Whitman and Mathematics: An Introduction

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[T]he anatomist chemist astronomer geologist phrenologist spiritualist mathematician historian and lexicographer are not poets, but they are the lawgivers of poets and their construction underlies the structure of every perfect poem.
—Whitman, Preface to *Leaves of Grass*[1]

THIS SPECIAL ISSUE of *WWQR* anticipates a sustained dialogue about the long-neglected relationship between numbers and letters in Whitman's writings.[2] Each featured essay proves in its own way that this dialogue is overdue: Whitman was well acquainted with mathematics in the schoolroom and thus in the growth of American democracy; his poems bear witness to the historically specific and multi-faceted cultural role of mathematics in the mid-nineteenth-century United States. Just as importantly, the essays collected here demonstrate how the Digital Humanities have conditioned this new subject, bringing calculation and non-alphabetic notation to the attention of twenty-first-century literary historians. This era of digital galleries, data mining, and colorful charts and graphs may also help us explore how the alphabetical and the numerical—poetry and mathematics—divide and recombine at different points in cultural history.

That said, the impetus for this special issue is neither technologically determined nor unprecedented. On the contrary, the relationship between Whitman and mathematics is particularly enticing for the fits and starts of attention it *has* received over the past three quarters of a century: Muriel Rukeyser's 1942 biography of mathematician Willard Gibbs, a prescient M.S. thesis written in 1965 by budding mathematician Kathryn Davies Lindsay, and a pair of close readings from 1989 and 1991 by Sister Charlotte Downey.[3] With no sustained attempt to account for or to develop the approaches advanced in this minor corpus of secondary sources, research on Whitman and math-

ematics has had little hope of thriving. Add to this the fact that as a "scientific" influence on Whitman, mathematics has, understandably, been overshadowed by sciences that figure prominently in the poet's biography and the thematics of his writings, such as the medical[4] and the natural sciences.[5] But even contextual overviews of the impact nineteenth-century popular sciences, from phrenology to astronomy, had on *Leaves of Grass* ignore the influence of nineteenth-century mathematics.[6] To date, general and particular accounts exclude mathematics from Whitman studies—all in spite of the fact that in his 1855 Preface Whitman himself names mathematicians among the scientific "lawgivers of poets."

The exception is Kathryn Davies Lindsay's M.S. thesis from 1965, which was significantly influenced by Muriel Rukeyser's consistent references to Whitman in her biography of mathematician Willard Gibbs, the co-inventor (with James Clerk Maxwell) of statistical mechanics and, independently, of vector calculus. In this brief introduction, I offer a backward glance over the relationship between Whitman and mathematics in the works of Lindsay and (more briefly) Rukeyser; I then provide context for and summary remarks on the essays in this special issue; lastly, I suggest possible routes of inquiry for further research on Whitman and mathematics.

The Lost M.S. Thesis: Whitman and Set Theory

In her lyric biography of Willard Gibbs, Muriel Rukeyser regularly alludes to Whitman, Gibbs's contemporary, to suggest correspondences between the poet's and the mathematician's modes of theoretical system building. Late in the biography, in a chapter that compares and contrasts the writings of Whitman, Melville, and Gibbs, Rukeyser explains the logic of these correspondences as follows: "The single faces of Whitman's people, the faces of principle in Melville, the stars seen as the molecules of a great bubble of gas according to Gibbs, the furnaces pouring metal—these are linked" (368). Linked, yes, but far from equivalent: for Rukeyser, Gibbs's mathematical discoveries complete the literary achievements of the "American Renaissance." Whitman's need of refinement is exemplary:

The failure of [Whitman's cataloging] method, when it fails, is because he was not, like Gibbs, interested in the relations between these facts (or systems) so much as in the facts themselves. . . . [I]n Whitman's clumsy and factual manoeuvre after scientific information, he had absorbed, as he often intuitively did, certain fundamentals which he could use in his own method, at his best. When he made myth out of this attitude, he reached his own height, and created the creative. (360-361)

Unlike Whitman's creative fumbling with facts for the sake of "his own method," Gibbs transcended himself, creativity itself even, by inventing abstract systems that could be brought to bear on material reality; indeed, these systems were ultimately responsible for reshaping the future of physics, chemistry, and industry around the world. In Gibbs, then, Rukeyser finds a mathematician who could do everything that a materialist poet like Whitman imagines himself doing and whom Whitman might help non-mathematicians appreciate. However, the poet never effectively bridges the gap between "creating the creative" and refashioning the world, between the arts and the hard sciences, or between poetry and mathematics.

