Soils, Science, and the English Realist Novel: 1840-1872

Jim Scown

Thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

May 2021

Summary

This thesis is about soils in mid-nineteenth-century literary realism and science. For novelists and scientists of the period, soils offered access to truthful knowledge of the world. This is my primary argument. In novels by Charlotte Brontë, Elizabeth Gaskell, Charles Dickens, and George Eliot, soil description situates studies of lived experience in a material world that is empirically verifiable as it is dirtied and imperfect. In the same years, chemists were developing new methods of analysis and experimentation to explore soils as never before; Justus von Liebig's organic chemistry promised to reveal the constituent minerals of soils and how these were assimilated by plants. As chemistry reduced soils from vital and unknowable spaces to a quantifiable set of nutrients, isolating the world's fertility for agricultural production, the novels I read resisted this productionist ethos, especially as it extended from soil to people. Yet while realist novels offered alternative investigations of soils, granting them agency and tracing the exploitative networks by which earthly fertility was being assimilated into a rapacious economics, realist narrative also remained committed to a providential patterning of soil as resource. Chemists and novelists alike saw a material world to be networked into a liberal capitalism in order to extract wealth or, read more favourably, improve human wellbeing. So as Brontë, Gaskell, Dickens, and Eliot expose the socioecological violences of a burgeoning world economy, they also perpetrate and extend these violences on lands and peoples beyond the bounds of realism's provincial focus; this tension emerges as a fracture in realist form between open economic and ecological networks and the need for narrative closure. My thesis thus unearths a shared interest in soils across literature and science of the period, augmenting the established conception of a psychological realism by revealing a novel form examining matter as well as mind.

Contents

Figures

Abbreviations

BAAS	British Association for the Advancement of Science
GPS	Geological and Polytechnic Society of the West Riding of Yorkshire
RASE	Royal Agricultural Society of England
YAS	Yorkshire Agricultural Society

Acknowledgements

I have benefitted from the support of many people during this research, none more so than Martin Willis. Ever since I first emailed him back in 2013 with a vague idea about 'literature and science', Martin has been a constant source of guidance and inspiration. On everything from structuring a thesis to split infinitives, Latour's networks to Loamshire's soils, copyediting to the cricket, I have enjoyed our talks immensely. I can't thank him enough – and would like to now take fully responsibility for any split infinitives that remain.

Ralph Pite has been another indispensable guide through this process. A great many of the ideas in this thesis have been thought through with Ralph in the coffee shops of Bristol, and all are immeasurably better for his thoughtful insights and sensitive comments. When I look back on the last four years of study, our talks are some of my fondest memories.

My work has benefitted tremendously from a number of other generous readers. Bill Bell has read much of this thesis in his role as my internal reviewer at Cardiff. Lindsay Wells read a draft of chapter 1, Lara Choksey, Barri Gold, Greg Lynall, and Paul Young read portions of what would become chapter 3, and Pippa Marland, Tess Somervell, and two anonymous reviewers for *Green Letters* read portions of what is now chapter 4. All my chapters are better for their perceptive thoughts and comments.

Soil is one of those wonderful topics that everyone has something to say about, and I could never thank all those whose ideas have contributed to this work, but I would also like to acknowledge Seth Armstrong-Twigg, Louise Benson James, Jamie Castell, Marianna Dudley, Peter Fifield, Regenia Gagnier, Katie Gramich, Jerome de Groot, Ursula Kluwick, Mark Lussier, Becky Munford, Rachel Murray, John Parham, Joan Passey, Sharon Ruston, Jack Thacker, Keir Waddington, and Corinna Wagner for their ideas, reading suggestions, and various favours, small and large, over the last three and a half years.

The library and administrative staff at Cardiff University and the University of Bristol have been hugely helpful, especially during the challenges of Covid. A special thanks to Erica Swain, always on hand to purchase e-copies of books in the depths of lockdown, to the inter-library loans department at Cardiff, who have sourced a great many texts for me over the years, and to the ENCAP PGR office, where Rhian Rattray has been an invaluable wellspring of knowledge on all things doctoral study. The staff at the Rothamsted Research Archive in Hertfordshire and the Beinecke Rare Books and Manuscript Library at Yale University offered support and suggestions during research trips in 2019 and 2020.

