ALICE MACKENZIE BAMFORD

Alice joined NLR *in 2017, first as an intern and then as assistant editor. In a sense, it was home from home. In 1984—four years before she was born—her father, the sociologist Donald MacKenzie, had written a powerful analysis of* US *nuclear-war planning for* NLR *I/148. Her mother, Caroline Bamford, had done her doctoral research on the British New Left, and Alice spoke of growing up with a shelf of old* NLR*s, appropriately mouse-nibbled, in her bedroom in their village home outside Edinburgh. She was a high-flier: a first in English from the University of Edinburgh, a Masters from Oxford and a Cambridge PhD in Criticism and Culture, passing the viva voce without corrections. We publish below extracts from her dazzling doctoral dissertation on mathematics and modern literature, which placed literary treatments of mathematics—Musil, Beckett, Mallarmé, Valéry, 'Oulipo', Stein—in dialogue with images of it constructed by mathematical manifestos. At Cambridge she convened a graduate seminar on literary theory and taught on the undergraduate English course. But, she said, she knew exactly how Wittgenstein felt about the place. In late 2016 she applied for an internship at Verso, where she pulled together ideas for a philosophy of science list—scouting, she laughingly put it, for the next Paul Feyerabend. Soon she migrated upstairs to* NLR*. Her first piece for the journal, 'In the Wake of Trilling', engaged Amanda Anderson's* Bleak Liberalism *in a fine and penetrating critique, adorned in Alice's beautifully queenly style: 'The term Victorian, while it has long ceased to be as pejorative as it was . . . is seldom unambiguously laudatory either'. Her next, 'Intaglio as Philosophy', found Bachelard labouring in the same trench as Bouvard and Pécuchet. There followed 'Counterperfomativity' (*NLR *113), co-written with Donald, an elegant essay in which the 'misfires' theorized by Austinian language philosophy illuminate and problematize the operations of the mathematical models at the heart of financial-derivative markets. She was a scrupulous copy editor, happy to muck in with office life or plan after-work sorties; taking part in all the everyday discussions about texts and things. But swallows can get vertigo; Alice was vulnerable, too. A diagnosis of* MS*—unthinkably hard—came as a destabilizing blow, though she struggled on. She was living on the Whitmore Estate in East London, a spirited participant in the evening clapping and pot-banging that resounded from the balconies under lockdown. Her sense of solidarity was deep-rooted: during a spell at St Pancras Hospital, she found a role as interpreter for the migrant waifs and strays who'd swept up there. In the second week of May, a friend who went round to check she was alright found her in bed, at peace. Blithe spirit, the poet said: like an unbodied joy whose race is just begun.*

ALICE BAMFORD

MATHEMATICS AND MODERN LITERATURE

Passages from 'Chalk and the Architrave'

Gamma, a student in Imre Lakatos's drama, *Proofs and Refutations*, suggests: 'Why not have mathematical critics just as you have literary critics, to develop mathematical taste by public criticism?'[1] Lakatos's drama is set in a mathematics classroom. The students are debating the proof of the Euler characteristic for polyhedra. *Proofs and Refutations* follows the journey of Euler's Theorem from its birth as naive conjecture through the mistakes and revolutions of nineteenth-century mathematics, to adulthood.[2] As they speed through a century of mathematical history, the students live Lakatos's lesson: rigour and proof are historically variable values and practices. *Proofs and Refutations* offers, too, an education in the value of error: mathematical knowledge develops by dialectical criticism.[3]

Lakatos's stated enemy was the 'formalist' philosophy of mathematics. In particular, he objected to the formalist *image* of mathematics, which equated mathematics with 'its formal axiomatic abstraction' and the philosophy of mathematics with metamathematics. In Lakatos's opinion, formalism was disconnecting mathematics not just from its philosophy but also from its history:

> According to the formalist concept of mathematics, there is no history of mathematics proper. Any formalist would basically agree with Russell's 'romantically' put but seriously meant remark, according to which Boole's *Laws of Thought* (1854) was 'the first book ever written on mathematics'.[4]

Mathematics further exempts itself from history, in Lakatos's view, by forced adherence to a particular style of writing. This 'Euclidean' or 'deductivist' style imposes a fixed structure on the presentation of mathematics: the text begins with a list of axioms, lemmas and/or definitions, this list is followed by the theorem, and the theorem is followed by the proof. Readers of mathematics are watching a 'conjuring act': the deductivist style enforces the dogma that 'all propositions are true and all inferences valid' and presents mathematics 'as an ever-increasing set of eternal, immutable truths'.[5]

By tearing the results from their heuristic context and hiding the mathematician's initial conjectures, the counter-examples and the work of proof-analysis, deductivist style enforces a sense of finality and steels itself against criticism. 'Deductivist style', Lakatos writes, 'hides the struggle, hides the adventure. The whole story vanishes, the successive tentative formulations of the theorem in the course of the proof-procedure are doomed to oblivion while the end result is exalted into sacred infallibility'. Lakatos advocates, instead, the adoption of a heuristic style, in which the text would tell the story of its own emergence: the adventure and struggle of conjecture, counter-examples, criticism and proof-analysis.[6]

These passages are drawn from the dissertation 'Chalk and the Architrave: Mathematics and Modern Literature', for which Alice MacKenzie Bamford was awarded the degree of Doctor of Philosophy by the University of Cambridge in 2015.