Nevertheless, Rukeyser's zealous embrace of mathematics in her biography of Gibbs inspired Kathryn Davies Lindsay to write her M.S. thesis on (of all things) Whitman and mathematics. Her modest tone belies the extreme boldness of her endeavor: "If Whitman had a single aim in his poetry," says Lindsay, "it would seem to be to express the totality of the universe. . . . Since mathematics deals with the inter-relationship between various quantities, concepts like set theory and mathematical series aid in understanding Whitman's ideas" (66-67). Lindsay takes at least one lead from Rukeyser when she notes the relationship between Whitman and "mathematical series" (i.e., 3/10, 3/100, 3/1000, ad infinitum…) (60). Here, Whitman's multiple "I" and expanding lists find their numerical doppelgänger. But Lindsay's comparative analyses of Whitman's poems using set theory occupy the bulk of her thesis and also push the Whitman-mathematics relationship beyond what Rukeyser allowed for in her biography of Gibbs.

Set theory, as Lindsay defines it, "is a method of ordering and conceiving of a whole in terms of its parts" (7). The relation between Whitman and set theory therefore is plain to see: "Starting with

familiar objects, absorbing and combining them, Whitman was able to communicate the impression of the totality, even though he was listing only some of its parts" (8). Lindsay struggles to ground her project in extant secondary literature, citing Norman Foerster's *Nature in American Literature* (1923) and Newton Arvin's biography *Whitman* (1938), both of which only discuss the poet's relationship to science in general, not mathematics in particular. Lindsay notes that Henry Seidel Canby compares Whitman and Gibbs in his *Walt Whitman, An American* (1943), but only to affirm the similarities and differences already established by Rukeyser the previous year. Thus Lindsay must be given credit for her courage in this matter: where Rukeyser at best finds analogies of mathematics in Whitman's poetry, Lindsay finds the two operating in a consistent fashion and from shared assumptions.

For Lindsay, the relationship between poetry and mathematics is more than analogous:

A major requirement of a mathematical system, consistency to its basic premises, is also a requirement for any system of literary thought. A mathematician accepts certain truths as self-evident and proceeds to build his conclusions logically from these premises. To do so he must carefully define his terms and be constantly aware of his aim and purpose. The poet, too, must define his terminology and be logically consistent. He must keep in mind the system within which he is working and constantly order and arrange his ideas according to some preconceived pattern. (26)

Lindsay trusts that poets and mathematicians are not only system builders, but that they build their systems the same way: they both operate within certain practical and symbolic parameters determined by the system preceding their acts, intentions, innovations, and indeed themselves. Rukeyser, on the other hand, claims the opposite, supposing that Whitman was one type of inventor (a poet) who lacked the traits of an inventor like Gibbs (a mathematician), with a superior set of skills that would have helped the poet discover the combining principle between the facts he clumsily listed in his famous catalogs. For Rukeyser, mathematical genius supersedes poetic genius by the end of the nineteenth century; for Lindsay, there is systemic consistency: set theory and poetics are different

expressions that simply need to be reunited.

Next to Rukeyser, the biggest influence on Lindsay's thesis is Richard Maurice Bucke, whose *Cosmic Consciousness* (1901) places Whitman among such religious visionaries and messianic figures as the Buddha and Christ. For her set-theoretical analyses, then, Lindsay selects poems "which best expressed and explained the inter-relationship of various parts of the cosmos" (37). Lindsay provides diagrams illustrating such inter-relationships of various parts (see Figure 1), but she does not guide the reader through the language, symbols, or axioms of set theory that she presumably based them on. And yet, the mere application of the language and symbols of set theory enhances Lindsay's work and proves to be as illuminating as her visual representations. For instance, in "Salut au Monde" the "world" *includes* (⊂) "man" and "geography"; "man" *includes* (⊂) "inventions of man"; "man" and "inventions of man" *intersect* (∩) with "geography" in the world, but they do not *include* each other.[7] The distinctions are significant in the langauge of set theory and consequential to the way the poem is read. To extrapolate from Lindsay's diagram: "man" and "geography" consist of some but not all elements of the "world"; "geography" appears to consist of a larger quantity of elements of the "world" than "man"; and, intriguingly, "geography" is not an "invention of man" but intersects, or shares at least one element of "man" and the "inventions of man," while not being limited to the circumscribed quantity of elements of which "man" or the "inventions of man" consist.