The South, West, and Wales Doctoral Training Partnership (SWW DTP) made this research possible in the form of an AHRC Doctoral Training Studentship, generously extended to meet the challenges of Covid. They also agreed to continue funding my project with the Soil Association through the pandemic, for which I am immensely grateful.

The three months I spent with the Soil Association ended up taking place over Zoom, but the project, linking the nineteenth-century history of soils to the contemporary perspectives of farmers, has led to a great many things. Returning from that experience helped me to see nineteenth-century soil and literature through a new lens. Thank you to Helen Browning and Louisa Pharoah for their support at the Soil Association, and to all the people I spoke to as part of the project.

A final word to my family. Jane and Tony Scown's shared love of the natural world suffuses all that I do. I would like to think the early years I spent 'helping' in the garden were crucially formative when it came to writing this thesis; they have always been there to listen to my thoughts and ideas, and in more recent years to read them too. One person who never imagined she would spend four years hearing about soil is Becky Stirk. I am grateful that she has listened so patiently, especially in the last year, when her love and support made completing this thesis a more enjoyable experience than it could ever otherwise have been.

Preface

Revised versions of sections two and three of chapter 3 appeared as ‘World-ecology “among the ooze”: *Our Mutual Friend* and the Chemistry of Sewage, Soils, and Circulation’ in the *Journal of Literature and Science*, 13.1 (2020), 1-17. Parts of the first section of chapter 4 appeared as ‘George Eliot and George Lewes in Justus von Liebig’s laboratory: realism, chemistry, and agriculture in the mid-nineteenth century’ in a special issue of *Green Letters* on ‘Agriculture and Environment’ (2020) <doi.org/10.1080/14688417.2020.1866998>.

Introduction. Soils, Science, and the English Realist Novel: 1840-1872

> [Dorothea] paused […] to talk to old Master Bunney who was putting in some garden-seeds, and discoursed wisely with that rural sage about the crops that would make the most return on a perch of ground, and the result of sixty years' experience as to soils – namely, that if your soil was pretty mellow it would do, but if there came wet, wet, wet to make it all of a mummy, why then –
>
> George Eliot, *Middlemarch*, 1871-72.[1]

> Without knowledge of the substances which plants cannot do without in their development, the food that they draw from the air and soil, the substances that we harvest from and must return in dung to the soil, that is, without knowledge of the chemical conditions of life, a rational cultivation of the soil cannot be considered.
>
> Justus von Liebig, 'Organic Chemistry in its Applications to Farming and Physiology', 1840.[2]

This thesis is about soils in mid-nineteenth-century literary realism and science. Across the two extracts above, soil is understood as first mud then mineral. The passage from *Middlemarch* offers a vernacular discourse of soils that, as Eliot looks back to the early 1830s, is experiential and local. The focus is on soil structure as Master Bunney describes how his ground might become 'mellow' or 'all of a mummy' depending on the weather. This contrasts with the second passage, taken from an advertisement written by Justus von Liebig to mark the publication of his *Organic Chemistry in its Applications to Agriculture and Physiology* in 1840. For Liebig, only 'knowledge of the chemical conditions of life' can provide the basis for farming practice. By offering a 'rational cultivation of the soil', chemistry promises to transcend Bunney's regional discourse of structure and composition to furnish scientific principles for future agriculture. Along with this epistemic shift comes a host of related movements, from Bunney's rural 'perch of ground' to Liebig's urban laboratory, from farming practice to chemical theory, and from local knowledge to a soon to be globalising model for agricultural production. My thesis is about these shifts, how they

[1] George Eliot, *Middlemarch*, ed. and notes by David Carroll, intro. by Felicia Bonaparte (1871-72; Oxford: Oxford University Press, 2008), p. 737.
[2] Justus von Liebig, 'Organic Chemistry in its Applications to Farming and Physiology, 25 August 1840', trans. by Pat Munday, in 'Sturm und Dung: Justus von Liebig and the Chemistry of Agriculture' (unpublished doctoral thesis, Cornell University, 1990), pp. 178-80 (180).

were examined and developed in novelistic and scientific writing during the mid-nineteenth century.

