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About the JLS

The *Journal of Literature and Science (JLS)* is a peer-reviewed academic journal published twice annually in Summer and Winter. The JLS was founded in 2007, and produced its first issue at the beginning of 2008. It was originally hosted by the University of Glamorgan's Research Centre for Literature, Arts and Science (2007-12), before moving to its own independent online site in March 2013, with the support of the University of Westminster and the Centre for the Study of Science and Imagination. The journal's first, and present, editor is Professor Martin Willis, Professor of Science, Literature and Communication at the University of Westminster. The Advisory Board includes leading scholars of literature and science from around the world. The JLS is published in digital format, is entirely open access, and requires no subscription fee.

The journal is dedicated to the publication of academic essays on the subject of literature and science, broadly defined. Essays on the major forms of literary and artistic endeavour are welcome (the novel, short fiction, poetry, drama, periodical literature, visual art, sculpture, radio, film and television). The journal encourages submissions from all periods of literary and artistic history since the Scientific Revolution; from the Renaissance to the present day. The journal also encourages a broad definition of 'science': encapsulating both the history and philosophy of science and those sciences regarded as either mainstream or marginal within their own, or our, historical moment. However, the journal does not generally publish work on the social sciences. Within these confines, essays submitted to the journal may focus on the literary and scientific productions of any nation or group.

All essays should be interdisciplinary in focus, offering an original view of both the literary or artistic subject matter and the science or sciences under consideration. While essays on individual examples of literary and artistic production are welcomed, these should also seek to show the wider significance of their analyses and interpretations. The journal does not publish essays focused exclusively on literature or art, or exclusively on the history and philosophy of science.

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“[M]ultitudinous and Minute”: Early Twentieth-Century Scientific, Literary and Psychological Representations of the Mass

Rachel Crossland

During his *annus mirabilis* of 1905, in addition to papers on the special theory of relativity and the quantum nature of light, Albert Einstein published a revolutionary paper on Brownian motion, following this up with four further papers on the subject over the following three years. Einstein's work in this area paved the way for the acceptance of the physical reality of atomic and molecular models, and can be seen as one of the most significant moments in the physical investigation of large numbers of molecules, an area of study which had come to the fore in the mid-nineteenth century. Physics was not the only field to be struggling with issues relating to large masses during this period: indeed, the emergence of social statistics in nineteenth-century France had already had a direct impact on scientific approaches to the mass (Porter 114). The ongoing social, cultural and political implications of such ideas outside of the purely scientific realm became particularly evident with Gustave Le Bon's 1895 declaration that “The age we are about to enter will in truth be the ERA OF CROWDS” (xv). In turn, the urban focus of much modernist literature, and in particular its emphasis on the place of the individual within city crowds, stresses the resonance of such issues across traditional disciplinary divides. This article will consider the ways in which the disciplines of molecular physics, crowd psychology and modernist literature (represented here by the writings of Virginia Woolf) both overlapped with and drew directly on each other in their engagements with and treatments of large-scale populations, whether of particles, human beings or fictional characters. Moreover, it will show how, in N. Katherine Hayles's terms, each discipline was drawn to focus on this problem because the “concerns” underlying it were “highly charged within a prevailing cultural context” (xi), a context which comprised rapid population growth and mass urbanisation, and which raised the question of the nature of the relationship between the individual and the mass.

Brownian motion is the name given to the movement exhibited by microscopic particles suspended in a medium made up of molecules of much smaller size and mass: in current GCSE science the examples most frequently used are pollen grains in water and smoke particles in air. Observed through a microscope, the individual pollen or smoke particles are each seen to be moving almost constantly in a random and “wholly haphazard” manner (Perrin, *Atoms* 83). However, as the Scottish botanist Robert Brown, after whom the phenomenon is named, proved in the 1820s, this motion is due not to living organisms, but rather “belong[s] to the particle itself”

("Brief Account" 338), thus making it a question for physics rather than biology (Brush 3).

Nearly one hundred years after Brown's work, Jean Perrin wrote that "the most striking feature of the Brownian movement is the absolute independence of the displacements of neighbouring particles, so near together that they pass by one another" (*Brownian Movement* 5), and indeed Brown himself was "unable to account" for the movements he observed ("Additional Remarks" 315). However, James Clerk Maxwell's development of the kinetic theory of gases in the 1860s and 1870s provided a possible explanation: Maxwell's model focuses on the movements, interactions and collisions of individual molecules, and scientists were soon looking to these molecular collisions to explain Brownian motion. Yet there were a number of problems with this idea: firstly, the molecular hypothesis was not universally accepted as a physical reality in the nineteenth century; and secondly, it did not seem possible that, if they existed, minuscule molecules could be responsible for the movements of comparatively massive particles. Indeed, in 1879 the botanist Karl von Nägeli highlighted what he considered to be the ridiculous nature of the molecular model of Brownian motion by showing that "a million water molecules must strike the starch particles (*Stärkekörnchen*) at the same moment and from the same direction in order to explain the single jerk of the Brownian granule" (M. Nye 26).

In tackling this ongoing problem in 1905, Einstein used the molecular hypothesis to explain Brownian motion through reference to molecular collisions, but added a key and radical insight: fluctuations in the medium mean that a number of molecules suddenly collide with a particle at the same time and in the same direction, thus causing it to move in that direction (Rigden 63-4).¹ This is the model rejected as ridiculous by Nägeli, but Einstein's addition of random fluctuations within the medium means that such an occurrence is by no means as unlikely or as preposterous as Nägeli had imagined. In addition, it helps to explain what Perrin called "the most striking feature of the Brownian movement": "the motions of the individual particles are mutually independent" (Einstein 132) because each is acted on by a different set of molecules moving according to a distinct fluctuation. While such a model highlights the independent movements of individual particles, Einstein, unlike other scientists working on Brownian motion during the same period, focused on "a probability distribution" rather than the "life history" of one or more particles (M. Nye 112). Einstein's explanation of, and accompanying formula for, Brownian motion sparked a wave of experimental interest, and was proved in 1908 by Perrin, notably through a close focus on the movements of a small number of individual particles, (Fig. 1). Perrin's results, and his explanations thereof, were very successful within the scientific community: they were translated "almost immediately" (M. Nye 148), with his 1909 work *Brownian Movement and Molecular Reality* appearing in English as early as 1910 in a translation by the noted physical chemist Frederick Soddy. Perrin went on to win the Nobel Prize in Physics in 1926 for his work on the physical reality of atoms, within which his experiments on Brownian motion played a vital part: as Perrin himself wrote in 1909, "the molecular theory of the Brownian movement can be regarded as experimentally established, and, at the same time, *it becomes very difficult to deny the objective reality of molecules*" (*Brownian Movement* 46).

The movement towards a model involving random fluctuations and probability distributions necessitates an obvious turn towards statistical measures, but while such an approach may have been relatively new to physics at the turn of the century, the same certainly cannot be said of studies within what we now call the social sciences. Indeed, it was the nineteenth century which saw the emergence and increasing

influence of the field of social statistics, a discipline which "begins by conceding that individual humans are too complex and diverse to serve as the basis of science, and has recourse instead to numerical frequencies as its elemental data" (Gigerenzer et al. 42). This realisation, and the practical applications thereof, had a significant impact on a particularly important nineteenth-century scientist who we have already had cause to mention: Maxwell. As David Bodanis explains, "it was by explicit acknowledgement to [social statistics] that Maxwell worked out his theory of gases where the scurrying molecules also were described only by overall statistics, and not individual biographies" (19).

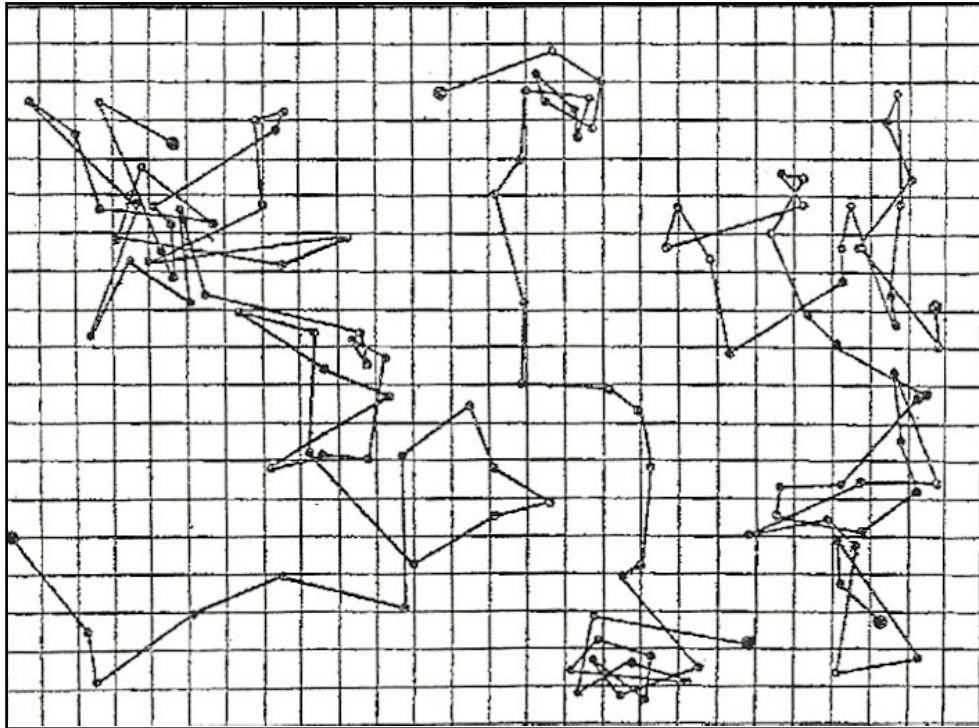


Fig. 1.

Brownian motion in action: "three drawings obtained by tracing the segments which join the consecutive positions of the same granules of mastic at intervals of thirty seconds"

Perrin, *Brownian Movement* 63-4, Shelfmark 193952 e.72. The Bodleian Library, University of Oxford. Reprinted with kind permission.

This explicit acknowledgement on Maxwell's part comes in a lecture that he delivered to the British Association in 1873, and which was subsequently published in *Nature*:

As long as we have to deal with only two molecules, and have all the data given us, we can calculate the result of their encounter, but when we have to deal with millions of molecules, each of which has millions of encounters in a second, the complexity of the [*sic*] problem seems to shut out all hope of a legitimate solution.

The modern atomists have therefore adopted a method which is I believe new in the department of mathematical physics, though it has long been in use in the Section of Statistics. (440)

Statistics thus entered into physics, and the relevance of this development thirty years later to Einstein and other theorists of Brownian motion is clear.²

Theodore Porter has described the links between nineteenth-century physics and statistics as forming "an interdisciplinary matrix," tracing models from statistical astronomy into social statistics and from social statistics into molecular physics (114). However, it is possible to extend such a matrix further by considering what Hayles calls the underlying "highly charged" concerns of the "prevailing cultural context" (xi) which encouraged, even necessitated, the emergence of social statistics as a discipline in its own right. Among such concerns, a rapidly expanding population is clearly a significant factor; the population of England and Wales alone more than doubled between 1841 and 1901, while the urban population in particular was growing at an unprecedented rate: "Towns of over 100,000 inhabitants increased from six in 1841 to thirty in 1901 – only London had been so large in 1801" (Banks 105). Nor was such growth limited to this country, with eleven cities of over one million inhabitants having emerged worldwide by 1900 (Bullock 59). Moreover, this was an increasingly organised population, the working-class section in particular (Bullock 61), which meant, to expand the interdisciplinary matrix yet further, that an understanding of crowd psychology rapidly became an urgent concern for those in government and other positions of responsibility in the early part of the twentieth century.

Gustave Le Bon is widely regarded as the most important, and "most popular" (R. Nye 167), proponent of a theory of the crowd, his ideas retaining their relevance even today, more than one hundred years after the publication of his highly significant 1895 work, *La Psychologie des foules*.

Le Bon's interest is not merely aimed at the crowd as a random gathering together of various completely unrelated people, however, but rather at what he calls the organised, or psychological, crowd:

Under certain given circumstances, and only under those circumstances, an agglomeration of men presents new characteristics very different from those of the individuals composing it. The sentiments and ideas of all the persons in the gathering take one and the same direction, and their conscious personality vanishes. A collective mind is formed, doubtless transitory, but presenting very clearly defined characteristics. The gathering has thus become what, in the absence of a better expression, I will call an organised crowd, or, if the term is considered preferable, a psychological crowd. It forms a single being, and is subjected to the *law of the mental unity of crowds*. (2)

Le Bon was not alone in suggesting such a different side to the crowd. In 1920 William McDougall explained the difference between a "mass of human beings" and "a crowd in the psychological sense of the word" particularly clearly:

There is a dense gathering of several hundred individuals at the Mansion House Crossing at noon of every week-day; but ordinarily each of them is bent upon his own task, pursues his own ends, paying little or no regard to those about him. But let a fire-engine come galloping through the throng of traffic, or the Lord Mayor's state coach arrive, and instantly the concourse assumes in some degree the character of a psychological crowd. All eyes are

turned upon the fire-engine or coach; the attention of all is directed to the same object; all experience in some degree the same emotion, and the state of mind of each person is in some degree affected by the mental processes of all those about him. Those are the fundamental conditions of collective mental life. (22-3)

For any reader of Virginia Woolf the most striking thing about the passage above is its similarity to certain moments in *Mrs Dalloway*, published just five years later. The early scenes involving the motor car and the aeroplane are particularly reminiscent of McDougall's description of a psychological crowd: in the former, "Every one looked at the motor car" (16), just as "the attention of all is directed to the same object" in McDougall. Meanwhile, we see that "all experience in some degree the same emotion," even though only for "thirty seconds," as "in all the hat shops and tailors' shops strangers looked at each other and thought of the dead; of the flag; of Empire" (19). This universally fixed attention on the motor car is preserved until the aeroplane appears, at which point "Every one looked up" (22): the attention of the crowd is shifted from the question "Whose face was it?" (15) to another question, "what word was it writing?" (23). As Gillian Beer emphasises, "Each person reads the plane's message differently," but "The message does not matter; the communal act of sky-gazing does" (161). Both incidents involve the formation of a psychological crowd as defined by McDougall, but interestingly, despite her inclusion in the first psychological crowd, Mrs Dalloway herself remains separate from the second, asking Lucy on her arrival back home not what word the aeroplane has written, but "What are *they* looking at?" (31) [my emphasis].

While *Mrs Dalloway* presents us with a number of examples of the formation of a psychological crowd, *Night and Day*, published one year before McDougall's study in 1919, provides instead a repeated focus on what McDougall calls the "mass of human beings." Towards the end of this novel, Katharine seeks Ralph among the rush-hour commuters around Lincoln's Inn Fields, picturing the crowd as "tend[ing] the enormous rush of the current – the great flow, the deep stream, the unquenchable tide" (374). Despite the sense here that everyone is moving in the same direction, there is no indication that the individuals within this crowd are pursuing anything other than their own ends; indeed, it is Katharine's pursuit of *her* own ends that forces these other individuals to appear, both for her and for the reader, as "two currents" (374): "More and more plainly did she see him [Ralph]; and more and more did he seem to her unlike any one else" (375). In a more chaotic version of a similar scene, although one in which reference is still made to "Streams of people," the protagonist of *Orlando* (1928) is confronted by the confusing multiplicity of the streets of London:

She looked anxiously at people's faces. But that confused her still more. Here would come by a man sunk in despair, muttering to himself as if he knew some terrible sorrow. Past him would nudge a fat, jolly-faced fellow, shouldering his way along as if it were a festival for all the world. Indeed, she came to the conclusion that there was neither rhyme nor reason in any of it. Each man and each woman was bent on his own affairs. And where was she to go? (191)

This scene provides a particularly clear example of McDougall's non-psychological crowd, and the verbal similarity between Woolf's penultimate sentence above and

McDougall's phrase "each of them is bent upon his own task" is surely significant; whether Woolf knew McDougall's work directly is unknown, although she did engage with other contemporary texts on crowd psychology.