[1] Imre Lakatos, *Proofs and Refutations: The Logic of Mathematical Discovery*, ed. by John Worrall and Elie Zahar, Cambridge 1976, p. 98.

[2] Euler's Theorem: the conjecture that for all polyhedra the number of their vertices, *V*, minus the number of their edges, *E*, plus the number of their faces, *F*, is 2 (V-E+F=2).

[3] Lakatos summarised the process of dialectical criticism in his appendix to *Proofs and Refutations*. First, there is a primitive conjecture (the thesis) and a 'proof' is formed ('a rough thought-experiment or argument, decomposing the primitive conjecture into subconjectures or lemmas'). Then comes the antithesis: 'global' counter-examples are found that appear to undermine the primitive conjecture. The proof is re-examined in order to find the 'guilty lemma': the subconjecture that can account for the global counter-examples. The guilty lemma, which may have been hidden or misstated in the original proof, is now made into an explicit condition of the primitive conjecture. This is the synthesis: the improved conjecture, produced by proof-analysis, supersedes the primitive conjecture. Lakatos, *Proofs and Refutations*, p. 127; hereafter PR.

[4] PR, p. 142. [5] PR, p. 142. [6] PR, p. 142.

Gamma's suggested new genre—'mathematical criticism'—can be found in the form of mathematical manifestos, prefaces, parables and essays that mediate and frame the discipline's entanglement with that which it understands to be other than itself—the liminal genres of modern mathematics. These works of prescriptive and performative disciplinary criticism seek to shape mathematical 'taste' by 'public criticism'. Mathematical manifestos reinforce and reconfigure the links between the disciplinary self-construction of mathematics, the repertoire of cultural images of mathematics and the social structure in which mathematical knowledge is embedded. The metaphors and rhetorical strategies deployed in 'peri-mathematical' or threshold texts are mediators: translating mathematics out of the formal language of proof and into a network of historical and rhetorical entanglements. At the same time, mathematical manifestos mobilise the political conditions and cultural assumptions of the historical moments in which they were written. Traces of the discipline's social and cultural history—of the making of mathematical values like rigour and exactness—are inscribed in the manifesto's mathematical criticism.

Manifestos mark crucial moments in the nineteenth and twentieth-century history of mathematics. The introduction to Augustin-Louis Cauchy's 1821 textbook, the *Cours d'analyse*, is seen by many historians of mathematics as marking a disjuncture between the hugely productive but informal development of the calculus over the previous 150 years and the start of its formalisation. Hermann Weyl's 1921 'Über die neue Grundlagenkrise der Mathematik' was the single most trenchant response to the late nineteenth and early twentieth century 'foundations crisis', a crisis that was in a sense the consequence of a series of mathematical results that showed contradictions in, or inherent limits of, efforts at formalization. N. Bourbaki's 'L'Architecture des Mathématiques' (1948) was an enormously influential mid-twentieth century effort to re-found mathematics. 'Nicolas Bourbaki' was the collective pseudonym of a group of predominantly French mathematicians whose *Éléments de mathématique* was designed to be a self-contained reconstruction of the core elements of modern mathematics in largely formalized language.

3

Mathematical manifestos are works of polemic and performative disciplinary criticism that announce a new foundational programme in mathematics, break with the previous order and promote a certain image of mathematics and its history. There are, certainly, broad parallels between 'modernist mathematics' and other forms of cultural modernism: a rupture with tradition, a turn toward formalism, and a heightened self-reflexivity. As such, mathematical manifestos may be read alongside other examples of the genre—literary and artistic manifestos such as Marinetti's 'Technical Manifesto of Futurist Literature' (1912), Pound's 'Vorticism' (1914), Khlebnikov's 'To the Artists of the World!' (1919) and the Oulipo manifestos (1960–73) of François Le Lionnais, Raymond Queneau and Jacques Roubaud.

References to mathematics pervaded the manifestos of the European avant-gardes. The deployment of mathematics as an organizing metaphor and appeals to the epistemic virtues of mathematics are, indeed, common strategies in the construction of literary and artistic movements: Novalis's definition of Romanticism, T. E. Hulme's geometrical classicism, or the mathematical analogies of Pound's vorticist manifestos, for example. Just as the history of mathematics bears witness not to a 'royal road' to modern precision, exactness and foundational rigour, but rather to the cyclical, strategic deployment of calls to foundational retrenchment, rigour and formalism, so, too, does literary history reflect the cyclical and strategic deployment of mathematics as a cultural and symbolic resource at moments of disciplinary re-negotiation: Musil, Pound or Beckett.