In her formal assessment of inter-relationships in "Salut au Monde," Lindsay begins reading Whitman as an early post-humanist: she depicts "geography" as a form of knowledge that "man" shares with the "world," not one that he has invented or that reveals his place in the center of the "world." This reading of Whitman from a mathematical perspective is only one of many that might depart from Lindsay's lost and (now) found M.S. thesis. Further elaboration on the variety of logics extrapolated from the poems and the way their formalization make some of the more abstract and difficult concepts in Whitman's poems articulable, even teachable, is still to come. But first, more context.
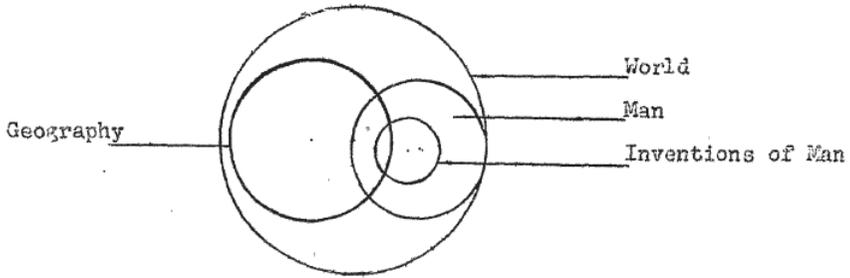
Figure 2

The World Set and Its Subsets
in the Poem "Salut au Monde"

Figure 1. Diagram from *Mathematics: A Clue to Whitman's Philosophy* (42).
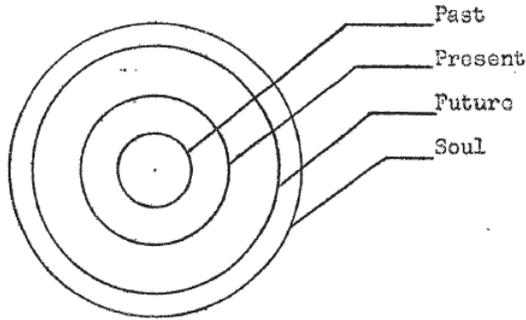

Figure 4

The Portrayal of Time in "Starting from Paumanok"

Figure 2. Diagram from *Mathematics: A Clue to Whitman's Philosophy* (47).

Alphanumeric Romanticism: Mathematics Enters Whitman Studies

Not all of Lindsay's mathematical interpretations of Whitman are based on set theory. She also discusses the role of numerical values in Whitman's poetic tropes: in "A Broadway Pageant," Manhattan is "million-footed"; during his visit to the "orchards of spheres" in "Song of Myself," he looks at "quintillians ripen'd" and "quintillions green" (30). Numbers enter into the musicality of "Out of the Cradle Endlessly Rocking," where "two" and "two together" in the second,

third, and fourth stanzas enrich the incantational, rhythmic character, both musical and mathematical, of the poem (33). Lindsay even comments on one of Whitman's most famous notebook entries, his heart-wrenching attempt to repress his feelings for Peter Doyle, whose initials are numerically encrypted as "164."[8] Lindsay informs us that the poet's use of numbers clearly "shows that Whitman employed the mathematical theory of ordered pairs which relates the individual members of two separate groups. Perhaps he was aware of the relationship that existed between the alphabet and the first twenty-six numbers of the number system" (35). Whitmanists and literary historians may take the relationship between the alphabet and the number system for granted when they find "164" in place of "PD," or are faced with a "million-footed" city or "quintillions" of spheres ripening throughout the unknown universe. But as the contributions to this special issue demonstrate, the correspondences between numbers and letters in Whitman's writings have more to tell us about acts of reading and writing in their mid-nineteenth century contexts.

