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His earlier newsletter essay 'Science + Religion' is available here.

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Different Descriptions

Creativity, Inspiration, Passion, Form, Imagination, Composition, Representation—this powerful list of words leads a reader's mind inevitably into the world of the arts. Perhaps it conjures up the shaping of a block of stone into the form of supple limbs and torso, or layering darkly tinted oil paints onto canvas to tease the eye into imagining a moonlit forest at night. Others may think of a composer scoring a symphony's climax—she summons the horns to descend as from a distant mountain peak to meet a harmonically ascending string bass-line in a satisfying resolution. A poet at his desk wrestles with meter and rhyme as he filters the streams of words, metaphors, and allusions that clamour for place on the page. The double miracle of art is not only that it allows humans to draw meaning from the world, but also that it reaches out to its listeners, viewers, and readers so that they may re-create for themselves something new and personal in response. Both by words and by images we are changed, troubled, made more aware as art enriches us in small ways or great. To engage in art by creation or reception and re-creation is to exercise one of the capacities that make us human. Indeed, the academic study of art's products and process falls under the class of disciplines we call the 'humanities.'

Experiment, Design, Formulation, Method, Theory, Observation, Hypothesis, Computation, Trial, Error—another list of words might lead to a different world of activity. These are more associated with disciplines we term 'the sciences.' Their energy seems to be of a different sort—we are not, perhaps, as emotionally moved by these terms; they do not suggest as much wild, unpredictable outcome. Are we encouraged to think, perhaps, of a laboratory setting—a careful mixing of liquids and a measuring of their temperature? Is the mental picture one of an observer carefully preparing a microscope, or calculating by computer the orbit of a distant planet? If the artistic associations are as likely to disturb as to excite, are the scientific associations more reassuring (the French cubist Georges Braque thought that, '*L'art est fait pour troubler, la science rassure*'[1])? Or do they disturb in a different way? Very likely this is a world that is unfamiliar and strange, less accommodating than the arts and, dare we admit it, less 'human' in some way (we do not class the sciences as 'humanities' after all).

Similar Practices

But there are other voices that choose the same language to talk about art and science, and even in the

1 Art is made to disturb, science to reassure.

same breath. Philosopher of science Karl Popper once wrote: 'A great work of music, like a great scientific theory, is a cosmos imposed upon chaos — in its tensions and harmonies inexhaustible even for its creator.'[2] This richly layered and dense commentary on music and science will need some background work to uncover Popper's meaning—its allusions immediately fail to intersect with the quite distinct word-lists that spring from usual talk of art and science. But it raises suspicions. Is a dualistic division into arts and science really faithful to our history, our capacities and needs? Does it spring from a deep understanding of what these twin human projects attempt to do—is it faithful, dare we ask, to their purpose? And if not, are we right to ask of our children, 'are they on the science-side or the arts-side?' or to reinforce the well-worn narrative of C. P. Snow that there are 'Two Cultures'[3] at work in our late- modern world, non-overlapping, mutually incomprehensible, and doomed to conflict?

If we are wrong to categorize culture, let alone people themselves in this way, then to make exclusive educational decisions based on such a dualistic assumption will be to trigger a process of atrophy in one or other aspect of those children's development, and in adult life to have closed off one or other world of expression, contemplation, creativity, enrichment—of complementary ways of being human.

Doubts intensify about a neat cultural divide if we take the all too unusual step of listening to an artist, or to a scientist, talk candidly about their creative journeys from early ideas to a finished work. For when we do that, the language-clouds of the arts and the sciences start to collide and overlap. It is much less common to discuss the long process of realization in art than to talk about the final article, composition, theory, or painting. Why this is, is hard to say. The famous exceptions (such as the evolution of Picasso's *Guernica*[4], the candid reflections of novelists Henry James[5] and Elena Ferrante[6]) underline the question.

