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Author: Matthew Wickman

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Scottish Newtonianism and Modern(ist) History

Matthew Wickman

In assessing Isaac Newton's impact on modernity from the perspective of the late twentieth century, John D. Purrington and Frank Durham arrive at the paradox that the past century 'is at once the most Newtonian [...] and the least Newtonian' of the centuries that have followed the 1687 publication of Newton's monumental *Principia* (the *Mathematical Principles of Natural Philosophy*). On the one hand, late-nineteenth- and early-twentieth-century innovations involving 'blackbody radiation, atomic and molecular spectra, specific heats [...] radioactivity', relativity and quantum mechanics have vaulted us well beyond the sphere of classical physics. But on the other hand, 'in the accelerated technological remaking of nature' and in our 'fundamental view that the universe is a rationally intelligible system, explicable in terms of [...] a small set of basic laws', we remain deeply implicated in Newtonian ideals.[1] As they see it, Newtonian thinking (as a mode of organising experience) is the engine which transports us beyond Newtonian thought (as the set of doctrines we associate with classical physics). To this extent, we think in (or through) the past even as we dwell in the present. Or perhaps it is the other way around: perhaps 'we moderns' inhabit a world of classical certitudes – of gravity and progress – even as our theories of that world hinge on such 'enigmas and guesses' as stochastic (or chaotic) probabilities and subatomic strings of energy.

We Moderns: Enigmas and Guesses is the title of a 1918 book by Edwin Muir which addresses in its own way the type of Newtonian paradox to which Purrington and Durham refer. Muir contends that modern time is out of joint, that the future is behind us: in order to 'emancipate' ourselves from present dogmas, we must 'go back – or, rather, forward – to Goethe, Ibsen and Nietzsche', and particularly to the latter's radical reformulation of the past.[2]

[1] John D. Purrington and Frank Durham (eds),'Newton's Legacy', *Some Truer Method: Reflections on the Heritage of Newton* (New York, 1990), 4–5.

[2] Edwin Muir, *We Moderns: Enigmas and Guesses* (New York, 1920), 104. Margery McCulloch reads Muir's interest in Nietzsche as autobiographical, inasmuch as Nietzsche enabled Muir to grapple with his own past. See *Edwin Muir: Poet, Critic and Novelist* (Edinburgh, 1993), 73.

Muir's contemporary, Oswald Spengler, made an even stronger (or at least a more voluminous) case for the backwards quality of the modern era, or for the 'decline of the West'. But Spengler wrote not only of Nietzsche and Ibsen but also of Newton, who articulated cultural habitudes in the guise of natural laws. 'Motion' and 'mechanics' were for Spengler less the manifestations of an objective science than indices of human activity and world-making. For Spengler, in other words, Newton was not only a philosopher of nature but also a poet laureate of modern alienation.[3] Muir shared Spengler's vision of alienation, but he projected that vision not onto Enlightenment science but instead onto Scottish national identity, which he imagined as a prototypical case of modern(ist) dissociated sensibilities. Muir's notoriously withering (if overheated) argument in his later book *Scott and Scotland* (1936) was that the Reformation and subsequent history had bifurcated thought and feeling in Scottish literature, dividing experience from its formal expression. Reprising popular conceptions of Scottish cultural schizophrenia (from Jekyll and Hyde to G. Gregory Smith's 'Caledonian Antisyzygy'), this problem nevertheless (and provocatively) bore an implicitly Newtonian flavour for Muir. For 'a man who writes in one language and thinks in another', or whose Scots-language reflexes mediate themselves through English, he asserted, 'the action of his intelligence is not contemporaneous with his feeling: it is action at a distance'.[4] 'Action at a distance' became a well-worn phrase for gravity during the Enlightenment, lending Scottish and Newtonian modernity a neat if tacit coincidence in Muir's formulation. Within the constellation of Muir's thought, Scotland thus exemplifies a modern disjointedness which itself appears symptomatic of Newton's more encompassing legacy. Scotland is the most 'modern' of nations because it is in some ways the most deeply (if not always the most self-consciously) Newtonian.