No such exploration has endured beyond Lindsay's M.S. thesis, most likely due to the gaping abyss between the rationality and impersonality associated with mathematics and the idiosyncracy and individualism associated with Romantic ideals of imagination, originality, and authorship in the literary arts. But Lindsay knew, as we do today, that this particular abyss is an illusion, a product of artificial disciplinary divisions, and that what lies beneath this illusion not only has much to teach us about the texts we read but also about the limits of our current methodologies. To that point, Rachel Feder's note for this special issue reads "Song of Myself" against the backdrop of eighteenth-century concepts of "infinity" (specifically Locke's) and their impact on British Romanticism (namely Wordsworth). Zachary Turpin explores the irresolvable and generative tension between letters and numbers in *Leaves of Grass*, while considering some of the theoretical roots of that tension in Whitman's time as in ours.

The full-length essays featured in this issue propose surprising new approaches to Whitman's writings: the numerical as well as rhetorical value of Whitman's apostrophes; the non-lexical markup found throughout his archived manuscripts; his need to distinguish between

the mathematical idealism that informed his antebellum writings and the morbid statistics of mass death during the Civil War. The latter case in particular explains why Whitman himself may have been instrumental in perpetuating a mythological division between mathematics and poetry—that is, the cold tallies of dead soldiers will not heal a nation on the mend. But *Leaves of Grass* is as much a book of internal conflict, disunion, and war as it is a book of forgiveness, reunion, and love.

The essays have in common a relatively unexplored aspect of the intellectual formation of nineteenth-century Americans: *arithmetization*. Alphabetization itself has only recently been welcomed into literary studies from the margins of cultural history thanks to scholars like Patricia Crain, whose work has thoroughly demonstrated how this low designation belies the alphabet's significant role in the operations of institutional power and its production of lettered subjects.[9] The low/high division between alphabetical primers and literature are paralleled by basic arithmetic and logic, the schoolroom genre and its higher orders of speculation, the everyday fiscal accounts and the calculus that builds bridges and digital networks. So, while the study of children's literature has become a rather serious matter in American cultural studies and has at least partially redeemed the alphabet as a medium worthy of study, numbers and arithmetic have yet to achieve this status. The essays featured in this issue not only introduce mathematics to Whitman studies, then, but also participate in and promote studies in the cultural history of mathematics.

All three essays refer to James B. Thomson's *Practical Arithmetic*. Thomson's book provides a solid starting point for exploring Whitman's knowledge of rudimentary math not only because the poet himself approved the book for use in public schools in his 1846 review for the *Brooklyn Daily Eagle*, but also because it explains the social meanings of arithmetic in the antebellum decades. As Thomson states in his preface, his *Practical Arithmetic* "embraces, in a word, all the principles and rules which the business man ever has occasion to use, and is particularly adapted to precede the study of Algebra and the higher branches of mathematics."[10] Which is to say that instilling students with the rudiments of personal economy is only the beginning of a

longer venture into the upper realms opened by numbers. But even basic socio-economic necessities begin with the low genre of simple counting from one to ten and its correspondence with various graphic notation systems. Before teaching his pupils to add and subtract, then, Thomson defines notation as the very possibility of Roman letters standing for numbers and Arabic numbers standing for exponentially expanding units that can be expressed in letters (14-16).

As Ed Folsom points out in his essay, the "large numbers" that appear in the language of *Leaves of Grass* may be as intmidating to us as they were to his contemporary readers: then as now, massive quantities are a conceptual menace to individual expression. Yet, given the way those readers learned numbers in school, they were arguably "better attuned than twenty-first-century audiences to the particular definitions of the numerical terms that Whitman so frequently employed in his poetry." In addition to noting Whitman's positive review and recommendation of Thomson's work, Folsom directs our attention to another primary source from antebellum schoolrooms, Benjamin Greenleaf's *Introduction to the National Arithmetic* (1847), which recommended the alphabetical transcription of "large numbers" as a schoolroom exercise, an exercise assuming that the literate student's slate was an interface for translating numbers into letters and back again. The branches of this alphanumeric foundation extend beyond the schoolroom to the pulpit of baptist minister Eli Noyes, whose published sermons integrate speculative thinking in numbers into projections of the divine, cosmic infinite. From one institutional context to another, from the pragmatism of literate, calculating subjects to the spiritualism of de-individuated transcendence, the operations of numbers were everywhere in the antebellum decades.