If art is shy about the sweat and tears of working out the form of an original idea, then science is almost silent about its epiphanies and moments of inspiration. Popper himself, celebrated for the most detailed modern outworking of a scientific method in his *Logic of Scientific Discovery*, wrote at length on how hypotheses may be refuted, but remained quiet on how they might be imagined in the first place. While acknowledging the vital necessity of such imaginative preconception, Popper declared that, as essentially non-methodological, he had nothing to say about it. There is some degree of logic and process in the testing and evaluating of a scientific idea, but there are no such recipes for conceiving them.

Nobel Laureate Sir Peter Medawar lays some of the blame for our blindness to the role of imagination in science at the feet of John Stuart Mill's *System of Logic*. Mill writes as if he believed 'that a scientist would have already before him a neatly ordered pile of information ready-made—and to these he might quite often be able to apply his rules.'[7] If science gathers to itself a narrative more weighted towards method, and art is more vocal about creative origins, then these retellings of partial truths will conspire to drive an illusory distance between them.

Inspiration vs Rationality

The contrasting traits of silence within the community of science on its imaginative energies, and of art on its workaday reckoning with material reality, is not restricted to our own times. William Blake, the eight-

Painting: Picasso's Guernica Berkeley: The University of California Press.

2 Karl Popper (1976 [2002]), *Unended Quest: An Intellectual Autobiography*. London and New York: Routledge.

3 C. P. Snow (1959 [1998]), *The Two Cultures*. Cambridge: Cambridge University Press.

4 Rudolf Arnheim (1963) *The Genesis of a*

5 Henry James (1934), *The Art of the Novel.* Chicago: University of Chicago Press (2011).

6 Elena Ferrante trans. Anne Goldstein (2016) *Frantumagli*. New York: Europa editions

7 Peter Medawar (1984), 'An essay on scians,' in *The Limits of Science*. Oxford: OUP.

eenth-century poet, artist, and engraver, famously inveighed against what he perceived was the destructive dehumanizing of 'natural philosophy', the term used for the quantified and experimental understanding of nature we would term 'science' today. He wrote of his own task:

> 'in the grandeur of Inspiration to cast off Rational Demonstration . . . to cast off Bacon, Locke and Newton'; I will not Reason and Compare — my business is to Create'.[8]

For Blake, inspiration has no place in Newton's work, and reason none in his own. There is some buried personal dissonance here given what we know of his own painstaking technical developments in copper engraving. He was not without cause for complaint against those early modern philosophers: John Locke, in his *Essays Concerning Human Understanding*[9] had identified 'the imagination' as the source of false and fantastical ideas, as opposed to experience, the reliable guide to the true. Yet there are other voices within the nineteenth century, that witness to a very different vision. One is Ada Lovelace, poet and mathematical collaborator of Charles Babbage, who in an essay from 1841 wrote in powerfully metaphorical terms about the power of imagination in the sciences, and of the sense of exploration in pursuing them:

> Those who have learned to walk on the threshold of the unknown worlds, by means of what are commonly termed par excellence the exact sciences, may then with the fair white wings of Imagination hope to soar further into the unexplored amidst which we live.[10]

Yet it is Blake's and Locke's compartmentalized assignments of inspiration and rationality that I find at work today among British high-school pupils. When participating in 'general studies' discussions of science in society, or the importance of interdisciplinary thinking, I like to ask advanced students who have not chosen to study science subjects (when from their intellectual engagement with the material it is clear that they could master anything they wished) why they made that choice. Among the brightest of them, I never receive the complaint that the sciences seem too difficult, but rather that they appear to lack avenues for creativity and the exercise of imagination. The conversation sometimes also reflects the expectation of a more playful engagement with the humanities, contrasting with impressions of seriousness and narrowness in the sciences.

I find this personally painful, and doubly saddening that these young people have been offered no insight into the immense fields for imagination offered by science, and that scientists have failed in communicating its call on creativity. As pioneer of science-art project curator and commentator, Sian Ede writes:[11]

> Compared with the cool rationalism of science with its material belief in wholeness, the theories employed by thinkers in the arts and humanities seem part of a playful circular game in which the truth is never to be privileged in one direction or another and is always out of reach.