4

Bourbaki's thunderbolt, the *Éléments de mathématique*, began its life as a somewhat modest, conventional project. Henri Cartan and André Weil were two young mathematicians responsible for teaching courses on differential and integral calculus at Strasbourg. In his memoir, Weil describes Cartan constantly complaining about the lack of a good analysis textbook and pestering Weil with questions about how to teach the calculus course. Weil proposed solving the problem for good: they would get a group of mathematicians together (friends of theirs who were teaching the same topics at various universities) and collectively write what they thought of as a new *Cours d'analyse*: a new analysis textbook. The group met on 10 December 1934 to discuss this 'Traité d'Analyse'. The minutes of this meeting record:

> WEIL presents his project—to establish the content of the certificate in differential and integral calculus for the next 25 years by jointly writing a treatise on analysis. It is agreed that this treatise will be as modern as possible.[7]

At the Committee's meeting on 14 January 1935, the analyst and functional theorist Szolem Mandelbrojt proposed 'un principe de généralité': that all the necessary general and abstract theories should be given at the beginning of the book. 'We must', Weil said, 'write a treatise that could be used by anyone: by researchers (university lecturers or not), by students, by future educators, by physicists and by all engineers'.[8] As such, the tools of mathematics were to be given in the most universal form. This abstract section grew until it engulfed the treatise on analysis. Bourbaki's project was reimagined as writing the 'ultimate mathematics textbook'.[9] Even the choice of title, *Éléments de mathématique*, was provocative: Bourbaki used '*mathématique*' in the singular (rather than the conventional *mathématiques*). An unpublished draft introduction opened on an even stronger note: 'THERE IS one mathematic, unique and indivisible: hence the rationale for the present treatise, which will expose the elements of it in the light of twenty-five centuries.'[10]

5

The name 'Bourbaki' today connotes mathematical structuralism and an austere, formalist, axiomatic style (and indeed, for those old enough to

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[7] Réunion du 10/12/1934, Delta 001, *Archives de l'Association des Collaborateurs de Nicolas Bourbaki*. See also André Weil, *The Apprenticeship of a Mathematician*, trans. Jennifer Gage, Basel 1992, pp. 99–100.

[8] Réunion du 14/01/1935, Delta 002, pp. 2–3, *Archives de l'Association des Collaborateurs de Nicolas Bourbaki*.

[9] Leo Corry, 'Writing the Ultimate Mathematics Textbook: Nicolas Bourbaki's *Éléments de mathématique*', in Eleanor Robson and Jacqueline Stedall, eds, *The Oxford Handbook of the History of Mathematics*, Oxford 2009.

[10] 'R145. Introduction au Livre I (Etat 2: Nunke)', *Archives de l'Association des Collaborateurs de Nicolas Bourbaki*.

remember it, the short-lived, heavily set-theoretic 'New Math' of 1960s curriculum reform).[11] Yet both Bourbaki's structuralism and their axiomatic style were ambivalent, even contradictory. Bourbaki's structures led double lives. 'Structure' had both a formal and a nonformal meaning in their work.[12] Bourbaki's structuralist image of mathematics belongs above all to their peri-mathematical writing: to their histories, parables, prefaces and manifestos and, in particular, to 'The Architecture of Mathematics', written by Weil's friend Jean Dieudonné and published in a special issue of *Cahiers du Sud*, edited by François Le Lionnais, in 1948. Le Lionnais, chemical engineer, poet and mathematician, would republish the 'Architecture' in his two-volume *Great Currents of Mathematical Thought* (an encyclopaedic project that was never, in fact, completed).[13] He would go on to become a founding member of Oulipo and to write the first manifestos of the Oulipo movement.

Bourbaki's manifesto argues that, despite the apparent splitting of mathematics into specialized branches, the discipline can and will retain its unity. The 'axiomatic method' is Bourbaki's insurance against the threat of the discipline's fragmentation: against the possibility of mathematics becoming 'a tower of Babel of autonomous disciplines'. Bourbaki's axiomatic method enables 'a systematizing of the relations existing among the various mathematical theories'. Bourbaki's project will show the underlying unity of mathematics by a process of analysis and synthesis. Each theory will be decomposed into its constituent elements, and the relations among those elements will be uncovered and reordered into a hierarchy of types of mathematic 'structure'. As such, 'mathematical structures become, properly speaking, the *sole "objects"* of

[11] In Germany the backlash against the New Math made the cover of *Der Spiegel* on 25 March 1974: the headline 'Macht Mengenlehre krank?' ('Sickened by set theory?') was emblazoned across the face of an unhappy-looking child. In the United States, Morris Kline denounced the Bourbaki-inspired educational reforms in *Why Johnny Can't Add: The Failure of the New Math*, New York 1973.