Contributing their own generous overview of mathematics in its early nineteenth-century institutional contexts, Matt Cohen and Aaron Dinin focus on the numerical traces found in Whitman's manuscripts, to show us that calculation was instrumental to the poet's writing process. Whether rudimentary calculations allowed him to locate his work in history or to plan the next edition of *Leaves of Grass*, mathematics is inseparable from Whitman's conception of himself as a poet, printer, and bookmaker. Cohen and Dinin also suggest that

our digital moment, which is ushering in a new era of manuscript studies, has begun to draw us out of an alphabetical regime and to position us at the beginning of a new one that looks back over the neo-Romanticism of Harold Bloom as well as the Marxist historicism of Alan Trachtenberg, with a lens attuned to the markup, formats, and thus material, formal, and mathematical elements involved in literary writing.

Along similarly post-Romantic and post-Marxian lines, Stefan Schöberlein demonstrates in his essay that, in Whitman's day, numerical calcuations, while employed in commercial activity, were recruited for manifold purposes, from disclosing the functions of the universe to tallying the mass death of the Civil War. For Schöberlein, the very children that learned numbers and letters in public schools were later counted like mere figures in a massive, bloody account book, a book that Whitman saw filled as he visited wounded and dying soldiers in the hospitals of Civil War Washington. For similar reasons, Folsom argues in his essay that Whitman's faith in large numbers, which influenced early poems such as "Song of Myself," "This Compost," and "Unnamed Lands," lapsed during the war; the poet's once prolific catalogs became morbid lists of loss and absence in his fragmentary, multi-genre memoir *Memoranda During the War*. To demonstrate how profoundly the war impacted Whitman's writings, Folsom provides a thrilling reading of the apostrophe in the section of *Memoranda* titled "The Million Dead, Too, Summ'd Up": the apostrophe not only causes the word "summ'd" to vacillate between the mathematical "summed" and the spiritual "summoned," but also marks the absence of the "one" now obliterated by the masses of unknown dead. Here, the apostrophe is not so much a punctuation mark as it is iconic of the interface between numbers and letters always at work in Whitman's writings.

And that continued to work in them: the prolific multiplicities of the early catalogs, even after the devastation of the Civil War, says Folsom, return as an undeniable truth in the post-bellum poems. Schöberlein takes a different tack, stating that Whitman's revulsion at the perverse use of mathematics to tally the mass death of the Civil War makes him "unaccountable." Ultimately, both Folsom's and

Schöberlein's essays meet on common ground, stating that the Civil War transformed Whitman's conception of the numerical universe, which offers cultural historians a narrative, complete with character development, for the changing role numbers played in Whitman's poetics from 1855 to 1892.

New Subjects: "Cultural Mathematics" and Axiomatic Set Theory

In his review of Rukeyser's biography of Gibbs for the May 12, 1944, issue of *Science* magazine, Edwin B. Wilson wrote:

> The author is a literary woman rather than a historian or scientist; she states as facts a great many things she can not possibly know, such as what some one felt or thought on a given occasion, even though there be no record to indicate it. As fictionalized biography has a great present vogue, many must like it and some may even consider this one "thrilling" in the places where it is best written, though I should think any one must consider a good deal of it as both badly written and boresome.[11]

Presumably, Wilson means to defend Gibbs's territory, but in doing so he assumes that he can lay claim to the "literary woman's" territory as well, asserting that "any one must consider" the book "badly written and boresome." Today, the defensiveness and double standards seem retrograde thanks to philosophers of science, from Michel Serres to Karen Barad,[12] who have opened a dialogic space between disciplines. Yet when mathematics and the humanities come together, their encounters remain controversial, even scandalous