These echoes of Blake in the words of today's brightest young people are painful to hear. They speak to the urgency of a project that goes beyond the confrontational assumptions of the 'Two Cultures' to deeper levels of human motivation, desire, experience—one that recognizes the dual qualities of rationality and inspiration, of seriousness and playfulness, of imagination and constraint, but challenges their automatic alignment with the axes of humanities and sciences, exploring instead how they play out in both.

8 William Blake, *Milton* (1804), book 2, pl. 41; Jerusalem, ch 1, pl. 10.

9 John Locke (2015), *The Clarendon Edition of the Works of John Locke*, Oxford: Oxford University Press, *An Essay Concerning Human Understanding Book II*.

10 Ada Lovelace (1841), quoted in Sam Illingworth (2019), *A Sonnet to Science*. Manchester: Manchester University Press.

11 Sian Ede (2005), *Art and Science*. London I. B. Taurus.

Inspiration in Science

Here is Einstein on the two components of scientific creativity:[12]

> The mere formulation of a problem is far more essential than its solution,
> which may be merely a matter of mathematical or experimental skills.
> To raise new questions, new possibilities,
> to regard old problems from a new angle, requires creative imagination
> and marks real advance in science.
> ~
> I am enough of an artist to draw freely upon my imagination.
> Imagination is more important than knowledge. Knowledge is limited.
> Imagination encircles the world.

Thomas Kuhn famously coined the notion of 'paradigm shifts' to denote discontinuous changes in the scientific framework for understanding nature. They entail revolutions in entire sets of presuppositions and current mutually supporting scientific ideas. They typically witness the entry of new ideas not deducible from prior reasoning.[13] Classic examples are the Copernican revolution in cosmology and the shift from classical to quantum physics. Beyond identifying the growing dissatisfaction with the existing framework, however Kuhn made no suggestions concerning the provenance of the new set of ideas—they are the protoplasm of his revolutions but seed no methodology.

The formulation of the fruitful question, posed in the right way, constitutes the great imaginative act in science. It requires a developed sense of the current era of scientific thought, of timing. Historian of science and chemist Lawrence Principe[14] has pointed out the appropriateness of questioning the structure of the solar system at the turn of the seventeenth century, when Tycho Brahe's meticulous observations of planetary motion and Copernicus' inspired partial solution to the new paradigm had opened up a field of potential progress. Johannes Kepler's deductions together with Thomas Harriot's and Galileo's new telescopic observations of the heavens, made asking about the dynamical consequences of gravity among the sun and the planets fruitful in a sense that it had not in any previous century.

If the scientific imagination is fed by the creative and timely question, it also needs the nourishment of the discontinuous, of leaps in thinking that receive their impulse from some other source than the worthy process of logical deduction. A generation on from the establishment of the orbits of the moon and planets within a heliocentric structure of the solar system, Newton's great imaginative conception was to contemplate a world in which the fall of an apple sprung from the same universal field of force as the monthly procession of the moon.

The presence of the creatively formulated question in as ancient a source as the Book of Job[15] (undatable other than to place it within the first half of the first millennium BCE) within the Semitic tradition, carries another salutary message to us late moderns. Alongside the complex history of ancient Hellenistic science from 500 BCE, it surely erodes any idea that science is in any way exclusively modern, beginning rootless at the enlightenment and blowing away the cobwebs of centuries of darkness, magic, superstition and alchemy. Sadly, much popular narrative of science history has it so, but claiming science as an exclusive property of the modern world removes the deep and slow cultural development of an imaginative and creative engagement with nature that develops, at least chronologically, alongside the story of art in its own

12 Albert Einstein and Leopold Infeld (1938), *The Evolution of Physics*. London: Cambridge University Press.

13 Thomas Kuhn (1966), T*he Structure of Scientific Revolutions*. Chicago: Chicago University Press.

14 Lawrence Principe (2013), *The Scientific Revolution: A Very Short Introduction*. Oxford: Oxford University Press.

15 For a magisterial survey of the *Book of Job*, see the three-volume work by David Clines, Thomas Nelson pubs. We will encounter an explicit example of scientific inspiration drawn from reading it in the story of the rainbow, told in Chapter 8.