This equation of Newton with Scottish thought (meaning thought *by* Scots as well as thought *about* Scotland) is the subject of this essay. I appeal to Muir at its outset because Muir summarised Scotland's modern/Newtonian condition brilliantly if in negative – meaning, he perceptively identified it even though

[3] Newton's, Spengler says, was an 'artist-nature'. What is more, he elaborates, 'the born mathematician takes his place by the side of the great masters of the fugue, the chisel and the brush; he and they alike strive … to actualize the grand order of all things by clothing it in symbol … [T]he domain of number, like the domains of tone, line and colour, becomes an image of the world-form'. Oswald Spengler, *The Decline of the West*, trans. Charles Francis Atkinson, 2 vols. (New York 1926), 1:61.

[4] Edwin Muir, *Scott and Scotland: The Predicament of the Scottish Writer* (New York, 1938), 37.

in one important respect he got it dead wrong. For while Scotland may have bourn the brunt of Newtonian 'progress' and correlative social regression in the industrial slums of Glasgow which so harrowed Muir as a young man, the nation's *most* conscientiously Newtonian moment found it perhaps the *least* in thrall to the Newtonian paradox of the early twentieth century.[5] That is, it was when Scottish intellectuals most conspicuously assimilated and earnestly defended Newtonian thought that their world view was (in Muir's and Spengler's terms) least truncated, least dissociated – the least, and therefore the most, modern.

I am referring here to a period in the late seventeenth and eighteenth centuries when Newton became a subject in Scottish universities decades in advance of Newton's of its doing so in own Cambridge, and when Scottish literati became Newton's most forceful advocates in Europe.[6] A full account of this history exceeds the limits of this essay, but we can perhaps begin to appreciate its scope in a crucial passage from the landmark long poem *The Seasons* (1730) by James Thomson:

> … [R]efracted from yon eastern Cloud,
> Bestriding Earth, the grand ethereal Bow
> Shoots up immense; and every Hue unfolds,
> In fair Proportion, running from the Red,
> To where the Violet fades into the Sky.
> Here, awful NEWTON, the dissolving Clouds
> Form, fronting on the Sun, thy showery Prism;
> And to the sage-instructed Eye unfold
> The various Twine of Light, by thee disclos'd
> From the white mingling Maze. Not so the Swain,
> He wondering views the bright Enchantment bend,
> Delightful, o'er the radiant Fields, and runs
> To catch the falling Glory; but amaz'd
> Beholds th'amusive Arch before him fly,
> Then vanish quite away.[7]

5 See especially Edwin Muir, *An Autobiography* (Edinburgh, 1993), 81–121.

6 On Newton's Scottish origin as an academic subject, see See John Friesen, "Archibald Pitcairne, David Gregory and the Scottish Origins of English Tory Newtonianism, 1688–1715," *History of Science*, 41:2 (2003), 163–91; cf. Anita Guerrini, "The Tory Newtonians: Gregory, Pitcairne, and Their Circle," *The Journal of British Studies*, 25:3 (1986), 288–311.

7 James Sambrook (ed.), *Spring*, in *The Seasons* (Oxford, 1981), ll. 203–17; Thomson's

This passage, in *Spring*, holds an iconic place in literary history: it represents the dissemination of Newtonian thought into eighteenth-century poetry and, more generally, into the culture of 'Enlightenment'.[8] And yet, by that same token, the passage also came to mark a symbolic Rubicon for Romantic poets. William Blake dismissed Newton as a soul-chilling agent of mechanical reason, and John Keats, following the lead of William Wordsworth, pledged '[c]onfusion to the memory of Newton' for having 'destroyed the poetry of the rainbow by reducing it to a prism'.[9] The rejection here was not only of an unimaginative science, but also of an eighteenth-century literary aesthetic which Thomson had helped articulate, and which bore the hallmark of Scottish Newtonian thought. 'Two cultures' divided here – literature from science, and English Romanticism from its more complex (more apparently conflicted) Scottish counterpart.[10]

But this is where Thomson's Newtonian picture, and the Newtonian picture of Thomson, grow more complicated. For the passage immediately following this paean to Newton modifies the science it purports to celebrate (in ways I will explain below):

> Then spring the living Herbs, profusely wild,
> O'er all the deep-green Earth, beyond the Power
> Of Botanist to number up their Tribes:
> Whether he steals along the lonely Dale,
> In silent Search; or thro' the Forest, rank
> With what the dull Incurious Weeds account,
> Bursts his blind Way; or climbs the Mountain-Rock,
> Fir'd by the nodding Verdure of its Brow.