It is interesting to note that these two different ways of approaching and representing the crowd, either as a "mass of human beings" or as a psychological crowd, seem to be mirrored in Perrin's explanation of the difference between Brownian motion and other particulate movement, in this case that of dust:

It is easy to see that the neighbouring dust-particles move in general in the same sense, roughly tracing out the form of the common current which bears them along, whereas the most striking feature of the Brownian movement is the absolute independence of the displacements of neighbouring particles, so near together that they pass by one another. (*Brownian Movement* 5)

Brownian particles thus resemble McDougall's non-psychological crowd, in which the individual "is bent upon his own task, pursues his own ends, paying little or no regard to those about him," much like Katharine in *Night and Day*. In contrast, individuals in a psychological crowd behave, in Le Bon's words, like "a grain of sand amid other grains of sand, which the wind stirs up at will" (13); they respond collectively to the same stimulus, as do the characters united in moments of visual spectacle and speculation in *Mrs Dalloway*.

While the apparent parallel between Perrin's writings on Brownian motion and the writings of crowd psychologists like McDougall and Le Bon may be no more than coincidence, the emerging discipline of crowd psychology certainly did make use of scientific ideas, language and analogies. It is worth noting before considering such examples, however, that there was already a precedent for the use of physical, scientific language in the depiction of crowds. Peter Nicholls has drawn attention to an insightful scientific image of the crowd, and an "increasingly popular metaphor" (16), in a paper by John Ruskin on "The Study of Architecture in Our Schools" which Ruskin read to the Royal Institute of British Architects in 1865: Ruskin envisages the crowd as "a tormented mob" in which "every creature is only one atom in a drift of human dust, and current of interchanging particles" (24). Such an image may remind us of Le Bon's "grain of sand amid other grains of sand, which the wind stirs up at will," but with its vocabulary of atoms in relation to particles and currents it is clearly possible to suggest a scientific link here, especially via the consideration that, according to Perrin, many early observers of Brownian motion "thought it analogous to the movement of the dust particles" (*Brownian Movement* 3). Friedrich Engels had also described modern urban life as "the world of atoms" in the 1840s (37), while the journalist W. E. Adams published his *Memoirs of a Social Atom* in 1903, stressing his choice of term as indicating his "insignificance" and describing himself as "a small speck on the surface of society" (xiii).

In the foundational texts of crowd psychology, scientific discourse is employed in a slightly different way and with a somewhat different purpose; that of legitimising the new discipline as scientific, as Deborah Parsons explains: "To emphasise the role of crowd psychology as a 'scientific' discipline, theorists employed terminology from other discourses such as medicine and evolutionary science" (44). Such examples are easy to find, especially in Le Bon's writing: for example, Le Bon describes how "the cells which constitute a living body form by their reunion a new being which displays characteristics very different from those possessed by each of

the cells singly" in order to explain that the individuals in a psychological crowd present new characteristics simply by being joined in a crowd (6). Likewise, in *Instincts of the Herd in Peace and War* (1916), Wilfred Trotter describes the socialised gregariousness of the hive as "like a new creature," adding that "The hive and the ant's nest stand to the flock and the pack as the fully organised multicellular animal stands to the primitive zoogloea which is its forerunner" (166-7). Alternatively, returning to Le Bon, the same idea can be explained with recourse to chemistry, where "certain elements, when brought into contact – bases and acids, for example – combine to form a new body possessing properties quite different from those of the bodies that have served to form it" (7). Examples of this kind suggest that crowd psychologists found in previous scientific work both inspiration for their own ideas and a means by which to reinforce and legitimise them when making them public.

While the employment of scientific language and imagery as a means of implying scientific validity for a new discipline is perhaps not surprising, it is noteworthy that scientific explanations of molecular movements at the turn of the century often drew on images and models of human crowds. Maxwell himself used such an image in his 1873 lecture on "Molecules" in order to describe the difference between diffusion in a gas and in a liquid:

In a liquid the diffusion of motion from one molecule to another takes place much more rapidly than the diffusion of the molecules themselves, for the same reason that it is more expeditious in a dense crowd to pass on a letter from hand to hand than to give it to a special messenger to work his way through the crowd. (439)

Similarly, Karl Pearson used the notion of the crowd as a means of explaining the discontinuous nature of matter in *The Grammar of Science* (1892):

A crowd of human beings seen from a great height may look like a turbulent fluid in motion at every point. But we know from experience that this motion is only possible because there is some void in the crowd. It may become so densely packed that motion is no longer practicable. Thus it is with that relative motion of the parts of bodies upon which so much of modern physics depends; absolutely close packing, that is continuity, seems to render it impossible. (202)

Metaphors of this kind provide scientists like Maxwell and Pearson with a rhetorical device with which to help their readers to understand and visualise the scientific theories under discussion, but they also, as in the examples of scientific imagery in crowd psychology, provide a means of persuading readers of the validity of these theories, in this case legitimising scientific ideas through reference to everyday experiences.

There is one further implication to consider here as part of the expanding interdisciplinary matrix, however: images of the crowd, familiar to both scientists and readers alike, suggest that such everyday experiences may themselves have influenced contemporary approaches to specific scientific questions; after all, as Bodanis writes, when formulating a scientific theory "what better place to get fresh ideas than to just look around you?" (18). Bodanis's exploration of the relationship between scientific ideas and social context focuses on Louis Pasteur: "The language of Pasteur and

conservatives generally against the masses of the people was almost exactly like the language Pasteur had developed to use against bacteria" (17). While Bodanis seems to be suggesting that Pasteur's science influenced his social analysis, he later reverses this apparent precedence by explaining that Pasteur's "fear of the mob" may in fact have come first (17): Bodanis draws attention to the extreme population growth which we have already considered, before stating that "One would not need to have been M. Pasteur to be attuned to swarming masses with that going on" (20-21). This article's explorations of Maxwell and other physicists, Le Bon and other crowd psychologists, and modernist writers like Woolf serve to emphasise Bodanis's point, and marks a return to Hayles's idea that "Different disciplines are drawn to similar problems because the concerns underlying them are highly charged within a prevailing cultural context" (xi).

While models which focus on a particular cultural context or interdisciplinary matrix are useful and important in studies which seek to work across traditional disciplinary divides, possible instances of direct influence remain relevant and should not be neglected. Woolf's direct engagement with the emerging discipline of crowd psychology can be traced through her diaries in particular, where we find her reading "Freud on Groups" in December 1939 (5: 252). The Woolfs also owned a copy of Trotter's *Instincts of the Herd* (see: *Catalogue*), which Leonard Woolf described as "exceedingly original" in his review for *The New Statesman* (327). Indeed, Leonard Woolf's statement that Trotter's "is not the ordinary beaten track of the writer on herd instinct and crowd psychology" (328) suggests the extent to which such works and ideas were familiar to both Leonard and his readers by 1916. Virginia Woolf also internalised, to some extent at least, Trotter's ideas: writing in her diary in 1917 she reports Roger Fry's "gloomy view, not of our life, but of the world's future," adding "but I think I detected the influence of Trotter & the herd, & so I distrusted him" (1: 80). However, she continues with a somewhat different tone:

Still, stepping out into Charlotte Street, where the Bloomsbury murder took place a week or two ago, & seeing a crowd swarming in the road & hearing women abuse each other & at the noise others come running with delight – all this sordidity made me think him rather likely to be right. (1: 80)

Allen McLaurin points out that in general the Bloomsbury group "interpreted the herd theory in a much more pessimistic sense than Trotter intended" (37), but even so, Trotter's ideas seem to have had a resonance for Woolf and her circle, affecting the ways in which they observed and interacted with their urban surroundings.

Perhaps unsurprisingly, Woolf's awareness of contemporary scientific ideas on molecular movements is harder to trace. However, images like those used by Maxwell and Pearson were also available in popular scientific texts which writers like Woolf are more likely to have known directly. Writing in *The Cornhill Magazine* in the early years of the twentieth century, the schoolteacher and Fellow of the Royal Society W. A. Shenstone explained the molecular make-up of a liquid in terms that are very similar to Pearson's above: "close packing would cause molecules to jostle one another, like people in a panic-stricken crowd in the street who have ceased to observe the rules of the road" ("Matter, Motion, and Molecules" 71-2). Shenstone's focus here on "a panic-stricken crowd" suggests a possible link to contemporary ideas of the crowd as a dangerous and unpredictable force, as expressed by Le Bon in particular (see: xix). In another article published during the same year, Shenstone describes liquid molecules as "like a man in a crowd, [. . .] constantly impeded by its

neighbours" ("About Solutions" 327), an image which again frames the crowd as something of a negative force. The importance for popular science writers like Shenstone of such recognisable and familiar images is emphasised in some of the ideas which he was trying to explain to his non-specialist readers: thus he describes molecules of hydrogen as "so small that about sixty million million million of them will go inside a lady's thimble," and adds that they move "not sluggishly, like dust in the air, but at the rate of seventy miles a minute, so that every molecule comes into collision with some other molecule about eighteen thousand million times in every second of its existence" ("Matter, Motion, and Molecules" 72). Such extraordinarily large numbers and such tiny particles are very difficult to imagine, so the familiar handles of a thimble, dust particles and a man in a crowd play a vital role in enabling the reader to follow the scientific ideas explored in texts of this kind.

Virginia Woolf's links to *The Cornhill Magazine*, at first through her father, Leslie Stephen, who was its editor from 1871 to 1882 (although he wrote for the magazine from 1866 to 1883) (see: Maurer), and later through her own contributions to its pages in 1908, are well known, and it is thus possible to speculate about her reading its popular science articles, of which Shenstone was the main contributor from 1903 onwards. However, Woolf (at the time still Virginia Stephen) and Shenstone (who died early in 1908) never published articles in the same issue of *The Cornhill Magazine*, thus making it impossible to say with any certainty that Woolf would have known Shenstone's work.

Like many modernist writers, Woolf uses the modern city, especially London, as the setting for a large proportion of her fictional and non-fictional texts, but even among her contemporaries Woolf seems to have a particularly clear grasp of and feel for the rhythms, movement and liveliness, what she calls the "perpetual race and disorder" (*Essays* 284), which such urban settings entail. One aspect of Woolf's portrayal of crowd and city scenes is her focus on their physical, even violent, nature: in a diary entry about walking home along Oxford Street in 1930, Woolf describes how "People fight & struggle. Knocking each other off the pavement" (*Diary* 3: 298), while more than ten years earlier, in 1918, she had written of the "jerks & spasms" of London (*Diary* 1: 95). Meanwhile, in *The Years* (1937) "People jostled and hustled and [Eleanor] quickened her pace in time with theirs" (82), while later Crosby pauses to rest before she goes on "to do battle with the crowd of shoppers in the High Street" where she will "have to shove and push, and be jostled this way and that" (222). In *Flush* (1933), on their arrival in Italy, "Flush leapt and jumped this way and that, and so did Wilson" as "They were forced on and off the pavement twenty times, to avoid a cart, a bullock, a troop of soldiers, a drove of goats" (65); and in "Abbeys and Cathedrals" (1932) the problem of sustaining a line of reasoned thought under such circumstances is emphasised as Woolf breaks off to reflect "how we jostle and skip and circumvent each other in the street, how sharply we cut corners, how nimbly we skip beneath motor cars" (*Essays* 302).

The violent and shocking aspect of early twentieth-century city life has been discussed by a number of critics, both at the time and since. Thus, commenting on the quotation from Ruskin which we have already considered, Nicholls explains that city life "was not always just a matter of 'drift', for the new pace of life in the city made the streets [. . .] a setting for violent collisions and confrontations" (16). Likewise, Walter Benjamin describes city life as "involv[ing] the individual in a series of shocks and collisions" (132), and these descriptions may well remind us of the molecular collisions at the heart of early twentieth-century discussions of both particulate movement in general and Brownian motion in particular. Similarly, Marshall Berman,

who, like Benjamin, is writing about the poetry of Charles Baudelaire, explores the "moving chaos" of the modern city street in some detail, explaining that it "lies not in the movers themselves – the individual walkers or drivers, each of whom may be pursuing the most efficient route for himself – but in their interaction, in the totality of their movements in a common space" (159). This leads to an interesting phenomenon:

In order to cross the moving chaos, he [the "man in the modern street"] must attune and adapt himself to its moves, must learn to not merely keep up with it but to stay at least a step ahead. He must become adept at *soubresauts* and *mouvements brusques*, at sudden, abrupt, jagged twists and shifts – and not only with his legs and his body, but with his mind and his sensibility as well. (Berman 159)

As such, in order to avoid the Brownian-esque collisions that the modern city threatens, Berman's modern man has to pre-empt them; yet such avoidance means that he still exhibits an equivalent spasmodic pattern of movement.

As discussed, Brownian motion is caused by the collisions of the molecules of a particular medium with the larger particles of a substance suspended within that medium. Woolf herself makes frequent reference when writing about cities and crowds to some kind of medium, most often one which is liquid in form as in "the current – the great flow, the deep stream, the unquenchable tide" in *Night and Day*, or her essay "Oxford Street Tide" (1932) which describes "the bounding, careless, remorseless tide of the street" (*Essays* 287). According to Gabriel Tarde, images involving a liquid medium "naturally come to mind every time we speak of crowds as well as publics" as both are "like streams with a poorly defined channel" (278). Similarly, Georg Simmel in "The Metropolis and Mental Life" (1903) describes the "stimulations, interests, uses of time and consciousness" of life in the metropolis as like a "stream" in which "one needs hardly to swim for oneself" (422). Interestingly in relation to Brownian motion and other examples of violent collisions, Simmel also speaks of the difficulty of maintaining one's individual personality under the "impact" of so many and such varied stimulations (422).

The idea that Brownian motion may provide a way in which to visualise, and even to understand, crowd behaviour has been suggested most directly by the historian of crowd psychology Serge Moscovici: "The crowd is filled with hundreds of incessant movements like those of particles suspended in a liquid and is perpetually milling and agitated" (274). However, although this model does seem to have some relevance to the ideas discussed here, it is important to note that it has not been elaborated fully and that, in particular, Moscovici offers no comment on the nature of the liquid medium which surrounds and influences the human particles of the crowd. It is not clear whether Moscovici means for the medium to be something abstract, what Michael Tratner calls "the social medium" (9), or whether he simply has not thought through the implications of the scientific model which he is employing here. Either way it is clear that to be of any wider use this model needs to be developed, expanded and explained, and that will be the focus of the remainder of this article.

One of Woolf's favourite images for crowd and city scenes is the item of debris being swept onwards by a stream: in *The Waves* (1931) Louis reflects "We are drawn through the booking-office on to the platform as a stream draws twigs and straws round the piers of a bridge" (21), while in *The Years* Charing Cross station is repeatedly described in similar terms, as "People on foot, people in cabs were being sucked in like straws round the piers of a bridge" (82; see also: 84, 172).³ As in

Moscovici's formulation, there is no indication as to the nature of the fluid medium here, yet it seems likely that it represents the wider, more generalised, crowd. Such an assessment is reinforced by a return to the passages from *Night and Day* already considered: Katharine pictures the crowd of commuters around her as "tend[ing] the enormous rush of the current – the great flow, the deep stream, the unquenchable tide" and as "two currents" (374), thus envisaging the crowd itself as a fluid medium.

Although, as Tarde suggests, the use of fluid metaphors to describe crowds may be seen as somewhat commonplace, Woolf's employment of such metaphors is significant due to her contrasting focus on distinct, non-fluid, individuals within the liquid medium. In *Night and Day* Katharine remains separate from the liquid crowd she perceives around her, as emphasised by Woolf's description of Katharine as a "spectator"; there is only one short moment during which Katharine is almost overwhelmed by and "absorbed" into the surrounding crowd, but in that instant her recollection of the individual figure of Ralph calls her back to herself: "Suddenly she was clutched, unwilling, from the outside, by the recollection of her purpose in coming there. She had come to find Ralph Denham" (374). Earlier in the novel, looking out of the window of an inn over the streets of Lincoln, Ralph had himself experienced a similar moment of revelation, as Katharine appeared among the crowd below which "seemed to him only a dissolving and combining pattern of black particles":

He was about to turn and ask the waiter to bring the bill, when his eye was caught by a tall figure walking quickly along the opposite pavement – a tall figure, upright, dark, and commanding, much detached from her surroundings. (193)

In both of these examples from *Night and Day* Woolf imagines an individual character as distinct and separate from a surrounding mass of other human beings. In addition, in the former example Katharine's focus on finding Ralph among the crowd enables her to see him "More and more plainly" as well as to recognise that "more and more did he seem to her unlike any one else" (375). Might it be possible, then, to approach individual fictional characters like Katharine and Ralph as if they were particles suspended in a medium like those which exhibit Brownian motion? And to what extent is this justifiable when both characters and medium ultimately consist of the same thing, that is, human beings?