For novelists and scientists of the period, soils offered access to truthful knowledge of the world. This is my primary argument. In novels by Charlotte Brontë, Elizabeth Gaskell, Charles Dickens, and George Eliot, soil description situates studies of lived experience in a material world that is empirically verifiable as it is dirtied and imperfect. In the same years, chemists such as Liebig were developing new methods of analysis and experimentation to explore soils as never before, revealing their constituent minerals and explaining how these were assimilated by plants. In this way, soils of the period functioned to bring novel writing and scientific inquiry down to earth, as it were. As chemistry reduced soils from vital and unknowable spaces to a quantifiable set of nutrients, isolating the world's fertility for agricultural production, so the novels I read sought to resist this productionist ethos, especially as it extended from soil to people. Yet I avoid an easy binary between a reductive science and an ecologically attuned novel form focused on lived complexity. While realist novels offered alternative investigations of soils, granting them agency and tracing the exploitative networks by which earthly fertility was being assimilated into a rapacious economics, realist narrative also remained committed to a providential patterning of soil as resource. Chemists and novelists alike saw a material world to be networked into a liberal capitalism in order to extract wealth or, read more favourably, improve human wellbeing. So as Brontë, Gaskell, Dickens, and Eliot expose the social and ecological violences of a burgeoning world economy, they also perpetrate and extend these violences, especially on those lands and peoples beyond the bounds of realism's largely provincial focus.

My four chapters all move through particular versions of these arguments. All are structured over four sections and each, broadly speaking, tracks from a provincial focus on English soil to the global ecological and economic networks in which these provincial soils were, during the mid-nineteenth century, becoming ever more enmeshed. Along the way, I examine the epistemological relationships between realism and the emerging mid-century science of soils, (in which Liebig was a foundational and controversial figure), and consider the implications of this shared epistemological project in a time of ecological breakdown. All four chapters end with short conclusions that read the social and ecological tensions they examine back through the form of the realist novel. Chapter 1 thus understands *Jane Eyre*'s realism in tension with the Gothic, and northern England in dialogue with the plantation agriculture that sustains domestic landed wealth. *Mary Barton* examines a rupture in nutrient circulation that forms the focus of chapter 2, but as Gaskell's conception of sympathetic

contact hopes to reconcile class conflict, *North and South* can only feed the poor by exploiting the soil fertility of North America. Chapter 3 approaches the London of *Bleak House* and *Our Mutual Friend* as the locus of a world-economy networking soils from across the globe, extractive capitalism into which Dickens's unique brand of realism offers important insights but that his fictions can do little to resist. And my final chapter takes the soils of Loamshire as the foundation of Eliot's realism, *Middlemarch* as the mid-century realist novel that comes closer than any other to addressing the extractive economics that play out through soils and peoples during the period, even as Eliot's narrative cannot eliminate such exploitation entirely. In this way, my four chapters together draw out the tensions and contradictions of the mid-century realist project in its proximity to soil.[3]

My introduction is also structured across four sections. Beginning with 'Liebig, Soils, and the Novelists', I offer a short history of the emerging 'chemistry of agriculture' in the mid-nineteenth century and establish links between this growing scientific interest in soils and the authors above. 'Ecologies of Literature and Science' then explains the ecological methodology I apply to reading scientific writing and realist narrative in both dialogue and divergence. This allows me to outline the postcolonial focus of my readings in 'Decolonising Soils', where I explain the ways chemistry acted alongside capitalism and colonialism to network the world's soil fertility, and how realist novels work to both reveal and elide the harm inherent in this process. My introduction concludes with an account of 'Realism in Ecological Crisis'. Here I make three claims about the importance of realist narrative in a time of ecological collapse, arguing that the mid-nineteenth-century novel is more interested in non-human agency than has traditionally been understood, that the form is valuable in focusing attention on the slow-moving violences of socioecological breakdown, and that realist narratives, struggling to achieve closure in worlds that evince radical openness, offer new ways to approach the challenges of capitalist modernity.