Schöberlein's essay, the last of the three featured here, draws on the late Friedrich Kittler's "cultural mathematics": a controversial marriage of philology and media history partly worked through in the incomplete, not-yet-translated into English, multi-volume magnum opus *Musik und Mathematik* [*Music and Mathematics*].[13] Kittler's project recovers the repressed technical foundations of European culture in the Greek alphabet, circa the eighth century BC, when it functioned as a universal medium for calculating sums, measuring interval ratios (octaves, fifths, fourths, and thirds), and—being the first alphabet to distinguish vowels from consonants—recording the voices of epic and lyric poets. Since, for Kittler, human senses rely on the media that

store and transmit sensory information, the Greek alphabet's capacity for processing numbers, tones, and voices produced a culture based on love (not war). Unfinished at Kittler's death, the projected final volumes of *Musik und Mathematik* were to proclaim the return of the repressed Greek notation system in binary code.[14] In lieu of his book-length expositions on the matter, we have intriguing aphorisms, such as: "In the Greek alphabet our senses were present—and thanks to Turing they are so once again."[15] Kittler's conception of digital technology has been rejected by American new media materialists,[16] and the digital return of ancient Greece has met with skepticism, even among supporters: "Many German media scholars regard Kittler as having gone off the deep end in his late years, and his most sympathetic critics . . . tend to have one foot in, one foot out of German-language debates" (Peters 24). However, Kittler's influence continues to grow through special issues of quarterlies, book-length digests of his life's work, and emerging translations.

In his reading of Whitman's "Eidólons" alongside the "eidola" educational interface, Schöberlein demonstrates that our software culture already promotes itself as a recurrence of the ancient in the digital world. All the better, then, that Kittler's late work insists on close attention to the technical and technological preconditions of storage, communication, and implementation then and now. This mode of interpretation may prove to be particularly apt for studies of Whitman, who is in one sense so representative of late American Romanticism and yet so distinct from the Romantics and even his contemporaries. After all, the "American bard," whose poems expect nothing less than a merge of author with reader in the print medium—"I pass so poorly with paper and types . . . . I must pass with the contact of bodies and souls" (Whitman 57)—may just be a (Kittlerian) Greek who was born at the wrong time. Perhaps "the parasitic relation of one discourse context to another" presented in such jarring moments—the "cultivated perversity," as Michael Warner says, of the poet's merge of the conventions of the publicly printed with the nakedly private—is rooted in Whitman's interests, as evidenced in his manuscripts and published works, in the ancient world and his visions of a globalized American English.[17] There has been very good scholar-

ship on Whitman's adventures in the history of language,[18] but there has also been too little of it. Now that digital resources like the Walt Whitman Archive are making the poet's manuscripts and published works accessible and researchable in one virtual space, all manner of discoveries and novel readings are likely to emerge, and Kittler's "cultural mathematics" provides one way to theoretically foreground how mathematics has always been and continues to be at work in the media that produces and reproduces the cultures of a given place and time.

Those intrigued by Lindsay's more abstract, less materialist approach to Whitman through set theory might set aside "cultural mathematics" and follow a line of inquiry into the interdisciplinary fusion of mathematics, philosophy, and literary interpretation found in the work of Quentin Meillassoux and, more infamously, Alain Badiou.[19] Badiou shares with Kittler a type of epiphanic idiom that proclaims the once repressed, now recovered place of mathematics in the history of philosophy. "[T]he science of being qua being [ontology] has existed since the Greeks," says Badiou; "such is the sense and status of mathematics. However, it is only today that we have the means to *know* this" (BE 3). While Badiou has the means to know that ontology and mathematics were once the same science (and will be again, if he has anything to say about it), mathematicians have denounced his use of their tools.[20] Their objections may be rooted in the fact that one of the more significant axioms for Badiou, the "axiom of choice," was already controversial among mathematicians.[21] But Badiou courts controversy: "within ontology, the axiom of choice formalizes the predicates of intervention" (BE 227); he offers the following example:

$$(\forall\alpha)(\exists f)[(\forall\beta)[(\beta \in \alpha \ \& \ \beta \neq \varnothing) \rightarrow f(\beta) \in \beta]]$$

Or "for all α, there is a function (f), for which all β, if β belongs to α, and β is not void, then the function of β belongs to β" (BE 226). In other words, β may belong to α, but the "function of β" allows for the possibility of choice or chance to intervene and to interrupt its relationship of belonging to α. The axiom of choice guarantees the existence of this function as a general condition for multiples that exist ($\neq \varnothing$), even when

they are subordinate multiples, and even though said function itself is hypothetical, theoretical, and has not yet been articulated or defined. Thus, the possibility of novelty and change—the significant upheaval in the given order of the world—is demonstrably "true."