[12] For the Israeli historian of mathematics, Leo Corry: 'On the one hand, ['structure'] suggested a general organizational scheme for the entire discipline, which turned out to be very influential. On the other hand, it comprised a concept that was meant to provide the underlying formal unity but was of no mathematical value whatsoever either within Bourbaki's own treatise or outside it': 'Writing the Ultimate Mathematics Textbook', p. 579.

[13] Bourbaki, 'The Architecture of Mathematics', in François Le Lionnais, ed., *Great Currents of Mathematical Thought, Vol. 1. Mathematics: Concepts and Development*, trans. R. A. Hall and Howard Bergman, New York 1971, pp. 23–37.

mathematics'. Bourbaki use two metaphors of modernization to explain their reconstruction project: Haussmann's Paris and Taylor's factory line. Mathematics, Bourbaki write, is:

> Like a great city whose suburbs never cease to grow in a somewhat chaotic fashion on the surrounding lands, while its centre is periodically reconstructed, each time following a clearer plan and a more majestic arrangement, demolishing the old sections with their labyrinthine alleys in order to launch new avenues toward the periphery, always more direct, wider and more convenient.[14]

The axiomatic method enables, Bourbaki argue, an 'economy of thought': 'It can thus be said that the axiomatic method is nothing but the "Taylor System"—the "scientific management"—of mathematics'. Yet the factory-line metaphor proves inadequate, and Bourbaki immediately retract their claim: 'this comparison is not sufficiently close; the mathematician does not work mechanically as does the worker on the assembly line; the fundamental role that a special *intuition* plays in his research cannot be overestimated'.[15] The manifesto is full of moments of disavowal.

While proclaiming themselves the heirs to David Hilbert's mathematical formalism, Bourbaki seek to absolve themselves from the charges levelled at formalism (that it is a 'lifeless skeleton', machine-like, divorced from physical reality, somehow inhuman) by deploying an organic register of biological language (they talk of organisms, 'mother-structures', 'nourishing sap' and so on) alongside the inorganic, modernist, often architectural register of structure and form. In fact, Bourbaki's biological language echoes Hilbert's own rhetoric. He, too, used the romanticist, biological metaphor of the organic whole to defend the unity of mathematics: 'Mathematical science is in my opinion an indivisible whole, an organism whose vitality is conditional upon the connection of its parts.'[16]

The manifesto's method of tropological substitution enables mathematical 'modernism' to co-exist with intuition, with romanticism, with the organic: in other words, with everything that modernism is said to have erased from mathematics. Bourbaki's project, the unification of

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[14] Bourbaki, 'The Architecture of Mathematics', p. 34.
[15] Bourbaki, 'The Architecture of Mathematics', p. 31.
[16] David Hilbert, 'Mathematical Problems' [1902], trans. by M. W. Newson, *Bulletin of the American Mathematical Society* 8, pp. 478–9.

mathematics, is thus played out in their manifesto at the tropological level: the unity of mathematics is brought about—albeit uneasily—by the unification of images of mathematics and varying metaphors for mathematical unity. Indeed, Le Lionnais hinted at this discursive unification project in his commentary: 'Bourbaki's message, so rich and so dense with meaning, has as its overall aim a systematic inventory of the analogies in mathematics and at the same time an elucidation of their validity and of their significance'.[17]

6

In the introduction to their volume on set theory, Bourbaki invoked the rigour of the ancients to defend the essential stability of mathematics: the invariance of the discipline's paradigm of legitimacy and its concepts of proof and rigour, and—one is forced to add—an essentially Western (and not Babylonian, Indian, Chinese or Arabic) genealogy.[18] They write:

> Ever since the time of the Greeks, mathematics has involved proof; and it is even doubted by some whether proof, in the precise and rigorous sense which the Greeks gave to this word, is to be found outside mathematics. We may fairly say that this sense has not changed, because what constituted a proof for Euclid is still a proof for us; and in times when the concept has been in danger of oblivion, and consequently mathematics itself has been threatened, it is to the Greeks that men have turned again for models of proof. But this venerable bequest has been enlarged during the past hundred years by important acquisitions.[19]

Bourbaki sought to identify and to codify the essential, invariant aspects of mathematical language: 'By analysis of the mechanism of proofs in suitably chosen mathematical texts, it has been possible to discern the structure underlying both vocabulary and syntax.' Bourbaki claimed that proofs can always be recognized as proofs because, beneath the local variations in the surface layer of the text, they share an underlying structure. Yet, since the mathematical text is defined by its hypothetical formalization, the underlying structure of proof exists only in the realm of potentiality. In practice, mathematicians do not and cannot make

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[17] Le Lionnais, ed., *Great Currents of Mathematical Thought, Vol. I*, p. 11.

[18] Compare, for example, Karine Chemla and Guo Shuchun, *Les neuf chapitres: Le classique mathématique de la Chine ancienne et ses commentaires*, Paris 2004.

[19] Bourbaki, *Elements of Mathematics: Theory of Sets* [1970], New York 2004, p. 7.