Liebig, Soils, and the Novelists

As William Brock notes in his excellent biography of Liebig, the German chemist 'might well have regarded himself an honorary Englishman' such was his impact on British science and industry in the nineteenth century.[4] His publication output was astonishing and his writing accessible to a non-specialist audience. Works such as *Organic Chemistry* (28

[3] I offer a more detailed chapter summary at the end of this introduction.
[4] William H. Brock, *Justus von Liebig: The Chemical Gatekeeper* (Cambridge: Cambridge University Press, 1997), p. 113.

editions in 10 languages from 1840) and *Chemical Letters* (51 editions in 19 languages from 1843) retained an extraordinary popularity throughout his life.[5] Equally influential in disseminating Liebig's ideas were the young chemists who studied in his Giessen laboratory. Many of them were British, and upon returning to British cities to take up positions in industry, public health, and university education, these men advanced and established Liebig's ideas. My thesis also reads the work of chemists such as James Finlay Weir Johnston, Lyon Playfair, Robert Angus Smith, and Joseph Henry Gilbert; the latter three all studied under Liebig to become influential figures in British agriculture and public health. [6] And while Johnston, like Gilbert, often challenged Liebig's ideas, the influence of former Giessen students ensured Liebig's work was a frequent topic of conversation at meetings of the British Association for the Advancement of Science (BAAS), (several of which Liebig attended in person), and advanced through publications such as the *Lancet* and the *Journal for the Royal Agricultural Society of England*.[7] And from these scientific meetings and publications, Liebig's ideas found their way into the popular periodical press. His is one of the famous, and largely forgotten, names of nineteenth-century science.[8]

The links between Liebig and the authors on which I focus are multiple: Charlotte Brontë immersed herself in *Blackwood's Edinburgh Magazine* and *Chambers's Edinburgh Journal*, publications in which Liebig's views were being reported and refuted in the 1840s; Elizabeth Gaskell referenced *Organic Chemistry* in her fiction and socialised in Manchester's civic circles with chemists who had trained under Liebig in Giessen; Dickens was a professed admirer of Liebig's work and published over twenty-five articles in *Household Words* and *All the Year Round* between 1850 and 1865 making reference to his chemistry in its various applications; George Eliot and George Lewes became firm friends with Liebig when visiting

[5] Munday, 'Justus von Liebig', pp. 143, 212.
[6] Johnston was co-founder of the British Association for the Advancement of Science (BAAS) and chemist to the Agricultural Chemistry Association of Scotland. Playfair was appointed by Edwin Chadwick as Officer for Health for Lancashire in 1843. He became the first consulting chemist to the Royal Agricultural Society of England (RASE) the same year. Smith was Manchester's first alkali inspector and famous today as the discoverer of acid rain. Gilbert was an agricultural chemist and creator, along with John Bennet Lawes, of the first commercially successful factory-produced fertilisers. Johnston's science is examined at length in chapter 1, Playfair's and Smith's in chapter 2, and Gilbert and Lawes's work features alongside Liebig's science in chapters 3 and 4.
[7] I examine the disagreements between Johnston and Liebig in chapter 1 and between Gilbert (and Lawes) and Liebig in chapter 4.
[8] Other influential chemists who studied under Liebig include William Gregory (professor of chemistry at Aberdeen and Edinburgh), Edward Frankland (professor of chemistry at Owens College, Manchester, and London's Royal Institution), as well as Germans Augustus Voelcker (chemist to the RASE after Playfair) and August Wilhelm Hofmann (professor of chemistry at London's Royal College of Chemistry – established by Prince Albert and modelled on Liebig's Giessen laboratory. Hofmann was appointed after Liebig had refused the post. See Brock, *Liebig*, pp. 104-05).