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emphasis. Subsequent references will be cited in the text.

8 Marjorie Hope Nicolson observes that, '[m]ore than any of the other poets, Thomson developed the "symbolism of the [colour] spectrum"'. *Newton Demands the Muse: Newton's* Opticks *and the Eighteenth Century Poets* (Hamden CT, 1963), 46.

9 Benjamin Haydon, *Autobiography and Memoirs*, quoted in Richard Dawkins, *Unweaving the Rainbow: Science, Delusion and the Appetite for Wonder* (New York, 1998), 39; cf. M. H. Abrams, *The Mirror and the Lamp: Romantic Theory and the Critical Tradition* (Oxford, 1953), 303 – 12 and Nicolson, *Newton Demands the Muse*, 1 – 2. On Blake's animus toward Newton, see Peter Ackroyd, *Blake* (London, 1995), 194.

10 I allude here to C. P. Snow's notion of the 'two cultures' debate. On the divergent (and variant) paths of Scottish Romanticism, see especially Ian Duncan, with Leith Davis and Janet Sorensen, 'Introduction', in ed. Duncan, Davis and Sorensen (eds), *Scotland and the Borders of Romanticism*, (Cambridge, 2004), 1 – 19; cf. Murray Pittock, *Scottish and Irish Romanticism* (Oxford, 2008), esp. 1 – 31.

> With such a liberal Hand has Nature flung
> Their Seeds abroad, blown them about in Winds,
> Innumerous mix'd them with the nursing Mold,
> The moistening Current, and prolifick Rain. [222–33]

The poem transports us with the botanist as he traverses dales, forests and mountains. Unlike the previous passage, where we encounter sage and swain at ground level, we now sweep across broad expanses of nature. Such movement typifies *The Seasons*, which habitually varies our perspective, taking us from, say, distant 'Aspiring Cities' buried by earthquakes and 'Mountains in the flaming Gulph' across Africa to 'nearer Scene[s]' at home [*Summer*, 1100–02]. In this respect, Thomson poetically articulates ideas which John Keill (the Scot who was the first person to lecture on Newton at Oxford) shared in his 1721 *Introduction to the True Astronomy*:

> That we may have a more Distinct knowledge of the Fabrick of the *World*, and that the admirable Beauty of the Universe, and the harmonious Motions of the Bodies therein contained may be more easily understood, it will be requisite that that Divine and immense Fabrick should not be observed from one Point or Corner only: … to have a true and just Notion of the World, we must suppose it to be observed, in different Situations and Distances.[11]

As gifted as Newton, Robert Hooke and other Enlightenment-era astronomers were, none illustrated this astronomic injunction as vividly as Thomson. Indeed, Keill's treatise amounted to an aesthetic imperative – a desideratum for 'suppose[d]' observation – invoking the imaginative arts as the visual complement to Newtonian science.

And yet, for Keill, the paradigm for astronomic 'figure' was not poetry as much as geometry. In the preface to his lectures, Keill declared that astronomy 'for the certainty and evidence of its Demonstrations is not inferiour to *Geometry*; its usefulness is manifold, and the Amplitude of its *Subject* is so large that it comprehends nothing less than the World itself' (ii-iii, Keill's emphasis). Astronomy was earth measurement (literally, *geo-metria*) in an encompassing sense, casting its eye not only to nature but also to metaphysics, enabling us to 'obtain at last a distinct Knowledge of this Immense Palace of *God Almighty*' (17, Keill's emphasis). Thomson imagined his work in similar terms, ranging