multitude of forms.[16]

Communities of Appreciation of the Arts and Science

On the other hand, if a distorted impression of creativity arises in part from selective silences on the part of their practitioners, then perhaps the same is true of their reception. Comment on the effect and the enjoyment of art is commonplace. It speaks of a healthy continuum from artist and performer to receiver and listener. We may not be able to paint or to sing like the great exponents of art and oratorio, but we are not silenced as a result from speaking, or even from critically appraising, paintings or performances.

There is understood to be a 'ladder' of participation and reception in the arts. In music, for example, the lower rungs are occupied by those of us who enjoy concerts, who pick up instruments in the company of forgiving amateur friends. We would never presume to perform in public, but nevertheless can confidently express an opinion on which recording of a symphony we prefer. The upper rungs are occupied by the performers on those very recordings.

It is harder to find comparable examples of reception and affect, in scientific creation. But this is not because of a lack of inherent appeal to human desire and need. The 'ladder of access' that we identified in a creative art such as music is not (as observed by Barzun in different terms) present in our current culture in science. This was not always the case—Shelley, Coleridge, and Wordsworth all thought that science could, and would inspire poetry (though Shelley foresaw that the inspirational beauty of science would be a hidden one). So, for articulated contemporary reception of science, we must usually listen to the scientists themselves.

Here cosmologist Subrahmanyan Chandrasekhar describes in remarkable terms an example of the moments of transport for which science longs:[17]

> In my entire scientific life, extending over forty-five years, the most shattering experience has been the realization that an exact solution of Einstein's equations of general relativity, discovered by New Zealand mathematician Roy Kerr, provides the absolutely exact representation of untold numbers of massive black holes that populate the universe. This 'shuddering before the beautiful', this incredible fact that a discovery motivated by a search after the beautiful in mathematics should find its exact replica in Nature, persuades me to say that beauty is that to which the human mind responds at its deepest and most profound.

The cosmologist is speaking of the extraordinarily simple yet utterly strange idea of a 'black hole'. For many years pure conjecture, observational evidence from stellar evolution and highly luminous galactic cores has pointed increasingly to the inevitable existence of these bizarre and terrible objects. Black holes are places in the cosmos where the local presence of matter is so great that gravity generates its runaway collapse towards a point where density becomes formally infinite, surrounded by a finite region of space in which the tug of gravity is so great that no light can escape. Possessing a terrifying and austere beauty, these objects are as near to instantiated mathematics as one could imagine. They can have no other properties than mass, spin and electric charge. All other attributes that their original matter once possessed are lost in its irreversible in-fall. The normal role of mathematics within theoretical physics is to provide approximate descriptions of natural objects, but in this case the attribution of a black hole's triplet of properties is complete.

The experience Chandrasekhar describes is a rarefied and extreme form of a precious wonder. Einstein put it thus: 'the most inexplicable thing about the universe is that it is explicable' and Eugene Wigner pointed

16 For a more complete and integrated account of the history of science, see the now classic work by David Lindberg (2010), *The Beginnings of Western Science: The European Scientific Tradition in Philosophical, Religious, and Institutional Context, Prehistory to A.D. 1450*, Second Edition, Chicago: Chicago University Press.

17 Subrahmanyan Chandrasekhar (1987), *Truth and Beauty: Aesthetics and Motivations in Science*. Chicago: University of Chicago Press.

towards it in the title of his celebrated essay *The Unreasonable Effectiveness of Mathematics in the Natural Sciences*.[18]

All this is not to deny a tradition of research and writing on the topic of creativity itself that includes scientific examples—far from it. Major edited collections of essays and research from psychologists[19] on creativity have recently spawned a subfield of cognitive neuroscience. The genre has even produced a 'Cambridge Handbook' on creativity.[20]

Imagination in Science and in Science Education

There is little discussion, however, of the way that imagination plays out in the experience of the thousands of people engaged in the scientific and artistic work that adds colour to our communities and national lives. There is also almost total silence within the educational formation of scientists on the topic of imagination, of the creative formulation of questions and hypotheses, or of the experience of scientific ideation. There may not be a method for this most vital of all scientific processes, but there are accounts, practices, and a communal experience that ought to be more widely and openly shared both within and without the scientific community.