Leibniz's dream real: they never write out their proofs in an entirely formal language. Such a project would be, Bourbaki point out, 'absolutely unrealizable' as 'the tiniest proof at the beginning of the Theory of Sets would already require several hundreds of signs for its complete formalization'. Bourbaki, therefore, must appeal to their implied reader's 'intuition', to their 'common sense' and to their 'confidence'—'a confidence analogous to that accorded by a calculator or an engineer to a formula or a numerical table without any awareness of the existence of Peano's axioms'.[20]

The rigour of a proof is, nonetheless, judged on 'the possibility of translating it unambiguously into such a formalized language'. The arts of reading and of writing mathematics require a kind of double vision: 'Thus, written in accordance with the axiomatic method and keeping always in view, as it were on the horizon, the possibility of a complete formalization, our series lays claim to perfect rigour.' Bourbaki's mathematical structuralism sounds rather like linguistic structuralism here (they could be discussing the *langue* and *parole* of mathematical language), and indeed they reference linguistics in defence of their project:

> Just as the art of speaking a language correctly precedes the invention of grammar, so the axiomatic method had been practised long before the invention of formalized languages; but its conscious practice can rest only on the knowledge of the general principles governing such languages and their relationship with current mathematical texts.[21]

Bourbaki, however, were not concerned with 'languages' in the plural. Bourbaki describe their 'axiomatic method' as a way to transcend the limitations of specialization. When faced with 'complex mathematical objects', Bourbaki 'separate their properties'—algebraic properties,

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[20] Bourbaki, *Elements of Mathematics: Theory of Sets*, pp. 7, 10–11. Peano's axioms are the canonical formalization of the natural numbers and thus of arithmetic.

[21] Bourbaki, *Elements of Mathematics: Theory of Sets*, pp. 8, 12, 9. Bourbaki's mathematical structuralism did occasionally cross paths with other structuralisms. André Weil, for example, worked with Claude Lévi-Strauss and wrote a mathematical appendix to Part One of *The Elementary Structures of Kinship*: 'On the algebraic study of certain types of marriage laws (Murngin system)'. For an extended analysis of Bourbaki's links with French structuralism, see David Aubin, 'The Withering Immortality of Nicolas Bourbaki: A Cultural Connector at the Confluence of Mathematics, Structuralism, and the Oulipo in France', *Science in Context*, vol. 10, no. 2, 1997, pp. 297–342.

topological properties, and so on—and 'regroup them around a small number of concepts': they 'classify them according to the *structures* to which they belong'. Indeed, where it was once thought that the results in each branch of mathematics were dependent on that branch's distinctive form of mathematical intuition, it is now, Bourbaki argue, logically possible 'to derive practically the whole of known mathematics from a single source, the Theory of Sets'. In light of this, Bourbaki give the principles of a single formalized language, and then specify how set theory 'could be written in this language', before showing how various other branches of mathematics might fit into their unified language project.

7

With its fictional author, the mysterious 'N. Bourbaki', and its grandiose proclamations, *Éléments de mathématique* was, as the Oulipo poet and mathematician Jacques Roubaud would write, a 'provocative and avant-gardist treatise'; even 'a sort of mathematical surrealism'.[22] Bourbaki's mathematical surrealism is perhaps most evident in the absurdist humour of their internal bulletin, *La Tribu*, 'the tribe', subtitled *Bulletin oecuménique apériodique et bourbachique*. While the humour of *La Tribu* tends towards a kind of surrealism, Bourbaki's treatise and their manifesto, 'The Architecture of Mathematics', reveal the group's affiliations with other valences of the avant-garde: with formalism, with revolutionary ambition, with modernist utopianism, with the *mathesis universalis* and other universal language projects, and with the desire to create an autonomous, unified work of art.

Formal experimentalism was equally evident in their historiographic method. 'Historical Notes' were appended to many of the chapters of Bourbaki's treatise. The 'Directions for Use' explains the rationale for the bracketing-off of history from mathematics proper:

> Since in principle the text consists of the dogmatic exposition of a theory, it contains in general no references to the literature. Bibliographical references are gathered together in *Historical Notes*, usually at the end of each chapter. These notes also contain indications, where appropriate, of the unsolved problems of the theory.[23]

[22] Jacques Roubaud, 'Mathematics in the Method of Raymond Queneau', p. 80.
[23] Bourbaki, *Elements of Mathematics: Theory of Sets*, p. vi.

In fact, rather than useful collections of references, these histories are strange pieces of prose, markedly different in style from the rest of the text: often highly subjective, sometimes lyrical, they oscillate between hagiography of individual, proto-modern mathematicians and appeals to the unstoppable, de-individualized force of ideas. Bourbaki's historical notes often spanned a wide expanse of time: sometimes reaching all the way back to the ancient Greeks or to the Babylonians. They tended to give the history of mathematics as the prehistory of Bourbaki.