The axioms of set theory appear to operate in Badiou's ontology as a type of specialized language for articulating the discontinuities of revolutionary history, and mathematicians and humanists alike no doubt take issue with the conflation of formal logic and historical processes.[22] Yet Badiou, like Rukeyser and Lindsay before him, opts for a high-risk experiment in thought and writing. Perhaps projects like Badiou's and Kittler's reflect the humanist's insecurity, a yearning for scientific authority at a time when the humanities are undervalued or a vainglorious attempt to unite the irreconcilably divided. But union among the divided is also the project of *Leaves of Grass*.

The contributions to this special issue have begun the work of illuminating how the poet joins the mathematical and the poetical and how their encounter informs the revolutionary aesthetics and political commitments of his writings, as Whitman studies, once again, attends to the repressed figures of cultural history, where even the most abstract symbolic traces become interpretable because sensible and sensual. My belief—the belief that motivated me to pitch this special issue to Ed Folsom (whose graciousness and open mind made it possible in the first place)—is that Whitman's writings support new explorations between numbers and letters. Nor should it escape us that to say so is not to make an intervention so much as it is to recover some forgotten traces and to affirm the golden age of digital scholarship, which comes, of course, with all of the attendant dangers and promises that one might expect from it.

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NOTES

1   Walt Whitman, *Leaves of Grass* (Brooklyn, New York, 1855), vii. Available on the *Walt Whitman Archive* (www.whitmanarchive.org).

2   For examples of single-author scholarship on this topic in other venues, see Seo-Young Jennie Chu, "Dickinson and Mathematics," *The Emily Dickinson Journal* 15 (2006): 35-55; also Zachary Turpin, "Melville, Mathematics, and Platonic Idealism," *Leviathan* 17 (June 2015), 18-34.

3   Muriel Rukeyser, *Willard Gibbs* (Garden City: Doubleday, Doran & Company, Inc., 1942); Kathryn Davies Lindsay, "Mathematics: A Clue to Whitman's Philosophy," M.S. thesis (Southern Connecticut State College, 1965); Charlotte Downey, "How the Mathematical Concepts Portrayed in the Language Patterns of Walt Whitman's and ED's Poems Relate to Meaning," *Dickinson Studies* 72 (1989), 17-32; and Charlotte Downey, "Direct and Indirect Variation in Walt Whitman's Style, " *Starting from Paumanok* 6 (Winter 1991), 1-2.

4   Harold Aspiz, *Walt Whitman and the Body Beautiful* (Urbana and London: University of Illinois Press, 1980); Robert Leigh Davis, *Whitman and the Romance of Medicine* (Berkeley: University of California Press, 1997).

5   Ed Folsom, *Walt Whitman's Native Representations* (Cambridge: Cambridge University Press, 1997); Lawrence Buell, *Writing for an Endangered World: Literature, Culture, and Environment in the U.S. and Beyond* (Cambridge: Harvard University Press, 2001); M. Jimmie Killingsworth, *Walt Whitman and the Earth: A Study in Ecopoetics* (Iowa City: University of Iowa Press, 2004).

6   Harold Aspiz, "Science and Pseudoscience," Donald D. Kummings, ed., *A Companion to Walt Whitman* (Malden, MA: Blackwell, 2006), 216-232; David Reynolds, *Walt Whitman's America: A Cultural Biography* (New York: Vintage Books, 1996).

7   Lindsay's diagrams have been deciphered with some assistance from Karel Hrbacek and Thomas J. Jech, *Introduction to Set Theory, 3rd Edition* (New York: CRC Press, 1999), 13.

8   Jerome Loving, *Walt Whitman: The Song of Himself* (Berkeley: University of California Press, 1999), 298.

9   Patricia Crain, *The Story of A: The Alphabetization of America from The New England Primer to The Scarlet Letter* (Stanford: Stanford University Press, 2000), 72-74, 91.

10   James B. Thomson, *Practical Arithmetic: Uniting the Inductive with the Synthetic Mode of Instruction. For Schools and Academies* (New York: Mark H. Newman, 1846), vi.