In seeking to answer such questions it is worth considering an image employed by Jinny in *The Waves*: "I am going to push out into the heterogeneous crowd. I am going to be buffeted; to be flung up, and flung down, among men, like a ship on the sea" (134). In this image Jinny is the ship while the surrounding mass of the crowd, gendered specifically as male, seems to represent the sea. This description of an individual within a crowd resonates with one of the images used by Perrin to describe Brownian motion:

Direct perception of the molecules in agitation is not possible, for the same reason that the motion of the waves is not noticed by an observer at too great a distance from them. But if a ship comes in sight, he will be able to see that it is rocking, which will enable him to infer the existence of a possibly unsuspected motion of the sea's surface. (*Atoms* 83)

Like Jinny, Brownian particles are "buffeted" by the surrounding mass but, as in *The Waves*, this medium remains indistinct, visible only through its effect on the particles being observed.

In her late autobiographical piece "Sketch of the Past" (written 1939-40), Woolf discusses "the invisible presences who after all play so important a part in every life," adding "I see myself as a fish in a stream; deflected; held in place; but cannot describe the stream" (*Moments of Being* 92). Tratner has argued that the depiction of this "invisible stream" was modernism's "peculiar task," and that a character in modernist fiction "is only a phenomenon whose movements, like those of a fish, are there to reveal the action of 'the stream', the social medium" (9). While there is certainly something in this idea, Tratner's "only" is too forceful: despite the obvious importance of crowds and masses to modern literary expressions of the city, and despite the key role played by changing social forces in Woolf's works, in particular those which cover an extended period like *The Years* and *Orlando*, it is clear that within such novels individual characters remain distinct and all-important for the reader – the very titles of *Mrs Dalloway* and *Orlando* emphasise this, while even in *The Waves* the reader is able to hold on to the six individuals as distinct, at least at certain moments within the narrative. A similar conflict between the individual and the mass can be found in both investigations of Brownian motion, explained in terms of probabilities by Einstein but proved through experiments focusing on individual particles by Perrin, and crowd psychology, which has frequent recourse to the idea of a possible leader for the crowd. What matters most, then, for all these disciplines, is the relationship between the specific individual and the generalised mass.

Woolf emphasises the difference between the individual and the mass by portraying the former as distinct from and more significant than the latter. This is particularly noticeable in "Abbeys and Cathedrals" where Woolf explains that "men and women seem to have shrunk and become multitudinous and minute instead of single and substantial"; Woolf contrasts the individual figures of William Shakespeare and Ben Jonson with "a million Mr Smiths and Miss Browns," reflecting that the latter "seem too many, too minute, too like each other to have each a name, a character, a separate life of their own" (*Essays* 301), terms which may remind us of the nineteenth-century movement towards statistical representations of the masses. In contrast, the opening of *The Voyage Out* (1915) presents us with a couple in comparison with which "most people looked small," this majority being described as consisting of "small, agitated figures," an image which resonates particularly strongly with Brownian motion by portraying the individuals in question as more massive than the surrounding moving medium (3). Likewise, in *Night and Day* Ralph sees Katharine as bigger than the crowds massing around her, reflecting that she "look[s] as if the scurrying crowd impeded her, and her direction were different from theirs" (106). At moments like this the individuality of a character is defined in contrast to the generalised, indistinguishable mass: the undifferentiated medium facilitates the recognition of the uniqueness of the individual, for themselves, for other characters and for the reader. Indeed, the medium is almost exclusively significant in the passages from *Night and Day* for the way in which they privilege Katharine and Ralph as individuals. As such, both Katharine and Ralph remain more significant than the crowd which surrounds them within their urban settings, even though they still seem to remain subject in some way to the influences and effects of this surrounding medium.⁴

One final image from *Night and Day* may serve to emphasise this point particularly clearly: Katharine, reflecting on the relationships between herself, Ralph, Mary, William and Cassandra, describes this set of individuals as “the lantern-bearers, whose lights, scattered among the crowd, wove a pattern, dissolving, joining, meeting again in combination” (266). There is no suggestion in this passage that the crowd plays a direct part in the movements of the novel's protagonists – the crowd, indeed, remains indistinct, and undefined here – yet in light of the ideas of Brownian motion this passage suggests the place of these “lantern-bearers” within the wider medium of the crowd from which they can never escape. Such an interpretation is aided by a consideration of Perrin's diagram (Fig. 1.), a pattern which represents something very similar to that which Woolf is describing above.

The question of the relationship between the individual and the mass was an urgent one in the early twentieth century, provoked at least in part by a rapidly expanding and organised population and increasing urbanisation. The question manifested itself in a turn towards statistical measures and the development of crowd psychology, as well as in the depiction of urban masses in literary works alongside an ongoing focus on individual characters. As parts of the contemporary interdisciplinary matrix and prevailing cultural context, molecular physics, crowd psychology and modernist literature were each drawn to tackle this question from their own disciplinary standpoints. Moreover, each discipline interacted with the approaches of the others, either directly as in Maxwell's use of social statistics, or more generally as in the adoption of scientific discourse into crowd psychology. By considering these different disciplines together, it is possible to recover a sense of how the concerns underlying the problem of large masses were actually experienced at the time. Such work involves the reconstruction of a particular period's interdisciplinary matrix, or at least specific section parts of it, a task which is the central challenge, as well as the great reward, of all interdisciplinary work.

Notes

1. It is worth noting that Einstein expressed some reservations as to whether the movement he discussed in his 1905 paper was actually Brownian motion (123).

2. In a more recent further development in this disciplinary interplay, the current study of crowd dynamics uses approaches drawn from statistical physics in order to model the crowd as "a many-particle system" (Schadschneider 22).

3. This image may have been suggested to Woolf by Desmond MacCarthy's dedicatory letter to Roger Fry in the first English translation of Jules Romains's *The Death of a Nobody*: "Individuality – character, the very pivot on which the art of the novelist has turned hitherto, is here made of no account. Individuals are as of little importance as wisps of straw riding down a river in flood-time, melting and dissolving as they pass, one straw going this way, one that" (vi-vii).

4. I have discussed elsewhere the relevance of these ideas to the figure of the flâneur in modernist literature, as well as the role of apparent fluctuations in fictional crowds (Crossland 257-66).

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Science and Fiction in Zadie Smith's *White Teeth*

Josie Gill

In 1943, long before his intervention in the two cultures controversy between C.P. Snow and F.R. Leavis, Lionel Trilling published an essay on E.M. Forster's first novel *Where Angels Fear to Tread* in which he offered a comparison of the methods of the scientist and the writer of fiction. In defence of Forster's melodramatic plots, from which, Trilling suggests, "contemporary taste draws back, insisting that life is not like that," he writes that

Plot is to the novelist what experiment is to the scientist, which is exactly what Zola did not know when he wrote his essay "The Experimental Novel"; Zola's defense of scientific naturalism in fiction has nothing at all to do with experiment. The science he had in mind as analogous to novel writing was medicine as practised by the great physician Claude Bernard; that is to say he had in mind an empirical, not an experimental science. And Zola's novelistic 'science' was a science of observation, and precisely not of experiment. He condemned plot as artificial, but experiment is artificial too – nature does not exist in test-tubes and retorts and under controlled conditions, and to conclude that what happens in the laboratory is what happens in the universe requires a leap of the imagination. But experiment, with its artificiality, is our best way of making things act so that we can learn about their nature. And plot in the novel does the same for human nature. (65)

Interviewed in 2002 about her short story *The Trials of Finch*, Zadie Smith refers to Trilling's scientific analogy as she reflects on the construction of character and plot in her own writing, coming to a similar defence of artificiality:

Real character gives itself away, I think, in the quiet moments, and, for me, it's a great effort to write the quieter bits, to not always explicate through plot. The objection, again, with Finch was this: life is not like that! But I'm still not sure what's meant by that idea. That's sort of why I'm studying the novel again. I do believe in the uses of plot – Lionel Trilling talked about it as a sort of laboratory of ideas. What happens in a lab is an artificiality that sets us up for an experience of the world. The scientist begins with a thesis he wants in some way to prove – he may not get the results he expects, but his experiment is tangential to the world, it has a place there. I think the intention is the same in fiction. ("Dreaming up Finch")

It seems likely that Smith came to Trilling's essay through her self-professed "love" of E.M. Forster, "to whom" she has stated, "all my fiction is indebted" ("Acknowledgements"). Smith has written of and, similarly to Trilling, defended Forster's melodrama, recognising its influence on her own work.¹ Following the publication of her first novel, *White Teeth* (2000), Smith was criticised for the artificiality of her style: James Wood branded the novel part of an emerging genre

which he dubbed "hysterical realism," novels characterised by improbable plots in which novelists "clothe real people who could never actually endure the stories that happen to them" ("Human, All Too Inhuman"). For Wood – espousing the kind of objection to melodrama that Trilling identifies – "they are stories which defy the laws of persuasion" ("Human, All Too Inhuman"). Smith's reflections, via Trilling, on the use of plot suggest that the 'artificial' elements of her writing are strategic and considered, rather than indicative of the out of control postmodernism that Wood considers them to be. However, what interests this article is Smith's use of scientific comparison as a means of justifying her literary craft. For what might otherwise appear as a convenient analogy takes on a more complex dimension when placed in the context of Smith's exploration of science in *White Teeth*.

This article argues that Smith interrogates the relationship between science and fiction in *White Teeth*, drawing on a Forsterian comic mode in her representation of genetics which ultimately reveals common ground between science and writing. Smith's tale of three London families, the Joneses, the Iqbals and the Chalfens, whose socially and ethnically varied backgrounds form the basis of their comic interactions, takes the new genetic science as one of its major themes: Marcus, head of the Chalfen family, is a geneticist whose experimental FutureMouse© has been designed to develop cancer and eventually die at a predetermined time - New Year's Eve 1999.² The development of his science has been possible only through the work of his predecessor and mentor Dr Perret, who is revealed to be the Nazi racial scientist who Archie Jones and Samad Iqbal had encountered during the Second World War, as Smith uncovers the often obscured connections between genetics past and present, offering what Ashley Dawson identifies as a "powerful qualification of optimistic readings of the novel forms that biopower is assuming today" (151). Yet the comic form that the novel takes – the Forsterian coincidence, irrationality, humour, melodrama and 'artificiality' through which Smith portrays science and scientists – enables Smith's engagement with science to move beyond an "inquiry into the recent past of genetic engineering" (McMann 619). *White Teeth* not only illuminates the narrative and fictional aspects of contemporary genetics, but also offers a metafictional consideration, in an extension of Trilling's analogy, of how the science it addresses might also inform the novel's construction. In so doing, Smith defends not only the novel's 'artificial' plot, but the capacity of fiction to explore and to represent science in the twenty-first century.

There has been a critical tendency to overlook the comic form of *White Teeth*, despite the fact that it was the novel's comedy which was arguably responsible for its almost instant popularity. The novel's back cover attests to the fact that Smith's humour was celebrated (and marketed) above all else: reviewers described the novel as "funny, generous, big-hearted," "swooping, funny," "relentlessly funny," "hilarious," "extremely funny" (Smith, *White Teeth*). However literary critics have focused more on articulating the postcolonial themes of the novel, on Smith's portrayal of race relations in late twentieth century London and of the inevitable hybridity and cultural mixing which the presence of immigrant populations has brought about (see: Thompson; Head; Walters). Where the novel's comedy is commented upon, it is interpreted as a tactical strategy through which Smith avoids being overtly political: for Claire Squires the comic deflation which characterises Smith's portrayals of racism works to show that racism is out-of-date (38), while for Susie Thomas, Smith's comic mode more problematically evades painful questions about race and multiculturalism ("Zadie Smith's False Teeth").

Yet Smith's comic style does not consist simply of the whimsical, the lighthearted or even the funny treatment of her subjects. Instead, it is the product of her emulation of the characteristics of the Forsterian comic novel, of which she has both written and spoken extensively. Asked in an interview about what appeals to her in Forster's work, Smith stated that "Forster represents one of the earliest loves of my reading life and the first intimations I ever had of the power and beauty of this funny, artificial little construction, the novel" ("A Conversation with Zadie Smith"). Smith identifies two characteristics of the Forsterian comic novel which have influenced her writing; the "artificial" (already touched upon, and of which more shortly) and, related to this, the "funny," which is characterised, for Smith, not only by humour but by the peculiarity, inconsistency and muddle of the human condition. She writes that:

There is a lot in Forster that fails, is both cloying and banal: his Pantheism, his fetish for the exotic, his idealisation of music. The mystic will occasionally look the fool. Forster took a risk, opening the comic novel to let in the things it was not designed for; small patches of purple prose were the result. But Forster's innovation remains: he allowed the English comic novel the possibility of a spiritual and bodily life, not simply to exist as an exquisitely worked game of social ethics but as a messy human concoction. He expanded the comic novel's ethical space (while unbalancing its moral certainties) simply by letting more of life in. ("Love, actually")

For Smith, Forster's strength lies in the fact that he "suggested there might be some ethical advantage in not always pursuing a perfect and unyielding rationality," and that he "wanted his people to be in a muddle: his was a study of the emotional, erratic and unreasonable in human life" ("Love, actually").

The influence of this Forsterian comic muddle on *White Teeth* is clear: from Samad's decision to send one of his twin sons to Bangladesh to remove him from the "corruption" (190) of English culture in response to his own affair with the twins' teacher Poppy Burt-Jones, to Archie's coin tossing to decide whether or not to commit suicide or whether to shoot Dr Perret, or Irie's decision to sleep with both twin brothers Magid and Millat within hours of each other, the novel is full of people who behave in emotional, unreasonable and funny ways. However it is arguably in her portrayal of science, and of her characters' interactions with it, that Smith's own "messy human concoction" is fully realised. For while Smith explores the implications of contemporary genetics through her depiction of Marcus's science, offering a "timely warning that the history of 'race' is by no means over" through an elucidation of the "closely interwoven utopian and dystopian potentials of the new biotechnologies" (Dawson 152, 172), she does so in a comic mode in which science is subject to the irrational and misguided interpretations of the novel's characters.

Smith makes popular misunderstandings about genetics part of the comic fabric of the novel, depicting the ways in which Marcus's genetic ideas infiltrate the thoughts of the other characters, where they become muddled and confused. Alsana's nightmare vision of the "dissolution, *disappearance*" that the immigrant fears is expressed through her comic misunderstanding of the process of genetic inheritance, her anxieties about the behaviour of her children merging with broader, cultural anxieties about the meaning of genetics:

Even the unflappable Alsana Iqbal would regularly wake up in a puddle of her own sweat after a night visited by visions of Millat (genetically BB;

where B stands for Bengali-ness) marrying someone called Sarah (aa where 'a' stands for Aryan), resulting in a child called Michael (Ba), who in turn marries somebody called Lucy (aa), leaving Alsana with a legacy of unrecognizable great-grandchildren (Aaaaaaa!), their Bengali-ness thoroughly diluted, genotype hidden by phenotype. (327)

Cultural, racial and genetic forms of inheritance become conflated in a kind of reductionism that Judith Roof has identified as characterizing popular understandings of DNA: "When we imagine genes as agents, they become literal representatives of our bodies, our wills, and our desires. We become our genes and our genes become us, so that we imagine that we, too, somehow survive from generation to generation" (Roof 149). Millat's attempt to shoot Dr Perret at the end of the novel comically becomes a mission determined by his genetic inheritance from his revolutionary great-great-grandfather Mangal Pande; "His is an imperative secreted in the genes and the cold steel inside his pocket is the answer to a claim made on him long ago. He's a Pandey deep down. And there's mutiny in his blood" (525). The genes become the ultimate carriers of historical meaning, history is "made to appear materially in the present, carried with us always [. . .] We are what we are because they were who they were" (Roof 201). Patterns of behaviour are repeated from generation to generation, the past lives on in the present, through the genes. Thus Samad's "sins" – his affair with Poppy – will be passed on to his sons "stored up in the genes" (161), while the Chalfens comically consider the success of their extended family in terms of the "*good genes* which were so often referred to" (314). In an analysis of film comedies about science, Roof suggests that "science comedies take over and amplify cultural beliefs as part of their generic working. Popular misconceptions about science become part of the stuff of the comedy so that comedies are much more symptomatic readings of myth than more 'serious,' or even fantasy, genres might be" (17). Such an amplification of cultural belief is evident in the comic misconceptions of genetics presented in *White Teeth*: making science the stuff of comedy and, specifically, the stuff of the comic novel, Smith uncovers the myths about genetics which circulate in contemporary culture.