Munich in 1858, touring his laboratory, sharing dinner at his house, and taking long walks with him in the countryside. Such was Liebig's renown my study could conceivably trace his impacts on English literature via a cultural osmosis. Yet I have limited the novelists I consider to those it seems likely read Liebig's work, either in its original text or as examined in the popular press. As Gillian Beer writes, '[r]eading is essentially a question-raising procedure', and integral here to understanding how these novelists explored and interrogated chemistry's ideas on soils in the worlds of realist narrative.[9]

The range of applications Liebig saw for his chemistry was staggering. As Pat Munday has uncovered, his two most popular works were *Organic Chemistry* and *Chemical Letters*, and these are the two scientific texts that I focus on.[10] The latter began as a series of newspaper articles before being compiled in a work outlining Liebig's theories to a wide audience. Published first in English, it incorporated many findings from *Organic Chemistry* and also Liebig's *Animal Chemistry: Or Organic Chemistry in its Applications to Physiology and Pathology* (1842), arguably the foundational text for biochemistry.[11] These texts were often translated into English (and other languages) by his former students. Liebig also published *Research on the Chemistry of Food* in 1847 and, as he became increasingly interested in practical questions at the other end of the food system, *Principles of Agricultural Chemistry* (8 editions in 4 languages from 1855) and *Letters on Modern Agriculture* (4 editions in 4 languages from 1859).[12] Liebig wrote widely too on the Victorian sewage question, arguing it was essential for future soil fertility that increasing amounts of urban sewage were used as manure for agriculture. *The Times* published multiple letters from Liebig on the subject in the late 1850s and early 1860s, and *Letters on the Subject of the Utilization of the Metropolitan Sewage* (1865) is unique among Liebig's works in being the one text to be published only in English.[13] Later in his career, he also wrote widely on scientific method. As my chapters examine, English realist novelists engaged with Liebig's ideas across a wide range of social and methodological questions, from public health, agriculture, global trade and questions of resource (re)cycling, to the epistemological tensions between practice and theory, and the ontological relationship between truth and reality. They

[9] Gillian Beer, *Darwin's Plots: Evolutionary Narrative in Darwin, George Eliot and Nineteenth-Century Fiction* (Cambridge: Cambridge University Press, 2009), p. 4.
[10] Munday, 'Justus von Liebig', p. 143.
[11] Brock, *Liebig*, pp. 213-14.
[12] Munday, 'Justus von Liebig', p. 143.
[13] Brock, *Liebig*, p. 254.

often did so at the places where these diverse concerns connected to the soils of urban and rural environments.

Liebig's *Organic Chemistry* marked a decisive shift in the scientific understanding of soils. The pre-existing humus theory was built upon the idea that dead organic matter retained a vitalising spirit or power of animation that lay dormant in the soil. Liebig's inorganic mineral theory fundamentally challenged this vitalist belief. Where plants had previously been thought to assimilate the decaying organic matter of other plant and animal bodies via their roots, and thus to imbibe some nebulous life force, Liebig's new chemistry argued that plants received only inorganic minerals from the soil. Whereas organic compounds are carbon-based and formed almost exclusively in living bodies, inorganic compounds may be formed without life's processes. In essence, then, as organic chemistry focused on chemical cycles in living nature, the emerging science sought to reduce vital processes in and between soils, plants, and animals from an intangible set of unknowns to a quantifiable series of nutrients and reactive processes.[14]