[11] John Keill, *An Introduction to the True Astronomy* (London, 1721), 16–17, Keill's emphasis. On the oscillation between macroscopic and microscopic perspectives in *The Seasons*, see Kevis Goodman, *Georgic Modernity and British Romanticism: Poetry and the Mediation of History* (Cambridge, 2004), 38–66.

poetically across the globe for the purpose of gaining 'The Heights of Science and of Virtue' (*Summer*, 1741), but his model was less geometry than physico-theology, the pervasive eighteenth-century discourse 'in which the discoveries and conjectures of scientists [we]re used to demonstrate the existence and benevolent attributes of God on the evidence of the created universe'.[12] Physico-theology was a synthetic rather than a self-contained discipline, intersecting with other 'sciences' and even with the pedagogical philosophy of Scottish universities, which emphasised a philosophical union of disciplines. Not coincidentally, Newton constituted the point of intersection between these discourses – astronomy and geometry, physico-theology and pedagogy. During Thomson's years as a student at the University of Edinburgh, for example, one of his teachers, Robert Stewart, 'taught astronomy according to Newton's system and taught it in such a way as to demonstrate religious truths'.[13]

The Seasons were thus Newtonian in ways which far surpass any mere reference to rainbows. In the poem's universe, the poet plays astronomer, mathematical scientist and moral philosopher, all of whom are Newtonian. But they are Newtonian in a curious way, as Thomson's passage on the 'living Herbs' attests, and as we will see below. This passage subtly modifies the Newtonian principles it purportedly exemplifies, and in doing so it makes up a fragment of a larger story which, as Keill intimates, is rooted neither in poetry nor in science, but rather in geometry. In the seventeenth century, astronomers, political economists, and natural and moral philosophers throughout Europe became increasingly concerned with problems of measurement in applied mathematics, and with the limitations of geometry in providing sufficiently detailed data. Traditionally, geometry held pride of place in such applications, in part because in sketching and logically deducing proportionate lengths it skirted the philosophical conundrum of irrational numbers (for example, of irreducible fractions and infinitely repeating decimals, neither of which amounted to anything 'whole', or to any 'one' thing: the longstanding metaphysical definition of existence). But in the seventeenth century, these ontological qualms began fading before the practical necessity of amassing increasingly detailed information about the globe – its relation to other celestial

[12] James Sambrook, *James Thomson, 1700–1748: A Life* (Oxford, 1991), 52; cf. Alan Dugald McKillop, *The Background of Thomson's* Seasons (Hamden CT, 1961), 6–8.

[13] Sambrook, *James Thomson, 1700–1748*, 13–14. For a recent discussion of eighteenth-century pedagogy, see Susan Manning, '"Whether Utility or Pleasure be the Principal Aim in View": An Edinburgh Perspective on the Value of English Studies', *Scottish Literary Review* 1 (2009): 1–15 (2).

bodies, but also its amenability to markets and overseas exploration, the viability of artillery systems and other ventures requiring numerical precision over proportional elegance. The axial innovator here was Descartes, who, one historian notes, resorted to algebra as a way 'to free geometry from the use of diagrams' even as he attempted 'to give meaning to the operations of algebra through geometric interpretation'.[14] Analytic geometry, as this new Cartesian mathematics was called, effectively translated geometric figures into algebraic form and vice versa, thus enabling the visual display of the types of complex equations best suited to numbers and variables.

Today, geometry and algebra are so intertwined that their practitioners tend to forget the historical and philosophical fault-line which once differentiated them. But eighteenth-century Scottish mathematicians underscored these divisions, symbolically if not always in practice. Geometry signified the modern era's link to the 'classical' past as well as the mind's ability to sketch its own thought processes and thus more fully connect reflection with perception. Scottish mathematicians partly followed Newton's lead here, though they eventually pursued this line of reasoning to greater lengths, particularly cultural lengths, than Newton ever conceived. Newton, an expert algebraist, was something of a convert to geometry. In his eulogy of Newton, Bernard le Bovier de Fontanelle reminded his readers that the young Newton had found Euclid 'too clear, too simple, too unworthy of taking up his time', and had 'leapt at once to such books as Descartes's *Géometrie* and Kepler's optics'.[15] But Newton later expressed regret at 'his mistake at the beginning of his mathematical studies, in applying himself to the work of *Descartes* and other algebraic writers'.[16]