Yet the novel suggests that science itself is part of the human muddle and mocks the attempts of scientists to extricate themselves from the unreasonable and irrational human behaviour which contributes to such popular misinterpretations of their science. Marcus, explaining his FutureMouse© experiment to Irie, emphasises the precision, predictability and rationality of his science, everything that the novel's muddled and impassioned characters are not: "if you *re-engineer* the actual genome, so that *specific* cancers are expressed in *specific* tissues at *predetermined* times in the mouse's development, then you're no longer dealing with the *random*. You're *eliminating* the random actions of a mutagen" (340). However, no amount of explaining can prevent the public's misunderstanding of his work. Waiting for Magid at the airport Marcus encounters an Asian girl reading his popular science book, whose interpretation of his science, "where are we going here? Millions of blonds with blue eyes? Mail order babies? I mean, if you're Indian like me you've got something to worry about, yeah?" (418) leaves him bemused;

It was exhausting just to listen to her. Nowhere in the book did Marcus even touch upon human eugenics – it wasn't his field, and he had no particular interest in it. And yet this girl had managed to read a book almost entirely concerned with the more prosaic developments in recombinant DNA – gene

therapy, proteins to dissolve blood clots, the cloning of insulin – and emerge from it full of the usual neo-fascist tabloid fantasies. (418-419)

What might otherwise be a sympathetic portrait of a scientist struggling to communicate the truth of his science is undermined, however, by the fact that in his desire for a straightforward and rational understanding of his science, a desire reflected in the design brief for the "white/chrome/pure/plain [. . .] uncontaminated cavity" (518) of the Perret Institute, Marcus has ignored the truth of his science's history; the fact that his work on FutureMouse© is the direct result of the racial scientific research of the Nazis. Dr Perret's photograph hangs on Marcus's wall alongside those of Watson and Crick, and at the launch of FutureMouse© at the Perret Institute, Marcus describes his mentor as "elemental and inspirational. Not only is he a personal inspiration, but he laid the foundations for so much of this work" (531). The racial aspects of Perret's science have become obscured in the present, their trace to be found only in small details, in the fact that FutureMouse© is programmed to lose its pigmentation and turn from brown to white, and in the ironically blank yet racialised space of the Perret Institute, which is "pared down, sterilised, made new every day by a Nigerian cleaning lady with an industrial Hoover and guarded through the night by Mr DeWinter, a Polish nightwatchman" (518). Science, Smith suggests, cannot exist in an empty, purified space, separate from the complexities and entanglements of its history; it is, unavoidably, part of the popular interpretations the public attribute to it, part of the unreasonable in human life that the comic novel strives to represent.

The implications of this stance are not lost on Smith. Making scientific rationality and truth the stuff of comedy and demonstrating that the 'irrationality' of science is something which literature is in position to uncover, the novel presents what could be deemed a typically literary or deconstructive view of science, of the kind objected to by scientists during the culture wars of the 1990s.³ Smith tackles this issue head on by satirizing the incomprehension of scientists toward literary studies of their work and thus self-consciously addressing the status of her own novel as a literary representation of scientific endeavour. Marcus consistently identifies literature as the antithesis of scientific rationality and reason, the Chalfens espousing a traditional belief in 'the truth' which, for them, is the opposite of humanistic study:

If you were arguing with a Chalfen, trying to put a case for these strange French men who think truth is a function of language, or that history is interpretive and science metaphorical, the Chalfen in question would hear you out quietly, then wave his hand, dismissive, feeling no need to dignify such bunkum with a retort. Truth was truth to a Chalfen. (312)

For Marcus, science and fiction have little to say to each other, "science and science fiction were like ships in the night, passing each other in the fog" (417). His popular science collaboration with the novelist Surrey T. Banks is a "split level high/low culture book, whereby Marcus wrote a 'hard science' chapter on one particular development in genetics and then the novelist wrote a twin chapter exploring these ideas from a futuristic, fictional, what-if-this-led-to-this point of view, and so on for eight chapters each," motivated purely by "pecuniary reasons" (416). Factual, high-culture science is pitted against fiction, which is culturally "low," as Smith pokes fun at both Marcus's polarised view of the two cultures and her own portrayal of genetics, as the novel itself becomes the target of Marcus's objection to the "great ocean of idiots, conspiracists, religious lunatics, presumptuous novelists, animal-rights activists,

students of politics, and all the other breeds of fundamentalists who professed strange objections to his life's work." (417-418). Perhaps anticipating a criticism of the novel that never actually materialised,⁴ Smith acknowledges the limitations of novelists' attempts to represent complex scientific ideas, something of which she was conscious when writing the novel: Christina Patterson, interviewing Smith, reports that Smith "read one 'incredibly boring' book about onco-mice and cancer genes in mice and talked to 'a lot of bright friends' in order to write the scientific stuff, but is still, with characteristic modesty, convinced that the science in the book is 'incredibly bad'"(9).

Yet the novel demonstrates that its own literary, comic representation of science has value by showing that, contrary to Marcus's view, science has similarities with fiction, and the novel's inevitable representation of partial, plural and multiple truths about science simply reflects the fact that science itself consists of both the truthful and the fictional. Smith thus rejects the idea put forward by Magid when he writes to Marcus, that "when you delve into the mysteries of inherited characteristics, surely you go straight to the soul of the human condition as dramatically and fundamentally as any poet, except you are armed with something essential the poet does not have: the truth" (366). Smith would not disagree with Magid's characterization of the literary as being inaccessible to a singular truth: she has written of writers' ability to "speak simultaneous truths" ("Speaking in Tongues" 145),⁵ and has said that the aim of her writing is "truth without generalization, without cliché, and without simplification — which is almost impossible. But that's the nice thing about the novel. The aim is way out of everybody's reach, so you keep on writing them just in case" ("A Writer's Truth"). Indeed the status of writing as a source of 'the truth' is questioned everywhere in *White Teeth*: Irie, "sick of never getting the whole truth" (379) turns to her grandmother's schoolbooks from Jamaica to try to discover the truth of her heritage, but the colonial books she reads — "*Dominica: Hints and Notes to Intending Settlers*" and "*In Sugar Cane Land*" — give her a false picture of "dashing Capt. Durham" (400), the Englishman who impregnated her great-grandmother Ambrosia Bowden. The history of Glenard Oak School is reconstructed inaccurately through a booklet written by the PTA, who decide to remember the school's founder, Edmund Glenard — the English colonialist who tried to rape Ambrosia — as "their kindly Victorian benefactor" (303). Samad is incensed by the way historians have written of his great-grandfather as a drunkard rather than a revolutionary, "the truth mutating, bending, receding" (255).

Smith demonstrates, however, that this might also be a description of science, which frequently takes narrative and fictional forms that disrupt any straightforward access it may claim to 'the truth'. Marcus ironically recognises the slippery nature of narrative as a source of 'the truth' when he dismisses the Iqbals' history, "'A great revolutionary. So I've heard. I wouldn't take any of that seriously, if I were you. One part truth and three parts fiction in that family, I fancy'" (339), yet is unable to recognise that his science is also part truth and part fiction. The boundaries between science and fiction are certainly more porous than Marcus is willing to admit: when Irie reads the FutureMouse© press release to a journalist, "Though she had repeated the words many times, they still seemed fantastical, absurd — fiction on the wings of fantasy — with more of a dash of Surrey T. Banks in them" (431). The communication of science to the public relies on the use of narrative, but this imaginative strain also becomes part of the science itself. Marcus inadvertently hints at this when he contradicts his earlier assertion about science fiction when introducing Dr Perret, whom he describes as "pushing the envelope, when work in this area was seriously underfunded and looked to remain in the realms of science fiction" (531). However it

is through FutureMouse© itself that his science becomes fiction: the hyperbolic promotion of FutureMouse© means that it becomes, in the public's eyes, a version of the cartoon character Danger Mouse, the mouse is a "*cartoon of an idea*" where "one expected the damn mouse to stand up and speak by itself" (431). Roof has argued that "representations of science render scientific facts less 'true' (or more culturally relative) while the figures of their representation become scientifically operative" (23). This is a paradox which *White Teeth* goes some way to uncovering: the science behind FutureMouse© is elided by the mouse itself, the mouse transformed into a fiction, which then becomes a kind of truth, as the novel ends with FutureMouse© escaping, Danger Mouse style, from its display case at the Perret Institute.

Suggesting points of similarity between Marcus' genetics and the fictional, Smith not only offers a comment on what happens to science in culture, on the two way traffic (to borrow Beer's phrase) between science and the representation of science, but also draws attention to the relationship between the novel itself and the science which it represents. If the comic novel conveys a Forsterian "messy human concoction" ("Love, actually") it does so, for Smith, through its portrayal of irrational, messy characters and, in the case of *White Teeth*, the entanglement of those characters with an equally unreasonable science. However the comic novel is also characterised by its artificial form: writing of Forster's muddled characters, Smith states that "what interests me is that his narrative structure is muddled also; impulsive, meandering, irrational, which seeming faults lead him on to two further problematics: mawkishness and melodrama" ("Love, actually"). As the introduction suggested, both Smith and Trilling recognise that Forster's plots, which consist of "all the old devices of recognition scenes, secrets, letters that prove something, stolen babies, destroyed wills, long-lost brothers, hidden sins, shocking revelations and even physical conflict" (Trilling 65), tend to melodrama, leaving his writing open to the charge of artificiality. Yet such artificiality of plot is justified, and has value, because it is the novelist's way of examining human nature, "of making things act so that we can learn about their nature" (Trilling 65), in the manner of a scientist. Trilling's comparison between scientific experiment and novelistic plot is a means of defending Forster's art but in *White Teeth* it becomes a means for Smith to further interrogate the relationship between science and the (comic) novel. For while Smith considers the ways in which science is like fiction, she also imagines how fiction is like science.

The artificiality and melodrama of the plot of *White Teeth* cannot be disputed. James Wood incredibly summarises what is arguably the novel's most melodramatic point – its ending – thus, "*White Teeth* ends with a clashing finale, in which all the novel's characters – most of whom are now dispersed between various cults and fanatical religious groups – head toward the press conference which the scientist, Marcus Chalfen, is delivering in London, to announce the successful cloning of his mouse" ("Human, All Too Inhuman"). The finale connects all of the novel's groups and characters together improbably in the same place, to which Smith adds the shocking revelations, recognition scenes and physical conflict of the Forsterian novel: Archie recognises Dr Perret as the Dr Sick whom he failed to kill during the war, Samad realises Archie's lie, Millat tries to shoot Dr Perret and FutureMouse© escapes. The muddle is complete, resolved with further, unresolvable muddle: it is unclear to the authorities which twin is responsible for the shooting, while it is also unclear which is the father of Irie's baby, a plot device too far for Wood; "Near the end of *White Teeth*, one of the characters, Irie Jones, has sex with one of the twins, called Millat; but then rushes round to see the other twin, called Magid, to have sex with him only moments after. She becomes pregnant; and she will never know which

twin impregnated her. But it is really Smith's hot plot which has had its way with her" ("Human, All Too Inhuman").

However Smith's "hot plot," like Forster's "hot melodrama" (Trilling 65) is more controlled than Wood imagines it to be. Smith self-consciously turns her plot into part of the experiment around which it revolves. In a kind of literalisation of Trilling's analogy, Smith imagines the manoeuvring of her characters through plot as a scientific experiment, inviting the reader to recognise the novel as a fiction, as artificially constructed and contrived as Marcus's FutureMouse©. Smith gestures towards this at various points in *White Teeth* where the novel's fictive, constructed nature is made explicit. For example, when Irie is employed by Marcus to organise his filing cabinet, and is arranging the letters between Marcus and Magid she "split the filing system in two, choosing to file by author primarily, then chronologically, rather than let simple dates rule the roost. Because this was all about people. People making a connection across continents, across seas" (365). This is how Smith has structured each of the novel's four sections – by character and date, two dates for each section: Archie 1974, 1945; Samad 1984, 1857; Irie 1990, 1907; Magid, Millat and Marcus 1992, 1999. That the novel is organised in the same way as Marcus's filing cabinet is funny, but it also draws attention to the possibility of an experimental exchange between what science does and what the novel does, an idea Smith develops more fully at the novel's end, where she imagines, in the manner of a scientist or social scientist, how people would react to the scene at the Perret Institute. Although initially referring to the imaginary "focus group" which has chosen the décor of the institute, the people Smith imagines as wanting to know about different strands of the plot become her readers, as Smith reveals how they too have been subject to the novel's experiment:

And there is surely a demographic pattern to all those who wish to see the eyewitness statements that identified Magid as many times as Millat [. . .] And it is young professional women aged eighteen to thirty-two who would like a snapshot seven years hence of Irie, Joshua and Hortense sitting by a Caribbean sea [. . .] And it could be that it is largely the criminal class and the elderly who find themselves wanting to make bets on the winner of a blackjack game [. . .] It would make an interesting survey (what kind would be your decision) to examine the present and divide the onlookers into two groups: those whose eyes fell upon a bleeding man, slumped across a table, and those who watched the getaway of a small brown rebel mouse (541).

The Perret Institute is transformed into a kind of laboratory in which, as with the design and engineering of FutureMouse©, there is "no question about who was pulling the strings" (489): Smith has, like a scientist in the lab, engineered the scene to see what results she gets, creating "an artificiality which sets us up for an experience of the world" ("Dreaming Up Finch").

The 'scientific' aspects of Smith's plot are also evident in the novel's emphasis on cause and effect. Marcus demonstrates complete mastery over FutureMouse© by being able to determine how and when the mouse will die; he creates "mice who year after year expressed more and more eloquently Marcus's designs [. . .] planting instructions and imperatives in the germ line to be realised in physical characteristics. Creating mice whose very bodies did exactly what Marcus told them." (312). His science is characterised by examining the consequences of actions in time, as he explains to Irie, looking at photos of the mouse with a progressively bigger tumour in

each picture, "what you really want to know is how a tumour progresses in *living tissue*" (339), "I plant a cancer and a cancer turns up precisely when I expect it" (341). Marcus's science is based on predictability and precision, on being able to determine exactly how a tumour will progress in time, a precision which the novel undermines in its emphasis on the unpredictable and the irrational. Yet it is such causality which gives structure to the novel's melodramatic plot. For Trilling, the Forsterian plot "represents the novelist's interest in causality" and "because it is concerned not only with states of being, but with consequences, gives the greatest reality to social forces" (Trilling 65, 66). Smith accords a similar importance to causality, writing that "It seems that if you put people on paper and move them through time, you cannot help but talk about ethics, because the ethical realm exists nowhere if not here: in the consequences of human actions as they unfold in time, and the multiple interpretive possibility of those actions. Narrative itself is the performance of that very procedure." ("Love, actually").

The plot of *White Teeth*, like Marcus's FutureMouse©, consists of the consequences of actions as they unfold through time: Archie, having saved Dr Sick during the Second World War, is not only destined to save him once again at the Perret Institute but his actions enable the rest of the plot to unfold in the existence of Marcus, his science and the relationship between Archie's daughter, Irie, and the Chalfen family. The consequences of Archie's coin flipping resonate throughout the novel, his predictable fate underscored by the repeated mantra that "Every moment happens twice: inside and outside, and they are two different histories" (360, 532). Of course the uncertainty of repetition, the possibility of difference in the predictably repeated which this phrase encapsulates, is what makes the novel different to Marcus's science: Marcus' concern to "eliminate the random" (341) allows no room for chance, whereas Smith recognises, as Alsana does when she understands that Magid (having been sent to Bangladesh) is more English than Millat, that "you can't plan everything" (289). An element of chance must also be factored into the plot, hence the escape of FutureMouse© at the end of the novel, and the fact that Archie's decisions rest on the toss of a coin. Trilling writes that "One thing to say is that certain kinds of unmotivated events in fiction represent what happens in life. Life is not only a matter of logic and motivation but of chance. The storyteller may – perhaps should – suggest this element of life" (Trilling 64). *White Teeth* celebrates chance, placing it in opposition to Marcus's scientific rationalism, but at the same time Smith self-consciously demonstrates that such chance is part of the artificial and constructed nature of the novel's plot and is, in this sense, comparable to the artificial experiments of the scientist (Marcus) in the laboratory.