11   Edwin B. Wilson, "Willard Gibbs by Muriel Rukeyser," *Science* (May 12,

1944) 99, 387.

12   Michel Serres, *The Parasite*, trans. Lawrence R. Schehr (Minneapolis: University of Minnesota Press, 2007); Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Durham, NC: Duke University Press, 2007); see also, among other examples of their works, Bruno Latour, *Pandora's Hope: Essays on the Reality of Sciences Studies* (Cambridge: Harvard University Press, 1999) and Donna J. Haraway, *Simians, Cyborgs, and Women: The Reinvention of Nature* (New York: Routledge, 1990). Press, 2007).

13   The only published volumes are: Friedrich A. Kittler, *Musik und Mathematik I: Hellas 1: Aphrodite* (Munich: Wilhelm Fink Verlag, 2006); *Musik und Mathematik I: Hellas 2: Eros* (Munich: Wilhelm Fink Verlag, 2009); *Musik und Mathematik 2: Roma Aeterna: 1. Sexus, 2. Virginitas* (Munich: Wilhelm Fink Verlag, 2016). There are rumors that the third volume on Turing will be pieced together from what was left at Kittler's death.

14   For an excellent summary and evaluation of the extant volumes of this project, see John Durham Peters, "Assessing Kittler's Musik und Mathematik,"*Kittler Now: Current Perspectives in Kittler Studies*, ed. Stephen Sale and Laura Salisbury (Cambridge: Polity, 2015), 22-43. See also Geoffrey Winthrop-Young, "Chapter 4: Greek Cultural Techniques," *Kittler and the Media* (Malden, MA: Polity, 2011), 82-119.

15   Friedrich A. Kittler, "Number and Numeral," trans. Geoffrey Winthrop-Young, *Theory, Culture & Society* 23 (2006), 59.

16   See, for instance, N. Katherine Hayles, *My Mother Was a Computer: Digital Subjects and Literary Texts* (Chicago: University of Chicago Press, 2005), 102; and Matthew G. Kirschenbaum, *Mechanisms: New Media and the Forensic Imagination* (Cambridge: MIT Press, 2008), 6.

17   Michael Warner, *Publics and Counterpublics* (New York: Zone Books, 2002). 287-88. For Whitman's studies in ancient writing systems see, for instance, *Daybooks and Notebooks, Volume III: Diary in Canada, Notebooks, Index*, ed. William White (New York: New York University Press, 1978), 671. For Whitman's beliefs about American English, see "America's Mightiest Inheritance," *New York Dissected*, ed. Emory Holloway and Ralph Adimari (New York: Rufus Rockwell Wilson, 1936), 55-65.

18   See, for instance, the first chapter of Ed Folsom, *Walt Whitman's Native Representations* (Cambridge: Cambridge University Press, 1997).

19   Quentin Meillassoux, *The Number and the Siren: A Decipherment of Mallarmé's Coup de dés* (Falmouth: Urbanomic x Sequence Press, 2012). See also Alain Badiou, *Being and Event*, trans. Oliver Feltham (London: Continuum, 2005), 191-98. Hereafter BE.

20   Ricardo L. and David Nirenberg, "Badiou's Number: A Critique of Mathematics

as Ontology," *Critical Inquiry* 37.4 (Summer 2011): 583-614.

21   For the controversial status of the axiom of choice among other axioms of set theory, see Yiannis Moschovakis, *Notes on Set Theory* (New York: Springer, 2006). "[Ernst] Zermelo introduced the Axiom of Choice explicitly in 1904, in a brief paper in which he used it to prove that every set is well orderable. This was a long-standing conjecture, and Cantor had outlined a proof of it in a letter to Dedekind, then still unpublished. His proof, however, . . . depended on intuitions about sets which were not sufficiently explained. In contrast to this, Zermelo made it clear, from the start, that his own detailed proof depended on the Axiom of Choice, and he was immediately attacked for this by some of the leading mathematicians of the time, for introducing a questionable method to derive an implausible conclusion" (112).

22   "[T]o call the French Revolution or any other politico-historical event an 'infinite multiple' is to deliberately obscure the basic ontological differences that made the modern discovery of infinity such a revolutionary event in human thought" (Nirenberg 598).