The source of this regret may well have been Newton's dispute with Wilhelm Gottfried Leibniz over the invention of the calculus. It is difficult to overstate the impact of calculus. Charting rates of movement over time, and thus measuring change in items ranging from the motion of planets to the movements of financial markets, the wide scope of modern phenomena into which calculus figures leads some scholars to label it the most important mathematical innovation in modern history.[17] Technically, the calculus enabled

[14] Carl B. Boyer, rev. by Uta C. Merzbach, *A History of Mathematics*, 2nd edn (Hoboken NJ, 1968), 339.

[15] Fontanelle, *Eloge de Neuton* (sic), cited in A. Rupert Hall (ed.), *Isaac Newton: Eighteenth-Century Perspectives*, (Oxford, 1999: 59–74), 59.

[16] Quoted in Hall, *Isaac Newton*, 79.

[17] The mathematical scholars James M. Henle and Eugene M. Kleinberg assert that '[t]he history of modern mathematics is to an astonishing degree the history of

the calculation of areas under curves, translating geometric proportions into numerical (and, invariably, algebraic) sequences of data. Newton's 'fluxional' calculus specifically measured the varying speeds (or 'fluctuations') and directions of moving points – points in motion which it portrayed as the basis of lines, thus converting algebra back into geometric form. Newton's feat here was to resolve irrational numbers (with their infinite and unrepeating decimals) into relative 'wholes' and then convert conglomerate series of these numbers into the form of flowing lines. Leibniz, meanwhile, enunciated a model known as the 'differential' calculus; while it too charted the motion of points along a graph, Leibniz emphasized the algebraic articulation of the infinitesimal differences between these points, and thus made little attempt to square 'analysis' with traditional geometry. The differential calculus enjoyed wider currency on the continent, and later advancements in the field built on Leibniz's system. While Newton was hardly forgotten in mathematical history, the Leibnizian model became simple shorthand for the history of calculus.

These later developments were anything but evident in the seventeenth and eighteenth centuries, when the quarrel between Newton and Leibniz devolved into a national conflict. Scots played a key role in its escalation. According to Rupert Hall, '[n]early all the [renowned British] mathematicians of this time', and 'nearly all the ardent Newtonians ... were Scots: David Gregory, [John] Craige, [Archibald] Pitcairne, [George] Cheyne, the Keill brothers [John and James], James Stirling, Matthew Stewart, [and] Colin Maclaurin'.[18] But history has not always – nor even often – been kind to these intellectuals. Newton's biographer Richard S. Westfall labels Keill, for instance, 'a crude and abusive man who did Newton's cause much harm before the learned world, which quickly learned to despise him'.[19] And more generally, Scottish mathematicians are seen to have presided over an era in which 'British mathematics fell behind that of Continental Europe', precisely on account of their collective adherence to geometry.[20]

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the calculus. The calculus was the first great achievement of mathematics since the Greeks and it dominated mathematical exploration for centuries. The questions it answered and the questions it raised lay at the heart of man's understanding not only of geometry and number, but also space and time and mathematical truth ... The methods it developed gave the physical sciences an impetus without parallel in history, for through them natural science was born ... ' *Infinitesimal Calculus* (Cambridge, MA, 1979), 3.