I have suggested elsewhere[21] that, because of the 'missing rungs' in scientific ladder of reception, it is lamentably less common for non-practitioners of science to experience the intensity of aesthetic response to a new understanding of nature, than for the scientists whose professional training has taken them to the ladder's higher footholds that still exist. But it is not impossible and could be as common as the learning of a new tune or appreciating an unfamiliar painting for the first time.

In a moving personal example, a friend told me of the moment when, gazing up at the moon one evening, he suddenly understood how its phases worked. A life of familiarization with the monthly cycle of crescent, half, full, and gibbous moon was not equivalent to 'seeing' how these shapes served as the signature of an illuminated orb. On that moonlit night shortly after sunset he allowed the two-dimensional screen of the sky to become, in his mind, a vast three-dimensional structure. The moon became a solid sphere, illuminated by a much more distant sun from different angles on different days, as seen from the centre of its orbit on the Earth. The celestial geometry and its circling dynamics found a home in his imagination—releasing an experience of pure joy. He described feeling present to the world in a deeper sense than before, and knowing that this stronger relationship was, once found, not going to be lost.

The Purpose of Science and Art

Experiences of such reception in science or in art, achieve at their most profound such an intensity of emotion and of felt transformation, that they must draw our exploration to a third level of parallel comparison—that of the human function of creative engagement with nature and, if we dare talk of it, of purpose. A nest of questions confronts us here: why do art, and early science, arise in pre-history? What do they achieve socially and psychologically today? Where do art and science appear, both explicitly and hidden, in the complex of cultural narratives? How do they receive, and provide, value and virtue? The humanities discipline of theology comes to aid here, for no other reason than that it is comfortable with the category and narrative of purpose. Recent writers have attempted to articulate a 'theology of' music (Begbie[22]), of art (Wolterstorff[23]), of science (the

18 Eugene Wigner (1960), *Communications in Pure and Applied Mathematics,* 13, No. I. New York: John Wiley & Sons, Inc.

19 James C. Kaufman and Robert J. Steinberg, eds. (2010), *The Cambridge Handbook of Creativity*. Cambridge: Cambridge University Press.

20 Robert J. Steinberg, ed. (1988), *The Nature of Creativity*. Cambridge: Cambridge University Press.

21 Tom McLeish, *Faith and Wisdom in Science* (OUP 2014).

22 Jeremy Begbie (2014), *Theology, Music and Time*. Cambridge: Cambridge University Press.

23 Nicholas Wolterstorff (1987), *Art in Action To-*

present writer[24]), and found that this trailhead leads to a fruitful landscape within which such questions of purpose can be attempted.

Exploration of a possible parallel purpose at the deepest level for art and science will steer our trajectory into headlong collision with those who have perceived an irreconcilable antithesis between the two. To navigate these stormy waters will need some historical perspective, for an oppositional framing seems to reawaken, at least in the modern period, with each generation. Forty years previous to the late twentieth-century combatants of the 'Science Wars', public intellectuals engaged in angry words over the 'Two Cultures'. But half a century before C. P. Snow and F. R. Leavis locked horns, a gentler but equally incisive debate, anticipating some of the later rancour between the arts and the sciences, was engaged by Matthew Arnold and Thomas Henry Huxley.[25] Before them, romanticism drove home with force the charge that science does precisely the opposite of (at least narrative and poetic) art in the meeting of human creative need. Blake's dismissal of reason as the antithesis of creation was by no means a solitary one. In his long poem narrating the story of the mythical serpent Lamia, John Keats complains of science—for him 'cold philosophy':

> Do not all charms fly
> At the mere touch of cold philosophy?
> There was an awful rainbow once in heaven:
> We know her woof, her texture; she is given
> In the dull catalogue of common things.
> Philosophy will clip an angel's wings,
> Conquer all mysteries by rule and line,
> Empty the haunted air, and gnomed mine
> Unweave a rainbow.