A 1947 *La Tribu* invented the incident of a mock-historical report given as a supposed-inaugural speech in order to poke fun at both algebra and the style of Bourbaki's historiography:

> The historical note to chapters 2–3 of the *Algebra*, read in the guise of an inaugural address, put the congress 'in the right mood' for algebra: it glorified Fermat, obediently followed the meandering of the linear and examined the influence of Mallarmé on Bourbaki.[24]

Paradoxically, the strictures of axiomatic style that were imposed on Bourbaki's treatise also generated the semantic excesses of *La Tribu*: an overflow of non-formal, playful language; of pastiche, parody, puns, nonsense and poetry, in which words grabbed the multiple meanings they were denied in the *Éléments*. Bourbaki's absurdist sense of humour, hidden in their archives, is missing from many characterizations of the group. Roubaud, for example, claimed that the Oulipo were at once 'an homage to Bourbaki' and 'a parody of Bourbaki, even a profanation of Bourbaki', since:

> Bourbaki's initial plan—to rewrite Mathematics in its entirety and provide it with solid foundations using a single source, Set Theory, and a rigorous system, the Axiomatic Method—is at once serious, admirable, imperialistic, sectarian, megalomaniac, and pretentious. (Humour has not been one of its prime characteristics.)[25]

Yet the issues of Bourbaki's bulletin were full of jokes, nonsensical stories, hoaxes, neologisms and ridiculous anecdotes about the various

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[24] *La Tribu: Bulletin oecuménique, apériodique et bourbachique*, 'Compte-rendu du Congrès de Noël' [1947], Archives Bourbaki.

[25] Jacques Roubaud, 'The Oulipo and Combinatorial Art' [1991], in Harry Mathews et al., eds, *Oulipo Compendium*, London 2005.

Bourbaki congresses. Many Bourbaki members were *normaliens*, and *La Tribu* abounds with the particular slang and the *canular* humour of the École Normale. Even the lists of members present at the Bourbaki congresses were defiantly odd: they sometimes included 'extras' (wives, children, locals, farm animals, etc.) and 'props' (cars, bicycles, prams, binoculars, aspirin, and other paraphernalia were listed alongside standards like the blackboard and its duster). Issues of *La Tribu* were also scattered with poetry: pastiches of, for example, Valéry or Mallarmé, that created a mythic genealogy for the figure of Bourbaki, or gave a mock-heroic account of his past triumphs.

La Tribu was often self-parodic. Issue 29, the report from the 'Congrès de l'incarnation de l'Ane qui trotte' is one such example: the incarnated 'trotting donkey' is a plodding mathematical exposition, and the report heaps further scorn upon Bourbaki's style in a satirical ballad. This *chanson paillarde* is to be sung, its author suggests, to the tune of 'J'ai une histoire à raconter' or 'En descendant la rue d'Alger'. It mocks the preface-manifesto, the 'directions for use', of Bourbaki's *Éléments*. The *chanson*, roughly translated, goes something like this:

> The directions for using this treatise (x 2)
> Are the height of simplicity (x 2)
> If there's something you still can't see,
> Never fear!
> Just think more abstractly
> And it will all become clear. (x 2)
> The alphabets of every nation (x 2)
> Will be used in explanations (x 2)
> For clarity's sake, we have
> Often enough
> Used the smallest font
> For the most important stuff. (x 2)
> The exercises are tantalizing (x 2)
> Their wording is so enticing (x 2)
> But don't bother trying to do
> A lot!
> We've heard two thirds of them
> Are false, or worse, are nonsense. (x 2)
> Our notations, as you'll see (x 2)
> Are as improved as they can be (x 2)
> According to the best of criteria
> Which is?
> That in the whole wide world
> No one can understand a single word. (x 2)

> The order of the presentation (x 2)
> Was the subject of long meditation (x 2)
> We've put the secondary points
> In front!
> What's more, we've buried in corollaries
> All the necessities: so you'll have to hunt. (x 2)[26]

Bourbaki were, therefore, already in the business of parodying Bourbaki (and doing so in verse) before Oulipo came on the scene. The Bourbaki movement was, at least in part, a series of experiments in genre: from their (admittedly minor) works of literary pastiche, through their parables and historiography, to the grand experiment of the *Éléments*, which turned the humble analysis textbook into the bearer of a utopian vision. Bourbaki's published writings and their archives show the tangled visions and discordant notes of their utopianism. Nonetheless, Bourbaki's nonformal structuralist image of mathematics gained traction both inside and outside the discipline of mathematics—evident not least in the formation of Oulipo itself.