18 A. Rupert Hall, *Philosophers at War: The Quarrel between Newton and Leibniz* (Cambridge, 1980), 161, 134.

19 Richard S. Westfall, *Never at Rest: A Biography of Isaac Newton* (Cambridge, 1980), 721.

20 Boyer, *A History of Mathematics*, 414.

And yet, this latter truism bears closer inspection. Helena M. Pycior observes that there were two basic schools of thought in eighteenth-century Scotland regarding algebraic innovation. The first, personified by Robert Simson, longtime professor of mathematics at the University of Glasgow (from 1711–61), was generally inimical, while the other, headed by Colin Maclaurin, professor of mathematics at Marischal College and then at the University of Edinburgh (and the author of the important *Account of Sir Isaac Newton's Philosophical Discoveries* [1748] and the rigorous *Treatise of Fluxions* [1742]), embraced geometry but also engaged readily with algebra.[21] In the former case, the resistance to algebra was motivated in large part by the conviction that 'many Propositions, which appear conspicuous in [Euclid, are] knotty […] and scarcely intelligible to Learners by [the] Algebraical Way of Demonstration'. This was because geometry shows 'Evidence by the Contemplations of Figures', as opposed to the 'Symbols, Notes, or obscure Principles' one finds in algebra.[22] Maclaurin, meanwhile, aimed to defend Newton's own ambivalent (i.e. geometric *and* algebraic) mathematical enterprise against such detractors as George Berkeley (who wrote a scathing treatise, *The Analyst* [1734], denouncing the fluxions) and the disciples of Leibniz on the Continent. In neither instance, crucially, was the debate over geometry really about geometry. For Simson, the anxiety over symbols amounted to a philosophical (or, today, what we would call a phenomenological) argument about experience, or about the relationship between reflection and perception.[23] For Maclaurin, geometry touched on a national ontology, specifically concerning the 'being' of Scottish identity – 'British' in declaring solidarity with Newton and 'Scottish' in retaining a connection with a classical (that is, a pre-modern, pre-Unionized) past and its intellectual traditions.[24] Geometry in eighteenth-century Scotland, in other

[21] Helena M. Pycior, *Symbols, Impossible Numbers, and Geometric Entanglements: British Algebra through the Commentaries on Newton's* Universal Arithmetick (Cambridge, 1997), 242–43.

[22] Keill, 'A Preface, shewing the *Usefulness* and *Excellency* of this work', in *Euclid's Elements of Geometry*, *from the Latin Translation of Commandine* (London, 1746), no pagination.

[23] The early nineteenth-century Scottish philosopher William Hamilton stated this principle most clearly: 'the mathematical process in the symbolical [i.e. the algebraic] method is like running a railroad through a tunnelled mountain; that in the ostensive [i.e. the geometric] like crossing the mountain on foot. The former carries us, by a short and easy transit, to our destined point, but in miasma, darkness and torpidity; whereas the latter allows us to reach it only after time and trouble, but feasting us at each turn with glances of the earth and the heavens, while we inhale the pleasant breeze, and gather new strength at every effort we put forth'. William Hamilton's 1838 *Letter to the Provost*, quoted in George Elder Davie, *The Democratic Intellect: Scotland and Her Universities in the Nineteenth Century* (Edinburgh, 1981; 1961), 127.

[24] On the 'classical' tradition in Scottish education, see Davie, *The Democratic Intellect*,

words, was a cultural rather than simply a mathematical battleground, and the mistake in perceiving it as retrograde is a function of seeing it too narrowly.

I do not have the space in this essay to elaborate on this culture war other than to remark that the phenomenological and nationalist dimensions of geometry pervade Scottish Enlightenment discourse, from moral and natural philosophy to aesthetics and historiography. Lord Kames's 1762 *Elements of Criticism*, for example, took its name from Euclid; Adam Smith explained sympathy through geometric metaphors of pitch and proportion; and geometry informed the elementary notion of common sense as a philosophy of relations, and thus achieved a prominent place not only in Thomas Reid's *Inquiry into the Human Mind* (and its forward-looking 'geometry of visibles', a thought experiment involving the curvature of space), but also, as I suggested above, in the pedagogical philosophy which permeated Scottish universities well into the nineteenth century.[25] Geometric thinking informed or even helped shape literature and the ways we imagine it. Critics speak of (non-) linear narratives and the emergent (i.e., the eighteenth-century) 'space' of literature at the margins of factual discourses.[26] Poems like *The Seasons* were even more literal, effectively translating spatial perspective into literary form through their presentation of elaborate scenes of nature accentuated by simple rhetorical pointing devices ('Now see … ' 'Here … ' 'There … '). Moreover, Thomson appeared expressly to embrace a fluxional poetics, as in his elegiac *Poem Sacred to the Memory of Sir Isaac Newton*, published shortly after Newton's death in 1727. There, Thomson extolled Newton as the physicist of gravity and the guru of fluxions, slighting the Cartesian theory of vortices by declaring '[t]he heavens […] all [Newton's] own, from the wide rule / Of whirling vortices and circling spheres / To their first great simplicity restor'd'.[27]

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169 – 200 and Craig Beveridge and Ronnie Turnbull, *Scotland After Enlightenment: Image and Tradition in Modern Scottish Culture* (Edinburgh, 1997), 135 – 52.