In articulating the ways in which the novelist's engineering of plot is comparable to a scientist's engineering of a mouse, Smith moves beyond a defence of melodrama, beyond Trilling's analogy, to consider what writing about science entails, which, the novel suggests, is a degree of reciprocity: in uncovering the fictional qualities of genetics as part of her wider critique of science's claims to rationalism, objectivity and neutrality, the novelist must also reflect upon her own claims to represent human messiness, the irrational, unreasonable and uncertain. Smith demonstrates that the fictional representation of the messy human concoction requires a degree of artificiality and, by making the novel's fictive, constructed nature explicit, reminds readers that what the novel does is only another form of what science does – both are practices which artificially test and experiment with (human) nature. In this sense Smith sheds a more considered light on the genetic engineering and creation of artificial beings which have so captured the public's attention, resulting in the kinds of

fears which are comically depicted in *White Teeth*: such engineering, the novel suggests, is only another form of the artificial construction of the real that the novelist is engaged in. This move is indicative of the kind of metafictional reflex which Patricia Waugh has argued is evident in contemporary fictional explorations of science; "as science has crept increasingly onto the public agenda, the earlier metafictional energies of the novel in the 1970s have been revived and turned inwards again towards an interrogation of the relative epistemological status and value of the understanding of life, the 'stories' offered by scientists, on the one hand, and humanistic understanding on the other" ("Science and Fiction in the 1990s" 65). Reflecting on the stories told by science through an examination of its own forms of storytelling, *White Teeth* demonstrates that the contemporary novel does more than simply explore scientific ideas in the manner of Marcus's collaborator Surrey T. Banks, "from a futuristic, fictional, what-if-this-led-to-this point of view" (416). It does examine the claims, forms of representation and cultural reception of contemporary science, but also thinks through its own relationship to the science which it represents. The novel would thus seem to throw Dominic Head's claim about contemporary fictional responses to science into doubt:

The dominant transnational forces of globalization are promoted through developments in science and technology, and this has become an area of human experience that is especially difficult for the novel to register. To engage with rapid technological change, an instantaneous response is demanded, and this is beyond the capabilities of a literary form that is, rather, cumulative in its procedures of reflection and commentary. (233-234)

White Teeth not only registers the rapid developments which led to the completion of the human genome sequence in the year of its publication, exploring the cultural impact of the public prominence of genetics, but Smith demonstrates that the novel's form, far from being the cumulative commentary to science's rapidity, is a reflexive form with the capacity to suggest points of confluence between science and fiction, and to shed light on both practices at the beginning of the twenty-first century.

Notes

1. Smith states in the same interview that "I know that I tend toward melodrama and caricature" ("Dreaming up Finch").

2. The climatic denouement of the novel at the Perret Institute, where FutureMouse© is set to be revealed to the world, echoes the millennial hype surrounding the race to complete the Human Genome Project in 1999, while FutureMouse© itself is inspired by Oncomouse, a genetically modified mouse susceptible to contracting cancer which was created and patented by Harvard scientists in the 1980s.

3. Patricia Waugh provides a succinct account of how the questioning of scientific knowledge at the end of the twentieth century led to "constructivist claims that objectivity and rationality are culturally produced systems, that science cannot arrive at knowledge of a mind-independent natural reality, that its methods are always relative to shifting and heterogeneous theoretical frameworks, and that the 'objects' of scientific knowledge are therefore as 'intentional' as those of a literary text...In other words, scientific knowledge and language are no more exact than aesthetic knowledge and language." ("Revising the Two Cultures Debate" 40).

4. On the contrary, geneticist Dimitris Kioussis, reviewing the novel, claimed that "Smith has researched her subject and transferred it to paper without misinterpretations and with a remarkable accuracy and clarity for those who are not involved in or have not been taught science" and praised the novel's "flawless description of the scientific background and its potential" ("Don't Shoot the Scientist!").

5. In this case the writer Smith has in mind is Shakespeare.

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"There the Facts Are": Andrew Lang, Facts and Fantasy

Leigh Wilson

In an article on Andrew Lang from 1901, G.K. Chesterton wrote in glowing terms of the breadth and scope of Lang's works, of his interest in matters from golf to Homer, from cricket to mythology. It was the nature of Lang's interests, though, that drew Chesterton's warmest praise. Lang, he says, collects "blue china because it is blue" and catches "fish because they are fishy" (481). Chesterton ended his article on Lang with the assertion that it was Lang's peculiar focus on the specifics of each interest that created in his work the sense that "more real facts are neglected in this practical world than we shall ever know" (481). What he called Lang's "overwhelming confluence of specialities" (481) led in the end for Chesterton back to the individual fact, and the individual fact whose reality challenged and upset the dominant view of the world. This reading of Lang as obsessed with facts across disparate subjects appears in most assessments of him, both before and after his death, but for most this "confluence of specialities" indicated his weakness rather than his strength. When Lang died in 1912, and for some time after, even the most sympathetic commentators remarked on the disappointment inherent in his now completed oeuvre. Lang's great friend, the novelist Henry Rider Haggard, quotes in his autobiography, *The Days of My Life* (1926), a charge that his fellow novelist Mrs Eliza Lynn Linton made to him that "Andrew would be the greatest writer in the language if only he had something to write about." While seeing this as "rather sharp," Haggard admits that Lang "like the amorous Frenchman [. . .] has ever been wont to *éparpiller son cœur* over a hundred subjects" (1: 229). This assessment of Lang, and a consequent sidelining of his work, has been continued by more recent scholarship, despite the fact that Lang's huge body of work covers many of the areas that have been of most interest to recent scholars of the fin de siècle, particularly literary and cultural historians exploring the intersections of science and culture during the period. Lang wrote a number of books of anthropology; he wrote on folklore and fairy stories; he wrote on and translated the classics; he wrote poetry, novels and short stories; he wrote histories, literary criticism and hundreds of columns in journals and magazines on a vast range of subjects. Despite this, Lang has remained a very minor figure, a footnote. Where he is mentioned, it is often to assert his marginal position; in her history of the British tradition in early anthropology, Henrika Kuklick mentions Lang only to call him an "intellectual gadfly" (56).

Certainly the wide range of Lang's interests and topics and his often light-hearted way of dealing with them does seem to impugn that most venerated of Victorian characteristics, seriousness. However, as Chesterton's praise suggests, one repeated concern of Lang does chime with some of the central and indeed serious concerns of late Victorian culture. It is the case that, throughout his work – both his lighter, more journalistic work and the work he saw as his most serious, his anthropology – Lang privileged facts, stressed the importance of facts, and castigated others for lapses in the presentation of facts. His major challenges to the ideas of others are rooted in the supremacy of facts; "there the facts are" he says very often in conclusion (*Myth, Ritual and Religion* 1: 5). In this, Lang's work seems to fit with a question which underlies many of the debates of the second half of the nineteenth century, as science hardened its boundaries and at the same time sent its methods and

assumptions out into those areas beyond them. Across the period, at stake in so many debates, in so many developments in scientific understanding and for so many of those who resisted them, is the relation between the substance of the world, that which is experienced through the senses, and what it *means*. Work in the history and philosophy of science has done much to unravel the complex relations between science and facts, and between science and its supposed 'others' through the course of the nineteenth century, but sharp divergences are visible across this work which suggest that there is still much to be said in this area. In particular, despite attempts to see the interactions between science and its perhaps most extreme 'other' – the literary – as complex and nuanced, these relations are still the site of disagreement. In his study of the legacies of Baconian induction in nineteenth-century science, for example, Jonathan Smith, in *Fact and Feeling: Baconian Science and the Nineteenth-Century Literary Imagination* (1994), sees through the period a fundamental instability and equivocation – between ideas of scientific knowledge and the imagination, between facts and feelings – at the heart of scientific method and debate. While increasingly through the century he argues that a "naïve Baconianism" was challenged and the role of imagination and speculation in science was gradually brought to the fore, such shifts could not then help but threaten science's claims to tell the truth and so send it back to its factual basis. In discussing William Whewell's assertion that facts and theories are inseparable, Smith argues that "[t]he implication is that ultimately there is no such thing as pure facts, but such an implication would just as clearly threaten the very foundations of science's authority, its access to knowledge that is true and permanent" (21).

Smith's focus is the literary and the evidence he presents reveals the continued imbrication of the scientific and the literary. The relation between the two was an anxious back and forth in which scientists and literary writers borrowed from each other, anxiously qualified that borrowing, then denied it and asserted difference, only to be sent back through the consequences of such denials to claims of mutuality and borrowing. However, in contrast, in tracing the construction of the concept of objectivity in science through the nineteenth century in their *Objectivity* (2007), Lorraine Daston and Peter Galison, whose focus is the work of scientific image-makers, argue that towards the end of the century scientists yearned not for imagination but the "blind sight" of objectivity; an objectivity which aspired "to knowledge that bears no trace of the knower – knowledge unmarked by prejudice or skill, fantasy or judgment, wishing or striving" (17). In opposition to a vision of the nineteenth century in which a veneration of Baconian induction gave way to a deductive method that made necessary speculation and interpretation, Daston and Galison assert that:

In notable contrast to earlier views held from the Renaissance through the Enlightenment about the close analogies between artistic and scientific work, the public personas of artist and scientist polarised during this period [. . .] The scientific self of the mid-nineteenth century was perceived by contemporaries as diametrically opposed to the artistic self, just as scientific images were routinely contrasted to artistic ones. (36)

The place of facts in nineteenth-century science, and the effect of this on the relations between science and its 'others', remains a live question, then, one still inflected by our own sense of values and disciplinary boundaries.

However, it is the case that what both the examples above share, despite their difference, is the sense that facts are key, and that they are fundamental to a scientific understanding of the world. While Smith's argument shows the complex back and forth between science and the literary, facts always remain firmly on the side of science. The tenacity of such a relation between science and facts can also be seen in the famous and influential debate in the 1880s between T.H. Huxley and Matthew Arnold on the relative merits of science and the classics as a basis for education. At the core of Huxley's challenge to the privileging of the humanities, and classics in particular, is his distinction between the facts of the natural world and words. Science as a "criticism of life" is for him more powerful than its rivals in the humanities because it "appeals not to authority, nor to what anybody may have thought or said, but to nature" (226). For Huxley science is pre-eminent not through a denial of the role of the observer and of all that is outside the realm of facts, but because, despite the power of the extra-factual, science insists again and again on the return to facts. In this, what is particularly challenged is the role of language:

[Science] admits that all our interpretations of natural fact are more or less imperfect and symbolic, and bids the learner seek for truth not among words but among things. It warns us that the assertion which outstrips evidence is not only a blunder but a crime. (226-7)

In Arnold's reply to Huxley, in his Rede Lecture given at Cambridge in June 1882 and printed in *The Nineteenth Century* in the same year, this distinction between words and facts is not disputed. Arnold acknowledges the split between words and things as the basis for scientists' assertion of the pre-eminence of their discipline, and concurs with the split: "This reality of natural knowledge it is, which makes the friends of physical science contrast it, as a knowledge of things, with the humanist's knowledge, which is, say they, a knowledge of words" (222). Where Arnold differs from the assessment of the "friends" of science is that he asserts, not that this is not the case, but that it is not enough. Human beings, he says, while they like to gather interesting facts, have a desire to link these facts to "our sense for conduct, to our sense for beauty" (223). Here Arnold asserts the move toward deduction rather than induction that Jonathan Smith argues is the overall tendency of the institutions and practices of science during the century. However, in Arnold, as in the assertions of Huxley, the assumption remains that facts and the literary are quite separate and separable things, however much both are necessary.

In what follows this article will argue that Lang's obsession with facts challenges both the battle lines of his contemporaries and those of more recent readings of the period. Lang's work suggests a quite different way of reading the relation between facts and fantasy during the period. In his work, the relations between facts and fantasy are often strange and contradictory, and the overall effect is to challenge the boundaries between science and its others. They demonstrate in their contradiction and awkwardness an impossibility within science that perhaps has not always been acknowledged. Lang's obsession with facts, his resistance to occupying just one disciplinary category, his intellectual restraint in terms of making up his mind, his dilettantism, can all be seen then, not as the reasons for his failure, as so many have suggested, but as the reasons for his significance.

This article will focus on two works by Lang, *The Making of Religion* (1898) and his short story "Romance of the First Radical" (1880), to show that while Lang's work ostensibly privileges facts according to the contemporary dictates of science, his

extreme assertion of their importance and his practice of interdisciplinarity has the effect of challenging the nature and status of the 'facts' of science. In both these works an ostensible cleaving to the methods and practices of science is shot through with a remaking of facts so that they have within them effects beyond the possibilities of empiricism; indeed, so that they contain within them the fantasised world of the literary.

The Making of Religion: A Book in Two Halves

The publication of *The Making of Religion* marked a particular culmination of Lang's work in anthropology. It established him as vital to anthropological debate and in particular as crucial in his championing of anthropology as a *science*. His work in anthropology had begun in the 1860s and his first important contribution was his assertion that anthropology was a science to the extent that its evidence consisted of facts (see: *Custom and Myth* 1884); he continued to denigrate theory or speculation throughout his career (see: "Science and Superstition" 1901). Lang's challenge to the philological work of Friedrich Max Müller on the origin of myths was precisely that Müller's theories were the result of scholarly fantasy rather than a consideration of the hard facts, that indeed the philologists were concerned with words rather than things. For Lang myths should be read not through words – they are too ephemeral, not sufficiently linked to the facts of the world – but through the material conditions of "early man" and the thinking produced by them:

The truth is, that while languages differ, men (and above all early men) have the same kind of thoughts, desires, fancies, habits, institutions. It is not that in which all races formally differ – their language – but that in which all early races are astonishingly the same – their ideas, fancies, habits, desires – that causes the amazing similarity of their myths. (*Modern Mythology* xvi)

More than this, not only does a focus on language misunderstand what is crucial about early human culture, but it allows the element of fantasy to creep in. The philological scholar, fixated on names, is led to explain myths only "in accordance with his private taste, easily accommodating the facts of the myth, whatever they may be, to his favourite solution" (xvii).

However, if it is in the field of anthropology that Lang most clearly claimed to work in and to define a science, it was precisely here that, in his treatment of the role of facts in *The Making of Religion*, he resisted its nascent disciplinary etiquette and boundaries. Unlike the central anthropologists of the period, including E.B. Tylor, whom Lang saw as his model and mentor, Lang did not balk at the increasing occurrence in modern society of those beliefs and practices which anthropology studied in 'primitive' cultures. While Tylor noted the similarities between them in *Primitive Culture*, Lang wanted to go further. In his introduction to a collection of essays published on the occasion of Tylor's 75th birthday, Lang acknowledged that "Mr. Tylor's affair was to discover great numbers of ethnological parallels to the *speciosa miracula* of spiritualism, and to leave the matter there for the present" ("Edward Burnett Tylor" 8). Lang, on the other hand, did not leave it there, and in a number of places in the 1890s – in *Cock Lane and Common Sense* (1894) and in *The Making of Religion* in particular – he asserted the need for anthropology to acknowledge and take seriously the aims, methods and evidence of psychical research in the area which anthropology had previously dismissed as 'fantasy'. In a letter to

the psychical researcher Henry Sidgwick he was more forthcoming: "Of course my Psychics are very unpopular, but Tylor brought them in, and left them in, and left them hanging in air, and did little to the civilised side of them. This was hardly scientific in my opinion" (qtd. in DeMoor 94). Here Lang claims science as his authority for including the fantastical material of psychical research in his anthropology. Yet Lang's treatment of these as 'facts' in *The Making of Religion* and his linking of them to the 'facts' of the early belief in a supreme god changes the nature of facts from those accepted by mainstream science at the time.