8

The Oulipo—'Ouvroir de Littérature Potentielle', or 'Workshop of Potential Literature', had its first official meeting on 24 November 1960, summoned by Le Lionnais and the *quondam* surrealist writer, Raymond Queneau. Bourbaki's doctrine of potential formalization inspired and justified the Oulipo's project of potential literature. Queneau's manifesto defended Oulipo's playful use of mathematics to generate formal poetic constraints. After all, history shows us that ludic, impure uses of mathematics are often, in the end, vindicated:

> Let us remember that topology and the theory of numbers sprang in part from that which used to be called 'mathematical entertainments', 'recreational mathematics' . . . that the calculation of probabilities was at first nothing other than an anthology of 'diversions', as Bourbaki states in the 'Notice Historique' of the twenty-first fascicle on Integration. And likewise game theory, until von Neumann.[27]

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[26] *La Tribu* 29, report on the 'Congrès de l'incarnation de l'Ane qui trotte', Celles-sur-Plaine, 19–26 October 1952, in *Archives de l'Association des Collaborateurs de Nicolas Bourbaki*.

[27] Raymond Queneau, 'Potential Literature', in Warren Motte, ed., *Oulipo: A Primer of Potential Literature*, London 1998, p. 51.

Oulipo draw on mathematics—combinatorial techniques, Boolean algebra and Bourbaki's axiomatic method, for example—in their literary practice. Their objective is to 'propose new "structures" to writers, mathematical in nature' or 'invent new artificial or mechanical procedures that will contribute to literary activity'. Queneau's manifesto went on to demonstrate a few Oulipean exercises: 'Redundancy in Mallarmé', 'The S + 7 Method' and 'Isomorphisms'.[28]

Bourbaki's structures were central to Le Lionnais's founding text for the group. 'Lipo: First Manifesto' begins as many manifestos do: by spoofing the genre's typically overblown rhetoric. 'Potential Literature' is announced as imminent, necessary and urgent: witness 'the impatience of the starving multitudes'. In Le Lionnais's re-casting, the Quarrel of the Ancients and the Moderns functions as a grandiose prehistory for the advent of Oulipo. The manifesto challenges its reader with absurd, overblown questions: 'Do you remember the polemic that accompanied the invention of language?'; 'And the creation of writing, and grammar, do you think that happened without a fight?'; 'Should humanity lie back and be satisfied to watch new thoughts make ancient verses?'[29]

9

A decade later, Le Lionnais's 'Second Manifesto' announced that it was time to broach 'the question of semantics'. Drawing on the rhetorical play of Bourbaki's 'The Architecture of Mathematics', he invoked an organic, biological register. Those sceptical of the Oulipo might ask:

> But can an artificial structure be viable? Does it have the slightest chance to take root in the cultural tissue of a society and to produce leaf, flower, and fruit? . . . One may compare this problem—*mutatis mutandis*—to that of the laboratory synthesis of living matter. That no one has ever succeeded in doing this doesn't prove a priori that it's impossible . . . Oulipo has preferred to put its shoulder to the wheel, recognizing furthermore that the

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[28] Queneau, 'Potential Literature'. Redundancy: since the essence of Mallarmé's sonnets was concentrated in the last word of each line, the rest could be eliminated. S+7: take an existing text and replace every noun with the seventh noun after it in the dictionary. Isomorphism: replace words in a text with others that sound similar.

[29] François Le Lionnais, 'Lipo: First Manifesto' [1962] in *Oulipo: A Primer of Potential Literature*, pp. 26–9.

> elaboration of artificial literary structures would seem to be infinitely less complicated and less difficult than the creation of life.[30]

If most artificial structures created by the Oulipo exist in a potential state, awaiting their cultural animation, some of those structures are discovered or uncovered in existing cultural forms: we stumble upon them in nature, so to speak. Le Lionnais's point recalls Bourbaki's remarks about mathematical structures and their relationship to empirical reality:

> From the axiomatic point of view mathematics appears on the whole as a reservoir of abstract *forms*—the mathematical structures; and it sometimes happens, without anyone really knowing why, that certain aspects of experimental reality model themselves after certain of these forms, as if by a sort of preadaptation.[31]

Indeed, it remains surprising—even astonishing—that the structures, equations and other paraphernalia that mathematicians invent for their own purposes so often turn out to be accurate models of natural processes or useful tools for understanding physical reality. Jean Piaget even considered the correspondence between Bourbaki's 'mother structures'—the algebraic structures, structures of order and topological structures—and the elementary 'operations' that children use as they begin to interact with the world.[32] What Bourbaki call 'preadaptation', Le Lionnais refers to as 'plagiarism by anticipation'. On occasion, he writes, the members of the Oulipo 'discover that a structure we believed to be entirely new had in fact already been discovered or invented in the past'. When this happens, Oulipo 'make it a point of honour to recognize such a state of things in qualifying the text in question as "plagiarism by anticipation"'.[33]

10

Many Oulipean texts are manifestos. Indeed, as the manifesto is a genre of potentiality—positioned between what has been done and what is to

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[30] François Le Lionnais, 'Second Manifesto' [1973] in *Oulipo: A Primer of Potential Literature*, pp. 30–1.

[31] Bourbaki, 'The Architecture of Mathematics', p. 36.