[25] See Adam Smith, *The Theory of Moral Sentiments*, ed. D. D. Raphael and A. L. Macfie (Indianapolis, 1982), 18 – 23 and Reid, *An Inquiry into the Human Mind on the Principles of Common Sense*, in *The Works of Thomas Reid*, ed. William Hamilton, 2 vols. (Boston, 2005), 1, 147 – 52.

[26] On the spatial relegation of literary romance to the Scottish Highlands in the eighteenth century, see my *The Ruins of Experience: Scotland's "Romantick" Highlands and the Birth of the Modern Witness* (Philadelphia, 2007), esp. chs. 1 and 2.

[27] *A Poem Sacred to the Memory of Sir Isaac Newton* in *Poems* (London, 1730), ll. 82 – 4. Thomson's friend and University of Edinburgh classmate David Mallet expressly contemplates Newton's theory of gravity and, tacitly, fluxions in his poem *The Excursion*: 'with transport I survey / The firmament, and these her rolling worlds, / Their *magnitudes*, and *motions* … ' *The Works of the English Poets, from Chaucer to Cowper*, 21 vols., ed. Alexander Chalmers (orig. pub. 1810; New York, 1969), 14, 22.

That does not mean, however, that Thomson's poetry is straightforwardly Newtonian. In the passage concerning the 'living Herbs', for example, our supposedly fluxional sweep of vision is actually less fluid than saccadic, or sporadic, with each location momentarily holding the gaze through its corresponding description – the 'silent Search' along the dale, 'the dull Incurious Weeds' that encumber our progress through the forest, and so on. While it is true, as John Sitter argues, that 'the scene unfolds sequentially', the poetic observer does not flow across a sinuous landscape as much as subtly mark a series of points differentiating them.[28] In this respect, motion here is more rectilinear than curvilinear, which in eighteenth-century fluxional treatises was a hallmark of algebraic analysis. Hence, in appearing more 'differential' than 'fluxional', Thomson's passage also seems more Leibnizian than Newtonian. The connection here to the calculus is analogical, though it hardly seems incidental. Consider the presence in Thomson's passage of numerical complexity: the botanist attempts to 'rank' and 'account' for the various floral species, but nature's sheer profusion, its 'liberal Hand', makes this an impossible exercise, flinging the 'Innumerous' seeds into the 'Winds' where they 'mix[]' with soil, currents and rain, and eventually recede from view into an unbounded expanse. In this way, the scene foreshadows what Kant would later call the 'mathematical sublime', as that which initially seems countable ascends into virtual infinity, where it escapes our (geometric) purview. Ralph Cohen argues that such sublime passages reflect Thomson's theology, which holds that a 'sensuous, creative nature beyond the ability of man even to catalog is the consequence of the fall of man' – that mortality, limiting us to place and time, hampers our ability to comprehend the full extent of God's creative design.[29] But Cohen's lapsarian point is also an implicitly mathematical one, for conceptual tools like infinite series and differentials reinscribe our fallen condition even as they compensate for it: they enable us to formulate simulacra of what we cannot see, but as Simson would remark, they also curtail the authority of our experience. Thomson's 'nature' thus eludes us precisely, he implies, when we begin cultivating it, measuring it – mastering it through our 'industry' and for our use.[30]

In this respect, this passage in *The Seasons* following the paean to Newton – literally, the poetic moment 'after' 'NEWTON' – probes the limits

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[28] John Sitter, *Literary Loneliness in Mid-Eighteenth-Century England* (Ithaca, NY, 1982), 178.