The Making of Religion is split into two parts, the first part looking at a number of "savage beliefs" and practices which had recently resurfaced, particularly since the beginnings of modern spiritualism in the 1840s. These chapters cover clairvoyance, crystal gazing, hallucinations, possession and the use of divining rods, and point out the convergence of accounts of such practices across traditional cultures, in the European past and in contemporary Europe. The second half of the book consists of Lang's most sustained challenge to date to the prevalence of the "ghost theory" among anthropological accounts of the origins of religion. This theory was first articulated and named by Herbert Spencer, initially in an article in *The Fortnightly Review* in 1870 and then in more detail in Volume 1 of his *Principles of Sociology* (3 volumes, published between 1874 and 1896). Spencer argued that those things which seemed unaccountable and absurd in 'savage' beliefs and practices in fact show that people in early and traditional societies thought logically with the material at their disposal. He suggested that savage beliefs and practices – hallucinations, possession, the belief in the animation of the inanimate, and the belief in spirits – all had their origin in traditional people's observation of the dead and of reflections in water, and in their experience of altered states of consciousness. All of these led early people to assume that humans have a "second personality," a double, distinct from the physical body, which survives death and can travel across distance and time ("The Origins of Animal-Worship" 536-7). This ghost theory, then, provides the basis of all beliefs in non-material beings and occurrences for Spencer, and for him constitutes the origin of religious belief per se. Belief in this double and its consequences evolved, he argues, eventually into what anthropology defined as religious belief.

At around the same time as Spencer fully elaborated his theory in the *Principles of Sociology*, E.B. Tylor was arguing too in his *Primitive Culture* (1871) for a version of the ghost theory. His concept of "Animism" describes "the deep-lying doctrine of Spiritual Beings, which embodies the very essence of the Spiritualistic as opposed to Materialistic philosophy" (1: 425). Tylor asserted explicitly that animism underlay all religious belief; it is "the groundwork of the Philosophy of Religion, from that of savages to that of civilised men" (1: 426). For Tylor too the beginnings of animism were in early people's misunderstanding of dreams, abnormal states of consciousness and dead bodies (1: 428). In both Spencer and Tylor, these accounts of the origins of religious belief was set, sometimes explicitly and sometimes more implicitly, within an evolutionary model which saw "progress" from magical beliefs, through religious belief, and finally arriving at science's true view of the world (Stenski 117). For Spencer and Tylor, and later James Frazer, magical and religious beliefs were rooted in facts but in their misreading, and this only changed when science, the result of progress in human understanding, could eventually read facts correctly.

Lang's challenge to the ghost theory, which he maintained throughout the rest of his life, writing his final complete statement of it in 1908 in "Theories of the

Origins of Religion," was that it ignored a substantial body of facts which suggested that, rather than the belief in "ghosts" leading eventually to religious belief, a belief in a supreme god was among the earliest of beliefs. This challenge was to one of the cornerstones of anthropology as it constructed itself as a 'scientific' discipline in the late nineteenth century. By the 1890s the ghost theory, and variants on it, had become the orthodoxy among anthropologists, and was even taken as such by lay people, as acknowledged in Grant Allen's popularising work, where he asserts as "proved almost beyond the possibility of doubt Mr. Herbert Spencer's luminous theory of the origin of polytheism from ghost worship and ancestor worship" (489). Lang's challenge powerfully undermined the status of the theory and while he was on the whole disappointed by the reaction from his fellow British anthropologists, particularly Tylor (see: "Theories of the Origins of Religion" 120 ff.), it was later acknowledged as being responsible for "knocking another nail into the coffin of Herbert Spencer's theory of the origin of religion" (Jennings Rose 25).

Lang's anthropology in his challenge to the ghost theory pits facts against theory in a way that suggests his idea of science is one of extreme empiricism. However, this straightforward alignment of Lang and hard facts is made problematic by the first half of *The Making of Religion*. Lang asserted that the two halves of his book – one concerning the 'facts' of psychical phenomenon and the other the 'facts' of early belief in a supreme god – worked together and strengthened each other. However, that the relation between the two is problematic can be seen in the first reactions to *The Making of Religion*. Of these, one which particularly disappointed Lang was the inability of readers to see the links between its two parts, to understand, in other words, his attempts to link the 'facts' of psychical research and the 'facts' of anthropology. In his preface to the second edition of the book in 1900, Lang acknowledges that:

Thanks to this daring novelty, the book has been virtually taken as two books; anthropologists have criticised the second part, and one or two Psychical Researchers have criticised the first part; each school leaving one part severely alone. Such are the natural results of a too restricted specialism. ("Preface" viii)

Lang attempts to account for this failure to understand what he is doing at the beginning of his preface to the second edition:

By the nature of things this book falls under two divisions. The first eight chapters criticise the current anthropological theory of the origins of the belief in *spirits*. Chapters ix.-xvii., again, criticise the current anthropological theory as to how, the notion of *spirit* once attained, man arrived at the idea of a Supreme Being. These two branches of the topic are treated in most modern works concerned with the Origins of Religion, such as Mr. Tyler's "Primitive Culture," Mr. Herbert Spencer's "Principles of Sociology," Mr. Jevons's "Introduction to the History of Religion," the late Mr. Grant Allen's "Evolution of the Idea of God," and many others. Yet I have been censured for combining, in this work, the two branches of my subject; and the second part has been regarded as but faintly connected with the first. (vii)

While it is true that "most modern works" cover both areas, they do not, like Lang, consider the first area as consisting of facts but rather as evidence of the obscuring work of fantasy in both early people and contemporary spiritualists. Moreover, if we take Lang at his word and try to construct a relation between the material presented in the opening chapters of the book and the detail of his challenge to the ghost theory, Lang's position becomes more strange and difficult to rationalise according to the demarcation which locates facts firmly on the side of empirical science and as problematically related to fantasy and the fictional.

Lang's central argument in the first part of *The Making of Religion* is that beliefs about psychical phenomenon are based on verifiable facts, even if these facts are erroneously accounted for by traditional people themselves. In other words, he remains within mainstream anthropology's claim to explain facts misread by traditional peoples, but what he takes as facts are not the dead bodies and states of abnormal consciousness of Spencer's ghost theory or Tylor's animism but the psychical phenomenon of clairvoyance, divining rods, crystal gazing, and so on. In Lang, the fantasy of Spencer and Tylor becomes fact. However, this is quite different from what he says about the origins of religion. Lang is not arguing that early peoples first had an idea of a creator and 'all father' because they based their assumptions on empirically experienced facts. Indeed, it may be that the charge against Lang made at the time – that his theory implied his assertion of the truth of divine revelation – was due to reading the two parts as parallel in their deductions. Lang insisted on the error of these readings, telling fellow anthropologist R.R. Marett in a letter in 1900 that he was anxious that his theories would seem "in no way mystical" (Marett 11). Indeed, in his challenge to the ghost theory Lang is not arguing that the existence of such beliefs suggest that the existence of God is a fact. Lang does not really ever attempt to give a reason for these early beliefs in a supreme god – the "high gods of low races" as he calls them in chapter 10 of *The Making of Religion* – he rather argues on the basis that such beliefs do exist, so the ghost theory cannot be correct. He acknowledges that "existing evidence will hardly support any theory of religion" (321), but nevertheless that evidence does exist for beliefs in a supreme god *before* any idea of propitiation, ancestor worship or belief in ghosts. Lang's insistence then that traditional beliefs about psychical phenomena are based on facts, and should therefore be investigated, is not structurally the same as his challenges to the ghost theory. In the former Lang is asserting that beliefs are based on the facts of experience; in the latter only that beliefs themselves exist as facts. However, that Lang *wants* these to work together is suggestive of his sense of the nature of facts. While Lang insists on separating facts from theories, what he will not separate is facts from fantasy.

Indeed, it is this assertion of facts outside any theory that, while seeming to align Lang with the most extreme empiricism, actually returns to facts something quite different. It is the case that much of Lang's work was prompted by a dislike of totalising theories, and he resisted the assumption that facts lead to totalising theories which finish or complete knowledge, and are significant only in as much as they lead to them and prove them (see: "Science and Superstition" 1901). For Lang facts are not this; rather they are in part a marker of strangeness and unaccountability. Facts for Lang remain isolated from a coherent and cohesive meaning that would explain them. The 'facts' of psychical research and the 'facts' of early beliefs in a supreme god may not be the same kind of facts, but what they share is a salience from the world made orderly by explanation. They are unlikely, incongruous, marvellous. They are, in other words, much more like fantasy. In his challenge to Spencer, in effect Lang

contests not just the specific claims of the ghost theory, but also the desire for total theory per se, and its implicit insistence that a survey of the facts via a scientific method could lead to a full account of and explanation for something.

What does link the two parts of *The Making of Religion*, then, is an insistence that facts need to be acknowledged and taken seriously, even when their existence is problematic for the theories of scientists. Lang asserts that the 'facts' of psychical experiences and the 'facts' of early beliefs in a supreme god need to be acknowledged even though they both challenge the central orthodoxies of disciplines assumed to be 'scientific'. In other words, these facts make necessary a change in what other facts *mean*. In this, Lang would seem to take the position of a hardline empiricist, and yet, as I have suggested, the nature of his book led to it being misread as a claim for divine revelation and for an innate sense of the divine in human beings. While in both parts of the book Lang insists that certain facts, however uncomfortable, must be acknowledged – whether of the prevalence of similar accounts of crystal gazing widely across time and space or of beliefs in an 'all father' – this insistence on a recognition of facts does not fit together into one clear position for Lang. Not all 'facts' are the same and Lang's linking together of these two groups of 'facts' troubles the division between facts and fantasy, between substance and interpretation. Facts, then, no longer belong to science, even if, as Lang insists, our attitude to them must be 'scientific'.

"Romance of the First Radical": Facts and Romance

Lang's "scientific" work, then, for all it tries to assert the status of science and its privileged relation to truth, returns again and again to the imbrication of fact and fantasy. This return can be seen too in his fictional writing. In "Romance of the First Radical," (first published in *Fraser's Magazine* in 1880) while again Lang ostensibly tries to keep them apart, in the end it is fictional writing that gives us the facts. This position seems to mark Lang as in opposition to the broad trend of the century. In his work on the popularizing works of geology in the nineteenth century, Ralph O'Connor has argued that the use of literary techniques in order to reconstruct the 'fantasy' worlds of prehistory was vital in communicating the discipline's recent discoveries. What O'Connor calls "imaginative restorations" (10) were not decorative tropes, but necessary in communicating the truth of the world. As he acknowledges, in the early part of the period, "the written word was widely felt to be the most reliable vehicle for calling up [. . .] pictures in the mind's eye" (4). However, in the later part of the period, John Tyndall's claim in his "Belfast Address" in 1874 that science involved imagination was qualified specifically around the ability to call up mental images, mental images produced not by words but by a knowledge of nature. Truths about nature "fall into place as a physical image" (12) for Tyndall without the mediation of literary writing. However, Lang's work does not nostalgically rest on earlier notions of the power of fictional writing. Rather, in its awkwardness and strangeness, it implicitly claims that power *through* its acknowledgement of science's claim to the fact.

In her article on Lang's short story, "Romance of the First Radical," Julie Sparks has argued that the tone and aim of the story is primarily satirical, and that in the story "the techniques of satirical fiction work in tandem with [. . .] scientific method" (132), indeed that the story is "both a work of fiction and a replica of 'straight' scientific writing" (131). In her reading of the story, she sees Lang as using the assumptions and methods of mainstream science at the time in a straightforward way:

Just as Darwin examined the tiny points on modern human's [sic] ears and deduced that our proto-human ancestors' ears were pointed, Lang looks at contemporary customs that seem peculiar to a rationalist and concludes that they must be vestiges of a former, more primitive culture. (137)

Sparks's reading does acknowledge the difficulty of the relation between fact and fantasy, however. From arguing that Lang constructs his fiction by using the methods and assumptions of science, and anthropological science in particular, she ends her reading with the acknowledgement that "scientists trying to reconstruct prehistory are – at least to some degree – story-tellers" (140). But science's complex and strained attempts to marry induction and deduction, observation and reconstruction, fact and imagination, through the century, brought to the surface in particular in those disciplines whose subject was the past, are rather smoothed out here. Whether Lang the short story writer is a scientist or whether the scientist is a "story-teller," however, what Sparks's reading implies is that science sits on one side, fiction on the other, and that Lang's story coheres the relation between the two. However it can be argued that "Romance of the First Radical" does not solve the dilemma of the relation between fact and fantasy, but rather enacts it through its reframing of the nature of facts. Lang uses both induction and deduction in the story, observation and reconstruction, but crucially they only work together because the story is fiction, and the methods are split between narrator and protagonist. That fiction provides the possibility for this coming together both reveals the troubled and difficult nature of the claims of science during the period, and privileges fiction as a site of the fullest possible truth.

That Lang calls his short story a "Romance" is crucial here. Lang's use of the term through the 1880s itself suggests the difficult nature of the relation between fact and fantasy, and the crucial place of fiction in it. In various places in his writing, Lang attempted to demarcate the scientific from the romantic, the nature of the fact from fantasy in the form of fiction. At points in this work this demarcation seems clear and stable. In his article, "Émile Zola," from 1882, Lang bases his criticism of Zola's theory, and his practice of it in his novels, on the insistence that science and literature are fundamentally different categories: "The word 'science' is always in [Zola's] mouth, and it does not seem to occur to him that art and literature are one thing, and science quite other" (443). It is not, Lang says, that the contents of each are in themselves problematic, but what is problematic is the contents of one category appearing in another: "the details of the dissecting-room, innocent in themselves, need not be discussed in the drawing-room" (443). Lang seems here not only to refuse a mixing of categories, but to cede to science precisely the possession of the facts of nature. Zola's failures as a novelist, for Lang, are precisely his attempts to be 'scientific': "He is as cold as a vivisectionist at a lecture" (452). Here, then, it is not that the content of Zola's novels is not true (or not necessarily); rather that the facts of Zola's novels are inappropriate to their setting.

However, elsewhere the nature of this boundary is less clear. Writing on *The Wrecker*, by Robert Louis Stevenson, in *The Illustrated London News*, Lang asks to what extent a novelist's method should be visible in their work: "should a novelist break up his own toy, and take us behind his own scenes?" Lang's conclusion is equivocal, torn between the claims of fact and those of fiction:

One's pleasure in fiction is always hurt when one recognises blocks of raw fact in the material [. . .] These remarks are, after all, perhaps too

individual; many readers may actually enjoy seeing the toy taken to pieces, may be pleased to watch the disintegration of the puppets. It is an odd taste, but it may be a taste which is prevalent. We are too curious; we have too much of the scientific spirit even in our pleasures. ("Behind the Novelist's Scenes" 83)

Some years later, in defending himself against a charge by George Moore that he unfairly keeps Zola out of the category of "Romance," Lang attempts again to delineate a "scientific" use of the word ("Romance and the Reverse" 4) and in doing so seems to rub out delineation *per se*. He says that romance is not always impossible, and that the impossible is not always romance, that novels can contain romance, and that "romances" can be unromantic. In introducing the crisscrossing of definitions here, Lang almost concedes that what "romance is, perhaps nobody will ever be able to define" (3). In the end, though, Lang suggests that romance is best defined as "that element which gives a sudden sense of the strangeness and the beauty of life; that power which has the gift of dreams" (4). It is a matter of vision rather than subject matter: "it is equally obvious that profusion of adventure no more makes a work 'romantic' – if the writer lacks vision – than the profusion of squalid incident and detail makes a book 'realistic' if the writer lacks the sense and grasp of realities" (4). Here, it is not so much the facts included in a novel that makes it realist or romantic, then, but the way that those facts are seen. However, the proper vision makes facts, not assimilable into a total vision, orderly and controlled, but strange.