Historical locus is important. Retrospective projection of arguments from our own times, such as simplistic assurances that the romantic poets had nothing to worry about concerning the draining of wonder from the world, will not get to the root of their disquiet. William Whewell coined, around 1836, the term 'scientist', which gathered currency first in America and then Britain throughout the century. Faraday and Maxwell both rejected the label, insisting on the older 'natural philosopher', yet the adoption of 'scientist' was complete by the end of the century. Momentously, the discoveries and theories of geology (Lyell's gradualist and ancient formation of geological strata) and of biology (Darwin's evolution by natural selection) were utterly transforming understanding of relationships between the human race and other species on Earth. The period of romanticism swept in a fragmentation of disciplines and a further distancing of 'the inhuman otherness of matter' unprecedented in thought.

A journey into the purpose of science, and of art, must learn from the misunderstandings and the mutual pain of fragmented disciplines. It must, finally, move from talk about relationship into a practice of it. If we do find familial fellowship between science and art in a deeper reappraisal, then we will surely notice a structural imprint of their shared cultural DNA as we proceed. Returning to our first perspective—the comparative practice of creative imagination—suggests the lines of a possible framework. No art results from unconstrained exercise of imagination. The poet's vision and communicated emotion take shape within the constraining form of sonnet or quatrain. The composer lets thematic material expand, combine, and develop within sonata form or rondo. The painter conjures with light, colour, representation, but only successfully when she observes the material properties of oil on canvas, or of watercolour on board. It is the tension between imagination and constraint, of idea within form, which focusses creative energy into artistic creation itself. The greater the imaginative impulse, the tighter the form is needed to channel and shape it.

Seen in this light, science no longer looks quite so strange. For if its task is to re-conceive the universe, to

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ward a Christian Aesthetic. Grand Rapids: Eerdmans.

24 Tom McLeish, *Faith and Wisdom in Science* (OUP 2014).

25 For a discussion of this debate see E. S. Schaeffer (1994), How many cultures had Lady MacBeth? in L. Gustafsson et al., eds., *Science and the Powers. Hasselby Castle: Swedish Ministry of Science and Education*, pp. 136-92.

create a mental map of its structure, the interrelationships of force and field, of the evolution of structure and complexity, to understand the patterns of matter from the earliest moments of time to its closing aeons, from the smallest fluctuation of space-time to the immensities of the cosmos, and to reconcile all this inhuman otherness to the finitude of our minds, then what task could possibly call on higher powers of imagination? What could demand a greater act of human creation? But what greater form, what more focussing constraint, could be supplied than the way we observe the universe to be? If writing a sonnet is the collision of creativity within constraint of expressing within a tight form and with new potency the human experience of the world, then science also becomes the conception of imagination within constraint. We re-create the universe by imagination within the constraint of its own form. Science becomes the writing of an immense poem.

Creativity and Constraint

Cousinly creativity with constraint—that is a starting hypothesis for a journey through art and science. It will be one with a listening ear. We need to spend time in the workshops of artists and of scientists and look without prejudice at the way their work is, or could be, received emotionally as well as cerebrally. We will need to stand back from our own time and look at longer narratives, and at other ways of differentiating disciplines. Reflection from the high medieval centuries will join as a continuous conversation partner to contemporary voices. The journey will require some close, even technical, readings of great creative examples of art, music, mathematics, and science. The choice of which imaginative voices in all these avenues we listen to closely will be a personal one but will be guided by the requirement that they should have reflected on the process of creativity itself. In such company, our journey will explore the hope that science might re-weave a rainbow in a way that Keats might have recognized as poetic, true, and constitutive of the human.

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