[29] Ralph Cohen, *The Unfolding of* The Seasons (Baltimore: Johns Hopkins, 1970), 30.

[30] Jonathan Bate overlooks this point in his brief mention of *The Seasons* in his eco-critical treatise *The Song of the Earth* (Cambridge, MA, 2000), 100.

of the geometry it appears otherwise to expound: it reflects critically, we might say, on what Keill would label its own powers of figuration, of imagination. In transporting its numberless seeds to places we no longer behold, and which we can only vaguely measure as abstractions, Thomson's 'nature' surpasses the geometrical horizons which the Scots defended in Newton. Hence, at this moment of Newtonian celebration in *The Seasons*, the Newton-inspired union of ancient and modern, shape and symbol already begins to turn against itself.

In this, Thomson's transmutation of the Newtonian project was no different in spirit from what the more rigorous mathematical Newtonians were themselves doing.[31] David B. Wilson describes Keill's Newtonianism as 'Aristotelian' in its defense of the 'forms' and infinite divisibility of matter; Maclaurin's, meanwhile, was 'Cartesian' in deploying Descartes's own methodological techniques to argue for rather than against the independent existence of matter.[32] Newton, in other words, became an object as well as the agent of innovation in Scotland – a compelling development when one considers Newton's role in shaping the modern world. One prominent line of argument in Newtonian studies is that the 'Newtonian universe, organized by Newton's physics and celestial mechanics, permitted an entirely new approach to nature'; it fostered innovation in the applied as well as the theoretical sciences.[33] With the gradual implementation of Newtonian curricula in universities across Europe 'a new "technical literacy" came into being along with the new manufacturing technologies', accompanying 'the ability to make mathematical calculations of increasing sophistication and the ability to read and understand technical drawings and models'. Such thinking fueled industrialisation as well as astronomy. Scotland bears a prominent if (as I am suggesting) still inadequately understood pride of place in this line of thought. In the eighteenth century, reputedly, the locus of this 'constellation of innovat[ion] … might have been in Edinburgh' given the rigorous nature of Newtonian instruction in the university.[34] Then again, one might make an equally compelling case for Glasgow's centrality, given the influence of the students who matriculated there, including the chemist Joseph Black, the natural philosophers John Robison and John Anderson (the latter of whom,

[31] This is an argument I develop at greater length in a forthcoming book.

[32] See Wilson, *Seeking Nature's Logic: Natural Philosophy in the Scottish Enlightenment* (University Park PA, 2009), 44 – 59.

[33] Betty Jo Teeter Dobbs and Margaret C. Jacob, *Newton and the Culture of Newtonianism* (Atlantic Highlands NJ, 1995), 1.

[34] Margaret C. Jacob and Larry Stewart, *Practical Matter: Newton's Science in the Service of Industry and Empire, 1687 – 1851* (Cambridge MA, 2004), 131, 120.

in 1796, founded Anderson's Institution, the world's first technical college which evolved into the University of Strathclyde), and James Watt, whose application of Newtonian mechanics in developing the steam engine enabled the Industrial Revolution.[35]

But my point is not that this or that place in Scotland was more at some Newtonian vanguard than others, but rather that the Newtonian thought which established itself throughout the West was already, in Scotland, a source of creative adaptation. This is true even though, or perhaps especially because, such adaptation took such 'old' forms as geometry. The nineteenth-century physicist James Clerk Maxwell, for example, was an expert geometer as a boy. And when he and his peers reformulated the foundations of the universe in replacing Newton's physics of force with a model based in a theory of energy, he did so in part by adapting Newton's Three Laws of physics to radically new ends. As new as these principles were, they were in this respect a late manifestation of what was already a rich tradition.[36]

University of Aberdeen

[35] Wilson, *Seeking Nature's Logic*, 69–70.

[36] Scotland was thus born as a 'modern' nation in the very process of modifying what we take modernity to be. Hence, and to return to the place from whence we started, when Muir imagines Scotland as a privileged site of the future anterior, or of the past which the modern world has yet to become, he is merely (if unwittingly) enunciating the latest chapter of an 'enlightened modernism' with a long and complex history.