Sparks's claim that fact and fiction are "in tandem" in "Romance of the First Radical" seems unlikely, given the nature of Lang's attempts to think through romance and its relation to facts in his journalism, and indeed the story itself is much stranger than Sparks's reading allows. At the outset, the story claims to be the scientific reconstruction, on the part of the narrator, of that which left no trace in history, but which is 'true' to the extent that it is reconstructed using the methods of comparative anthropology:

The Devil, according to Dr. Johnson and other authorities, was the first Whig. History tells us less about the first Radical – the first man who rebelled against the despotism of unintelligible customs, who asserted the rights of the individual against the claims of the tribal conscience, and who was eager to see society organised, off-hand, on what he thought a rational method. In the absence of history, we must fall back on that branch of hypothetics which is known as prehistoric science. We must reconstruct the Romance of the First Radical from the hints supplied by geology, and by the study of Radicals at large, and of contemporary savages among whom no Radical reformer has yet appeared. In the following little apologue no trait of manners is invented. (179-80)

In the story, Lang clearly uses anthropological evidence from contemporary studies of Australian aboriginal culture, from totemistic practices and from the mythologies of various peoples in his work of reconstruction. Like the early geological writers, his story draws attention to the fact that such scientific work is the construction of precisely a story, one of O'Connor's "imaginative restorations," science's need for which throughout the century made so problematic its assertion of its basis in fact. This is what the story does; but what it reconstructs is the life of the "First Radical" whose break with tradition consists of the discovery of the methods of induction. The

story has as its protagonist a young man called Why-Why, living among his tribe "shortly after the close of the last glacial epoch in Europe" (180). Why-Why questions the superstitions and magical practices of his tribe using the inductive method. He observes the world, experiments with that which he observes and uses his experience in order to disprove the 'truths' of traditional belief. He eats oysters before he has been initiated into manhood, the consequence of which, according to the mythology of his tribe, and based on the ideas of sympathetic magic, should be that "the earth would open and swallow the culprit":

Not daunted by this prevalent belief, Why-Why one day devoured no less than four dozen oysters, opening the shells with a flint spear-head, which he had secreted in his waist-band. The earth did not open and swallow him as he had swallowed the oysters, and from that moment he became suspicious of all the ideas and customs imposed by the old men and wizards. (187-8)

Because of such challenges to traditional belief, Why-Why is eventually estranged from his tribe and lives for two years in a kind of paradise with his lover, a young woman from another tribe called Verva. However, this idyll – which is described as being "like a dream" (205) – is destroyed when a party from his own tribe, led by the chief medicine man, finds them and kills them both. Their relations have offended the totemistic taboos of their tribe as Why-Why and Verva are of the same totem. After the death of his protagonist, who has challenged superstitious religious belief through his inductive method, Lang's deductive narrator does not link Why-Why with science, however. Here, he differs from the anthropological, despite his use of the comparative method to frame his story and give it authority. In the ghost theory of Spencer, and in Tylor's animism, magical beliefs are rational views of the world, given certain conditions and premises, which are eventually superseded by the rational methods of science itself. This evolutionary line was, of course, made even more clear and central by Frazer in *The Golden Bough*, for whom magic is more like science than either are like religion, but which nevertheless is eventually superseded by science because it, unlike science, is wrong about the relations between cause and effect (59). However, at the end of Lang's story, the evolutionary leap made by Why-Why through his radical questioning and his refusal to accept the authority of tradition is linked by the narrator not with science but with poetry:

Many thousands of years later the cave was opened when the railway to Genoa was constructed, and the bones of Why-Why, with the crown, and the fragment of iron, were found where they had been laid by his repentant kinsmen. He had bravely asserted the rights of the individual conscience against the dictates of Society; he had lived, and loved, and died, not in vain. Last April I plucked a rose beside his cave, and laid it with another that had blossomed at the door of the last house which covered the homeless head of SHELLEY. (209)

Here Lang's ostensible championing of induction against the conservative superstition of early human culture is made less straightforward by its articulation via the reconstructions of the deductive method, by its "romance," and by its explicit linking of his hero with Shelley, who may have been, as Sparks argues, "the most famous persecuted freethinker of the period" (133), but who was also a Romantic

poet. In his essay "Realism and Romance" (1887), Lang links the desire to read such romances with Tylor's idea of survivals – those elements of "primitive culture" which persist, anachronistically, into the present – and the literary per se: "If we will only be tolerant, we shall permit the great public also to delight in our few modern romances of adventure. They may be 'savage survivals' but so is the whole of the poetic way of regarding Nature" (690). The reader of "Romance of the First Radical," then, is acting on that which remains in them of the "savage," that within them that misreads facts, that confuses what is in the world and what is in their mind. In doing so, the reader uses their residue of "savagery" in order to read, via a narrative of "creative restoration," of a character who sloughs off his own "savagery" through the inductive methods of science and who is in his turn linked with the "poetic way of regarding Nature." In this story fact and fantasy are bound so tightly together that they cannot be separated.

This remaking of the fact in Lang's work has wide implications. In the work of Bruno Latour, the status of the fact is seen as the most crucial point for the whole conceptual edifice, not just of science but of modernity per se. In *We Have Never Been Modern*, Latour challenges the claim of the sciences, the hard and the social, that they make meaning from a position of objectivity and reveal those places where unilluminated subjectivity reigns (in the non-modern, the traditional, the working class and so on). Latour makes it clear that modernity is per se the act of division and the institution of boundaries – "we are modern. Our fabric is no longer seamless" (7) – and that the primary boundary of modernity is that which "cleanly separated material causality from human fantasy," in contrast to "the olden days, which illegitimately blended together social needs and natural reality, meanings and mechanisms, signs and things" (35). Latour's work shows, however, that this construction of modernity is contrary and impossible – the relation between nature and human thought is constantly breaking down within these central vehicles of Enlightenment thought. In *On the Modern Cult of the Factish Gods*, Latour argues that the primary division that modernity makes between nature and human imagination and fabrication – between true facts and constructed fetishes in Latour's terminology – is itself a human fabrication. Against this, he urges that both facts and fetishes are fabricated, and that both can be true: "Within the depths of their roots, both conceal the intense work of construction that allows for both the truth of facts and the truth of minds" (21). Facts then are fundamental to the discourse of science and to the claim that we are "modern," but, as Latour argues in *We Have Never Been Modern*, the very claims made for facts by science implicate science in that which it would disavow, human fantasy. Summing up the effects of Robert Boyle's work in the seventeenth century on the construction of science as a discourse, Latour glosses both the claims and their implications:

In themselves, facts are mute; natural forces are brute mechanisms. Yet the scientists declare that they themselves are not speaking; rather, facts speak for themselves. These mute entities are thus capable of speaking, writing, signifying within the artificial chamber of the laboratory [. . .] With Boyle and his successors, we begin to conceive of what a natural force is, an object that is mute but endowed or entrusted with meaning. (28-9)

Science then relies on a notion of the fact within which fantasy resides, not as a contradiction but as an essential part of its construction. Lang's work, through its

contradictions and its at times troubled interdisciplinarity, makes visible the extent to which the imbrication of fact and fantasy lies at the heart of late-Victorian science and its access to truth.

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Jessica Kuskey, “Our Mutual Engine: The Economics Of Victorian Thermodynamics.” *Victorian Literature and Culture* 41. 1 (2013): 75–89.

It is becoming an increasingly accepted critical commonplace that in the Dickens world, a steam boat can become “an enormously magnified insect or antediluvian monster” (*Martin Chuzzlewit*, 1844) as effortlessly as man can acquire “a good deal of train oil in his system” (*Bleak House*, 1853). This image of instability, of energetic volatility, encapsulates the “thermo-dynamism” which Jessica Kuskey’s article, “Our Mutual Engine,” seeks to unleash.

Throughout the central Victorian period, discussions of industrialisation constructed the workplace as an imagined space of porous boundaries, wherein the expending of energy and subjectivity migrated between workers, machines, and the industrial landscape itself. Kuskey conceptualises this persistent renegotiation of industrial subjectivity alongside a recycling of the ‘waste’ implicit in the laws of thermodynamics. The Dickensian characters of *Our Mutual Friend* are constantly alert, Kuskey argues, to the social pressures placed on them “to exert a constant level of purposeful, well-directed energy” (75).

Of course, the nineteenth century was claustrophobically tangled up in a web of energy-laden industrialisation which, in itself, was intimately bound to notions of productive improvement and advancement. In the heat of industrial turmoil, Dickens rapidly came to conceive the self of the industrial age as one whose expending of energy meshed closely to specific scientific, social and economic doctrines. Kuskey’s article explains that “mid-century popularizations” of thermodynamics encouraged Dickens to grapple with such theories in relation to wider cultural and ideological contexts. As a result, he produced a vast corpus of periodical and literary works which energetically bubbled with scientific and social fizz. The Dickensian interrelations between ‘the scientific’ and the social are initially explored by Kuskey in relation to Smilesian discourse. For Samuel Smiles, explains Kuskey, “energy and character are exhibited by the dutiful pursuit of socially useful work.” According to Kuskey, Smiles’s theories interestingly reunite the “cultural conception of energy – the inner will to work hard and push through – with the emerging scientific definition of work meaning mechanical effect” (76).

Rather than reading *Our Mutual Friend*’s overall preoccupation with ‘waste’ in the highly popularised contexts of Victorian filth and sanitary reform, Kuskey resituates the novel alongside the emerging scientific theories surrounding work, waste, and energy. She argues that the novel’s fixation with the “economic and moral stakes of wastefulness” are part of “a scientifically inflected work/waste dichotomy” (77). Building upon Ted Underwood’s important analysis of early thermodynamics in Romantic and early-Victorian literary culture, Kuskey explores how Thermodynamic science leapt to prominence so rapidly in nineteenth-century culture because “Victorian scientists, lecturers, and journalists believed that it ratified a productivist conception of industry they already cherished” (78). Putting forth her Marxist-oriented interpretations, Kuskey explains that the new science of energy was “fundamentally shaped by ideologies including the necessity of hard work, maximization of efficiency, and the moral imperative against waste, all of which predisposed scientists to see the work of an engine in economic and moral terms” (79).

As the discoveries of the new physical science made clear, the fact that ‘energy’ was universally accessible meant that it was up to the individual to choose how to use his or her energy wisely for useful work. Unlike steam engines, ‘human engines’ were expected to focus their energies on the production of moral, as well as economic, utility. This celebration of human will over the unthinking and incessant activity of mechanism recalls the epoch’s wider concerns about the collapsing boundaries between the hybrid human-machine. As a character so tightly connected with the unthinking automaton and the mechanical, Eugene Wrayburn – whose name, Kuskey suggests, is both a close anagram of *engine*, and also associated with images of heat and burning (*Wrayburn*) (81) – has to be taught how to purposefully use and renegotiate the expenditure of his energy for moral good. Before marrying Lizzie Hexam, Eugene’s lazy, ineffective, unproductive outlook on life casts him as an anomaly amidst an array of characters who constantly resist the disorder associated with entropy and the decaying of energetic and economic value.

Our Mutual Friend’s focus on the “recycling, reusing, and repurposing” of energy is part of the novel’s larger concern, Kuskey argues, with “the economic and moral imperatives to minimise and *undo* waste” (82). From the sifters of the dust mounds who transform filth into wealth and Lizzie and Gaffer’s recovery of corpses from the Thames, to Jenny Wren’s industrious conversion of scrap materials into dolls dresses, the characters of the novel all find new ways to reclaim the value ‘latent’ in seemingly wasted materials.

Kuskey’s work is well-situated amidst contemporary cultural contexts, and it likewise reaffirms the importance nineteenth-century scientific thinking had for literary and cultural minds. Kuskey reminds her readers that an intricate critical discourse exists between scientific theory and cultural values, be they moral, social or economic. In short, “Our Mutual Engine” is an article which purposefully directs its readers toward the reciprocal relations surrounding the science of energy and the social ramifications of its (mis)use. It reveals the ways in which thermodynamics and the social values of energy, work, and waste were all products of a shared economic and ideological context.

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Jay Clayton, "The Ridicule of Time: Science Fiction, Bioethics and the Posthuman." *American Literary History* 25.2 (2013): 317-43.

Focusing on the bioethical challenges associated with genetic engineering, Jay Clayton's article explores the relation between postwar works of science fiction and the recent policy-oriented publications on transhumanism that often allude to these works. This wide-ranging exploration covers a broad range of texts, from Arthur C. Clarke's *Childhood's End* (1953) to Octavia Butler's *Dawn* (1987) and Francis Fukuyama's *Our Posthuman Future* (2002), and further includes references to the writings of H.G. Wells and Margaret Atwood and to films such as *2001: A Space Odyssey* (1968) and *Gattaca* (1997).

On the basis of this material, Clayton makes several claims about bioethical fiction and non-fiction. In contrast to "the mistaken notion that SF warns against the consequences of biotechnology," he argues that literary science fiction "is overwhelmingly positive about the possibility of transforming the human" (319). Additionally, Clayton contends that the postwar interaction between literary science fiction and bioethics can be divided in two main phases: an early phase (until the late 1950s) which explored evolutionary genetic change and advocated tolerance of the new minority species, and a later phase (from the mid-1970s onwards) which concentrates on deliberate genetic engineering and actively embraces new hybrid identities. Both phases suggest that the message of such books cannot be reduced to simple "advocacy for or against biotechnology" (328) and that they are inextricably linked to contemporary social issues, the fears provoked by totalitarian regimes in the first phase and new social movements defending the rights of female, queer, disabled and immigrant citizens in the second. As far as non-fiction is concerned, Clayton points out that scientists and policy makers writing on bioengineering often use the term 'science fiction' in a derogatory sense that fails to do justice to the class of literature it can also refer to. At the same time, he criticises "[l]iterary theorists of the posthuman" (320) such as Cary Wolfe and Katherine Hayles for paying more attention to Foucault, Haraway, Luhmann and associated theorists than to the discourse of bioethics, and consequently, for neglecting to "bring the analysis of posthumanism to bear on problems with tangible impact on patients, health-care providers and scientific policy" (339). Turning to this neglected discourse himself, Clayton argues that jeremiads as well as encomia about biotechnology use various rhetorical strategies to hide their differences from scientifically grounded projections as well as their similarities with literary forms of science fiction. He therefore concludes that literary fictions are more suited to performing thought experiments than such pseudo-scientific works of non-fiction, as "[t]he formal conventions of fiction alert readers to the provisional nature of analogy and extrapolation" (332-333). Perhaps surprisingly, it appears that "nonfiction about the posthuman is more susceptible to the ridicule of time than works of SF" (333).

Clearly, these are important claims and there is an admirable breadth and ambition to the article. Clayton's fascinating analysis of bioethical themes in modern science fiction will provide scholars of literature and science with a solid foundation for further analysis, while the argument that theorists working on posthumanism should consider non-fiction and policy-related publications is an important intervention, even if the specific benefits of Clayton's alternative approach for patients, health-care providers and scientific policy are not detailed. Overall, however,

the article leaves a number of questions unanswered. For one thing, the idea that some works of fiction and non-fiction are more exposed to “the ridicule of time” than others could be seen as unproductive; as Clayton himself indicates, the accuracy of their predictions is not the sole standard for evaluating such works. The argument that science fiction is more positive about the possibilities of transforming the human than most people think is interesting. However, it depends on a bracketing of cinematic and literary forms of dystopia, which are consequently relegated to the sidelines and treated collectively as “a special branch of science fiction,” as “the exceptions, not the rule” (319) or simply as “outliers” (339). It might therefore be more accurate to say that the subgenres Clayton is interested in are positive about transforming the human, and it remains to be seen whether dystopia can be disentangled so easily from other subgenres of science fiction. Clayton does, however, indicate that the truth is more complex, suggesting that in first wave science fiction novels “[t]he suspicion of genetic engineering [. . .] coexist[s] uneasily with enthusiasm for the arrival of a posthuman stage” (324), and also that in Butler’s second wave work there is an ambiguous, “complicated” (329) portrayal of invasive biomedical technology. More generally, does their contextual dimension not imply that there is much more to these books than the science, strictly speaking? Does Clayton’s approach not risk reducing these books to their “take-home lessons” (319) as well? Finally, the article does not discuss the “formal conventions of fiction” (332) in detail, which implies that the precise benefits associated with literary fiction – not to mention its relation with our broader “science-fictional” (319) frame of mind – remain unclear. But these unanswered questions ensure, no doubt, that Clayton’s work will be vital in inspiring further research on genetics, biotechnology and science fiction.

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C. R. Resetarits, "Experiments in Sex, Science, Gender, and Genre: Hawthorne's 'Dr. Heidegger's Experiment,' 'The Birthmark,' and 'Rappaccini's Daughter'." *Literary Imagination* 14.2 (2012): 178-193.

In this rich and illuminating article, C. R. Resetarits considers three short stories by Nathaniel Hawthorne in light of Hugo Gernsback's concept of "scientifiction." The term refers to proto-science fiction: stories which meld romance, prophesy, and scientific fact. Resetarits fills a gap in Hawthorne studies by considering, in one discussion, the tales' dysfunctional male-female amorous relationships alongside their "scientifiction" and "sexual dynamics" (178-79). Resetarits draws two key conclusions: Firstly, that Hawthorne sees interactions between male characters as ultimately more important than those between men and women; secondly, that Hawthorne extends his discussion of "issues of sexuality and science" to include "power" (192). Resetarits draws on David Leverenz's work, stating: "These power struggles exist not only between genders but also within a male dynamic that Leverenz labels the 'ideology of manhood'" (192).