[32] Jean Piaget, *Structuralism*, trans. Chaninah Maschler, London 1971, p. 28.

[33] Le Lionnais, 'Second Manifesto', p. 31.

be done—it is a particularly suitable vehicle for the group's 'Potential Literature'. The analogy between literature and mathematics is essential to the Oulipo. The group's members have included professional mathematicians like Roubaud himself, Claude Berge and Paul Braffort. Roubaud argues that for the members of Oulipo, the 'exhaustion' of traditional literary forms and rules 'is the starting point in the search for a *second foundation*, that of mathematics'. Oulipo want to replace rules with axiomatic constraints, and forms with Bourbakian structures. Where earlier literary and artistic avant-gardes—Vorticism, Futurism—developed and deployed diverse, often largely informal mathematical vernaculars, Oulipo sought to explicate and to codify their literary mathematics. Oulipo did not use mathematics simply as a legitimating discourse, as a code for their modernity, autonomy or aesthetic stance, nor merely as a source of metaphors; rather, for Roubaud, Queneau and their comrades, literature's affiliation with mathematics was and is an end in itself: 'Mathematics repairs the ruin of rules.'[34]

Yet, here we might pause and recall Adorno's criticism of such aesthetic affiliations with mathematics. For Adorno, although mathematics shares certain characteristics with art ('on the basis of its formalism, mathematics is itself aconceptual; its signs are not signs of something, and it no more formulates existential judgements than does art; its aesthetic quality has often been noted') attempts to directly equate aesthetic forms and mathematical forms are acts of self-deception and self-renunciation. Like Roubaud, Adorno saw the recourse to mathematics as motivated by the ruin of rules. Roubaud was content to look to mathematics for inspiration: for the axioms and structures through which to generate his 'potential literature'. Adorno, on the other hand, argued that mathematics could not repair the ruin of rules:

> Mathematization as a method for the immanent objectification of form is chimerical. Its insufficiency can perhaps be clarified by the fact that artists resort to it during historical periods when the traditional self-evidence of forms dissolves and no objective canon is available. At these moments the artist has recourse to mathematics; it unifies the level of subjective reason attained by the artist with the semblance of an objectivity founded on categories such as universality and necessity.[35]

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34 Jacques Roubaud, 'Mathematics in the Method of Raymond Queneau' in *Oulipo: A Primer of Potential Literature*, p. 93.

35 Theodor Adorno, *Aesthetic Theory*, trans. Robert Hullot-Kentor, London 2009, p. 181.

For the artist to reach outside the domain of the aesthetic for a source of legitimacy is, however, only to further undermine art's claim to legitimacy. 'Rather than embodying the abiding lawfulness of being, its own claim to legitimacy', Adorno writes, 'the mathematical aspect of art despairingly strives to guarantee its possibility in a historical situation in which the objectivity of the conception of form is as requisite as it is inhibited by the level of consciousness'. Structures imported from mathematics might offer the 'semblance' of objectivity. Yet, Adorno argues, those structures and that objectivity crumble in the act of translation: 'the organization, the relation of elements to each other that constitutes form, does not originate in the specific structure and fails when confronted with the particular'.[36]

For the Oulipean Queneau, that crumbling, that failure, that patchy translation, was something to be embraced and represented. In 'The Foundations of Literature (after David Hilbert)', Queneau formulates an axiomatic system for literature.[37] The text is at once a tribute to Hilbert, a pastiche of Hilbert's axiomatic style and a critique of Hilbert. The first paragraph of *À la recherche du temps perdu*, Flaubert's sentence structure and chapter XCVIII of *Tristram Shandy* are variously sifted, filtered and warped as they are tested against the axioms lifted from Hilbert's *Foundations of Geometry* (1899). Queneau thus stages a confrontation between the axiomatic method and the particularities of literature, creating a manifesto that enacts, via its own internal logic, the impossibility of complete formalization.[38]

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[36] Adorno, *Aesthetic Theory*, pp. 188–9.

[37] Hilbert had responded to Frege's objection to his axiomatic system by claiming: 'But it is surely obvious that every theory is only a scaffolding or schema of concepts together with their necessary relations to one another, and that the basic elements can be thought of in any way one likes. If in speaking of my points I think of some other system of things, e.g. the system: love, law, chimney-sweep . . . and then assume all my axioms as relations between these things, then my propositions, e.g. Pythagoras's theorem, are also valid for those things': David Hilbert to Gottlob Frege, 29 December 1899, excerpted by Frege, in Gottlob Frege, *Philosophical and Mathematical Correspondence*, Oxford 1980, Letter IV/4, p. 39.

[38] Raymond Queneau, 'The Foundations of Literature (after David Hilbert)' [1973], trans. Harry Mathews, in *Oulipo Laboratory: Texts from the Bibliothèque Oulipienne by Raymond Queneau, Italo Calvino, Paul Fournel, Jacques Jouet, Claude Berge & Harry Mathews*, London 1995, pp. 2–15.