Resetarits's nuanced readings of each short story are as stimulating as the article's over-arching conclusions about Hawthorne's fiction. For Resetarits, in "Dr. Heidegger's Experiment" (1837), the author employs gothic and science imagery to show "that the real sexual play" in the tale is between Dr. Heidegger and his deceased bride rather than between the widow and the doctor's three male guests as is usually stated (182). Resetarits adds: "Hawthorne takes the gothic interest in necromancy and alchemy and gives it new life through 'scientifiction,' allowing scientific doubt and the anti-Faustian character of Dr. Heidegger [. . .] to breath [sic] new life into a very ancient idea" (182). In the analysis of "The Birthmark" (1843), Resetarits asserts that the scientist, Aylmer, is driven to remove his wife Georgiana's defect not just by "revulsion," as has been suggested, but by sexual attraction: "In Georgiana he [Aylmer] has the perfect project, one that offers him the look of science and the feel of sex" (186). The focus of the tale, however, is the "state of mutual dependence and competitive individualism" that exists between Aylmer and his male scientific sidekick Aminadab (190). Should Georgiana not have died when the birthmark was removed "there might not have been a place for her in Aylmer's competitive and perfecting (progress at all costs) world" (190). Resetarits speculates "that, unless Aylmer and Aminadab can create their own progeny in the lab, their world of science is not sustainable" (190). Similarly, while in "Rappaccini's Daughter" (1844) there exists the gothic feature of "three men rivaling for the love of a beautiful young woman" (190), Resetarits notes that Hawthorne's "genre-straddling gothic or science fiction [. . .] makes the rivals more interested in the *science* than the person of Beatrice" (190). Moreover, the anxiety expressed by the main protagonist, Giovanni, is more expressive, Resetarits argues, of his desire for status within the male scientific community, than "his normal, young male attraction to a beautiful woman" (191). In this story, the critic states, "Hawthorne finally makes the bifurcation (of science or intellectual passion and sexuality or physical passion) explicit" (191). Further, Beatrice's father Rappaccini's "experiment[s]" on his daughter make her poisonous and prevent her from mixing with other men until he sees fit (192). For the critic, Giovanni's contamination by Beatrice and his consequent assumption of her role as isolated prisoner in Rappaccini's garden make him "Rappaccini's next creature or creation" (192). According to Resetarits, the fact that Giovanni both takes the place of

a woman who is manipulated by a man and retains his 'male' scientific credibility makes his gender indeterminate. This indeterminacy, the critic suggests, also applies to the genre of Hawthorne's stories which combine the gothic, romance, prophesy, and science.

The article makes significant contributions to both Hawthorne studies and the field of literature and science, most notably perhaps by illuminating the origins of what we now call science fiction, and showing how Hawthorne anticipates many of the genre's preoccupations, for instance those of "time, immortality," notions of a "perfect future in the present," and "the pursuit of 'new and improved' genders, creations, procreations, ways of knowing, and the power games that accompany such displays of power" (188, 192). Resetarits's research could be further developed through greater examination of the feminist sexual-political implications of male-female interactions in Hawthorne's proto-science fiction, and through an expanded analysis of the narrators' commentary. In the final lines of "The Birthmark," for example, the implication is that men can achieve a heavenly state of happiness in their earthly life by embracing what we might interpret as women's "fallen nature," an idea which needs to be analysed along feminist lines. One might ask why the narrator deems the notion of women's "badness" necessary to men's contentment. The former perhaps sees "fallen" women as enabling men to feel comforted by a sense of moral superiority to their female counterparts. Consideration of this issue would fruitfully extend Resetarits's scholarly, sophisticated and powerfully persuasive argument.

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Uppinder Mehan, "Postcolonial Science, Cyberpunk and *The Calcutta Chromosome*." *Intertexts* 16.2 (2012): 1-14.

Literature and science studies have, to date, largely focused on science in the Western world and, to an extent, the literary production of 'the West'; the global history of science, and science as it figures in postcolonial and world literature, have remained relatively unexplored. Uppinder Mehan's article offers scholars an introduction to these topics as it surveys the complex history of science in colonial contexts and, using Amitav Ghosh's *The Calcutta Chromosome* (1995) and Nalo Hopkinson's *Midnight Robber* (2000) as case studies, examines how the seeming opposition between Western science and Eastern mysticism is addressed in postcolonial fiction. Mehan's contention is that these novels "trouble all manner of genre distinctions and by doing so draw attention to the constellation of science, colonialism and cultural production" (1).

The article begins by situating these novels in the context of debates amongst postcolonial critics about the relative merits of the promotion of Western science education in the colonies. The colonialist view that the colonies were "devoid of any meaningful science" and "the possessors of only ancient technologies" influenced even anti-colonial reformers, who encouraged Western science education (2). While some critics, such as Sandra Harding, suggest that a way to move beyond the equation of Western science with reason and Eastern science with superstition is a more inclusive definition of science as "any systematic attempt to produce knowledge about the real world," others, such as Nandra Meera, are concerned that the removal of the scientific method from the definition of science would legitimise retrograde and fundamentalist practices while diminishing the "hard-fought gains [. . .] of the Enlightenment" (2).

Interweaved with this discussion is an analysis of *The Calcutta Chromosome* which, Mehan argues, explores the "clash between western and eastern understandings of science and technology" (2) through its portrayal of British scientist Ronald Ross, who is conducting malarial research in turn-of-the-century India and whose scientific method is manipulated by his assistant, Mangala, who is engaged in an alternative experiment to transmigrate souls. While Ghosh critiques "western" notions of "objective science" and reason through portraying the blindness of Ross to Mangala's genius, he also, Mehan contends, "forces the reader to question this counter-scientist group's oppositional ground by showing their methodology to be fairly similar to the conventional notion of doing science" (7). Although Mangala is portrayed as a scientist "outside rational modernity" (7) who is worshipped as a divine figure by her followers, her discoveries rely on the manipulation of Ross's experiments. Mehan traces the ways in which Ghosh links this group's belief in alternate realities to potential artificial intelligences in virtual worlds, as the novel shifts between colonial India and the future in which a New York based computer programmer begins to investigate the disappearance of the man who was searching for the "other mind" (i.e. Mangala) behind the discovery of malaria.

Mehan's central argument is that by depicting a world in which "the East is the source of powerful technological [. . .] realities" and where "transmigration" is "not only a philosophy of the transference of the self" but also of the global movement of people, Ghosh offers us "a glimpse of a Third World cyberpunk novel" (10). Comparing *The Calcutta Chromosome* with the cyberpunk fiction of William

Gibson, Mehan suggests that Ghosh emphasises the mystical elements of artificial intelligence, and thus the “romantic,” “fantasy aspect” of cyberpunk (11). The article concludes with a brief analysis of Hopkinson’s *Midnight Robber*, which Mehan argues shares with cyberpunk a concern about the relationship between the human and the machine, and with Ghosh a concern about the relationship between the postcolonial and science.

Mehan’s ambitious article is packed with a variety of historical and geographical examples of European science in colonial contexts; India, China, Japan, Africa and the Philippines are all discussed as Mehan surveys colonial science from the seventeenth century through to the Second World War. Such breadth is paralleled by an equally wide discussion of literature and theory; science fiction, fantasy, cyberpunk authors, postcolonial theory, Heidegger, Heisenberg’s uncertainty principle, Caribbean and Indian writing all make an appearance, with the effect that the thrust of the argument becomes somewhat lost amongst digressions which, given their number, inevitably lack depth. As such, while the article makes interesting connections between cyberpunk and *The Calcutta Chromosome*, its main offering to the scholar of literature and science is as an introductory survey of the global history of science and an overview of the science fiction and fantasy genres which some postcolonial writers have employed to explore this history. These are important, yet little explored lines of enquiry in literature and science studies and Mehan’s article demonstrates this to be a fertile area which requires greater investigation.

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Laura J. Faulk, “Destructive Maternity in *Aurora Leigh*.” *Victorian Literature and Culture* 41.1 (2013): 41-54.

Feminist readings of *Aurora Leigh* (1856) are *de rigueur*. Indeed, as Laura J. Faulk acknowledges, “feminists revived Barrett Browning’s poem in the 1970s after years of obscurity” (42). Yet, Faulk’s essay suggests that most of these critics, though obsessed with Elizabeth Barrett Browning’s romance and marriage, have neglected to discuss her difficult experiences with pregnancy. They have also overlooked the division of the poem into nine sections, “a significant number considering *Aurora Leigh*’s connection with motherhood” (52). Faulk’s essay is not the first work to discuss writing, rape, prostitution, and childbirth in the poem as separate concerns; she cites articles by Deborah Byrd, Mairi Calcraft-Rennie, Deidre David, Linda Lewis, Dorothy Mermin and several others. But Faulk hopes to redirect critical attention away from ubiquitous discussions of the dangers of childbirth for Victorian women, and towards the equally damaging before and after: the violent physical effects of pregnancy (sometimes exacerbated by rape or prostitution) and self-sacrificial mothering as akin to being “buried alive” (45).

Faulk’s essay arranges the major female characters in the poem into categories based on the mothering “type” they seem to represent: Aurora’s mother as the ideal dead mother, Marian as the ideal “living dead mother” (44), the childless Lady Waldemar as “The Destructive Mother” (46) and Aurora herself as “The Hesitant Mother” (48). The least compelling reading, which focuses on Lady Waldemar as “destructive mother,” depends primarily on references to her milky white skin. While the most compelling is the analysis of Aurora herself as troubling the relationship between giving birth to children and giving birth to art. Together, Faulk argues, the women “expos[e] the inconsistencies in both the trope of idealised motherhood and medical assurances of its benefits” (52).

Scholars of literature and science will note Faulk’s discussions of medical discourse as a source of misconceptions about mothering. Medical journals and tomes, according to Faulk, offer “the old maid” as “physically unwomanly” (41), pregnancy as a “benefit [to] a woman’s health” (41), and an overall strategy to “den[y] female desire by idealizing motherhood” (49). The challenge for Faulk’s essay, as for all historicist readings, is the strain of coming to general conclusions about “Doctors” (41) or “Victorian society” (41) based on a limited number of primary sources. Faulk credits Jenny Bourne Taylor and Sally Shuttleworth’s anthology *Embodied Selves* (1998) for her primary sources in medicine and physiology. Judith Flanders’ *Inside the Victorian Home* (2003) is a crucial reference for information about mortality rates at the end of the century; Faulk suggests that earlier records are unavailable.

In making her case for *Aurora Leigh* as unique, Faulk only sketches its place within the canon of representations of mothering. However, she does allude to “countless fictional characters” (42) who represent the Victorian “exaltation of maternal love” (42). Equal numbers of characters offer a strong counternarrative (Becky Sharp, Hetty Sorrel, Leonora Halm-Eberstein, Isabella Linton, Tess Durbeyfield, Sue Bridehead). Such characters, from novels by William Makepeace Thackeray, George Eliot, Emily Brontë and Thomas Hardy, join *Aurora Leigh* in figuring mothering as “a threat to woman’s body and desires, turning her sexuality into a peril to herself and others” (42-43). Ellen Rosenman and Claudia Klaver’s

essay collection *Other Mothers: Beyond the Maternal Ideal* (2008) offer a starting point for readers interested in supplementing Faulk's conclusions. Faulk references several articles from the *Examiner* that gesture towards the rich conversation about infanticide and unnatural mothering conducted within the periodical press, while Nicola Goc's *Women, Infanticide, and the Press, 1822-1922* (2013) offers a number of additional leads.

Faulk is correct that what was common in fiction and the popular press was rare in poetry. Perhaps Faulk's longer project, a dissertation about female physicality in Victorian literature, offers suggestions about this generic distinction. Faulk's study also gestures towards a second avenue for future research: how women participated in the myths about motherhood that limited their self-expression. Aurora's poetry, in "attempting to diminish female sexuality by aestheticizing the female body and motherhood as something beyond bodily desire" (49), performs the same work Faulk attributes to the medical discourse, which leads to further questions about how women writers may "embody," or even perpetuate, the patriarchal discourses that describe them. In summary, Faulk's essay offers two important reminders to scholars of literature and science. In discussing scientific or literary understandings of reproduction, scholars must not neglect the crucial period between conception and birth. In discussing maternity within works of literature, we should remember that poetry, as well as prose, should be part of the conversation.

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Tami I. Spector, "From the Molecular to the Machine." *Representations* 117.1 (2012): 1-29.

Objectivity can be a shady matter. More so when it supposedly arises from the "shadow images" portrayed by nanoscopy. Starting from a specific molecule, benzene, and the story of its discovery, Tami Spector builds an account that entwines the micro-world of nanomolecular studies with more general philosophical concerns for the representation of non-visible objects: "We had seen the unknowable. Or had we? Can we?" (1). Problems with negotiation of meaning between the object and its structure are the underlying leitmotifs of a story that spans from Friedrich August Kekulé's epiphanic discovery of benzene's structure in 1865, to the 2001 STM (Scanning Tunneling Microscope) image of C60 (buckminsterfullerene).

Spector's article begins by presenting Kekulé's depiction of benzene as an historical marker for molecular representations. She argues that Kekulé's idea of portraying benzene's cyclic valence structure in the form of an "uroboros," transformed a chemical formula into an enduring symbol and into a powerful signifier "where structure begets properties and properties recapitulate structure" (3). Images of molecules, like Platonic solids, which synthesise the quintessence of the objects from the tangible world, are but "imperfect simulacra" (5) of a reality that escapes our senses. Spector claims that, very much like those solids, such representations can operate on a metaphorical level stimulating productive connections and generating new understanding. It is within this framework that she presents the case of buckminsterfullerene ("buckyball" for brevity), a "carbon-based polyhedral structure" (5) imbued with a "primal Platonic essence" (9). According to Spector, however, the resemblance of this molecule with an everyday object such as a soccer ball, gives it an adjunct value in respect to Platonic solids. Its ball-like nature reflects its function in real life as a potential vehicle for delivering drugs to a specific target in the body: "not only does it look like a real-world object; it theoretically acts like one too" (9). For Spector, Buckyball also marks the passage from molecules to more complex switch-like functioning systems called molecular machines: organised aggregates of molecular components that produce kinetic responses to specific stimuli, mimicking their macroscopic homonyms. These idealised mini-machines represent one part of that "machine" mentioned in the title of Spector's article, the other part being the actual machines, such as the STM or the SPM (Scanning Probe Microscope), used to detect them. The symbolical union of the object of study and the recording device, registered in the title under one single all-encompassing word, hints at Spector's main argument that the real substance of nanotechnology consists of nanomicroscopy images rather than the actual nanoscale objects (17).

Spector shows how SPM images, omnipresent in scientific literature, derive their authority from the photographic-like way in which they depict atoms and molecules, hiding human mediation behind the idea of a "neutral knowledge" (22) achieved through the misleading objectivity of the snapshot. Their "narrative of neutrality and authority" (23) is further supported by a caption that always accompanies them. For Spector, the caption has a double function: it invests the picture with meaning, calling on the specific knowledge of the viewer for interpretation, and, at the same time, derives its own authenticity from the charismatic power of the photograph. SPM creates new kinds of aesthetical scientific entities that appear to have finally satisfied the craving for visualizing the unknowable and for

synthesizing the noumenon. Our expectations, Spector concludes, are fulfilled. These pictures confirmed theoretical predictions: “buckyballs look like buckyballs and benzene like benzene, an uroboros of representational continuity; we are ‘at home amongst appearances’” (25).

The open ending of the article is a call for interpretation. Spector’s clear emphasis on the role of “language” (be it a structural formula, words or pictures) in the construction of knowledge, suggests that the quest for meaning has to be a shared effort between humanities and science. New scientific proceedings demand a constant reassessment of the concept of objectivity (historically considered a stronghold of the sciences alone) in the process of negotiation between different fields of study. There is a high level of correspondence between the topic of the article and the narration itself: it advocates connectivity while showing how connectivity works. Almost like the majestic truncated icosahedron dome of the buckyball, Spector’s narrative gives rise to a number of metaphorical connections hosted under a cohesive structure that merges on the surface with a common question: what do we really see?

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