In Liebig's hands, this understanding of soil offered an ideology that would change the world. If fertility alone depended on the presence or absence of certain inorganic compounds, soils were a resource that industrial modernity might enhance and improve. As Liebig wrote in 1840, '[a] time will come when fields will be manured with a solution of glass (silicate of potash), with the ashes of burnt straw, and with the salts of the phosphoric acid, prepared in chemical manufactories'.[15] By Liebig's death in 1873, factory-produced fertilisers were embedded in the global economy. As Brock outlines, factories producing chemical fertilisers soon existed across much of Europe and America, forming a 'multimillion-pound world industry' in the second half of the nineteenth century.[16] My thesis explores the ways mid-nineteenth-century chemistry offered frameworks by which to conceptualise soils as static and inert resources, making them easily assimilable into a particularly rapacious version of capitalism. This chemical model for agriculture has paved the way for exponentially increasing yields over the last century and a half, but at huge

[14] It is worth noting that Liebig was not an outright materialist himself – and would likely have denied any appraisal of his chemistry in materialist terms. His science retained a place for God as Creator. Nevertheless, his science helped to beget a generation of scientific materialists, likely influencing figures such as Karl Vogt, Ludwig Büchner, and Jacob Moleschott. For more on this see: Brock, *Liebig*, pp. 309-12; Pat Munday, 'Sturm und Dung. Liebig's metamorphosis from Organic Chemistry to the chemistry of agriculture', *Ambix*, 38 (1991), pp. 135-54 (142-44). I consider Liebig's seemingly contradictory relationship with vitalism – rejected in his chemistry of soil but retained in his chemistry of the animal body – in chapters 1 and 4.
[15] Justus von Liebig, *Organic Chemistry in its Application to Agriculture and Physiology*, trans. by Lyon Playfair (London: Taylor and Walton, 1840), pp. 187-88.
[16] Brock, *Liebig*, pp. 128, 180.

ecological cost. The effect has been to reduce the diversity and unknowable liveliness of the world's soils to a simple and replicable system of chemical inputs and outputs, an understanding that has led to the intensive monoculture agricultures of twentieth- and twenty-first-century capitalism.

As Lesley Kingsley has recently shown with her work on guano, the nineteenth century saw the increasing application of off-farm nutrients to the soil. Nitrogen-rich seabird excrement was used commercially on British farms for the first time in 1837, forming part of 'the onset of capitalist, intensive agriculture' through which 'the old, closed circle of nutrient cycling was broken apart'.[17] Following early success and confirmation from chemists as to its fertilising properties, this guano was taken from islands off the coast of Peru and sold to European farmers as manure throughout the mid-nineteenth century. My thesis, however, is not specifically about this trade. The last few years have witnessed a growing ecocritical interest in the nineteenth-century extraction of guano, (work that offers a valuable insight into the discovery, use, and exhaustion of a non-renewable resource), but there remains very little work on the wider development and impacts of agricultural chemistry in these years.[18] As Munday writes, '[m]any of our contemporary views regarding the integration of agriculture with the larger economy, the use of inorganic fertilisers, agriculture as a material balance, and chemical cycles in nature were first given clear expression by Liebig in 1840'.[19] As a cornerstone of agricultural intensification, it is surprising that the birth of agricultural chemistry has received relatively little scholarly attention, especially given its lasting social and ecological consequences.

Factory-produced fertilisers were being sold commercially by the mid-1840s. Among the first to conduct field trials on chemical fertilisers was Lyon Playfair – one of Liebig's star pupils and translator of *Organic Chemistry*.[20] Liebig tried to launch a range of manufactured

[17] Lesley Kingsley, 'Guano and British Victorians: An environmental history of a commodity of nature' (unpublished doctoral thesis, University of Bristol, 2020), p. 221.
[18] See, for example, Lesley Kingsley, 'Guano, science and Victorian high farming: An agro-ecological perspective', in *Victorian Sustainability in Literature and Culture*, ed. by Wendy Parkins (London: Routledge, 2018), pp. 126-45.
[19] Munday, 'Justus von Liebig', p. 1.
[20] As Munday reports, Playfair's initial attempts failed due to forces beyond his control. As he reported in an 1842 letter to Liebig, translated by Munday: 'The manure which I call Galloxoid (Greek for "milk for land"!!) I made in this way – I took some fine ground bones, according to your suggestions & mixed it with acids, […] so convinced was I that this would prove a good manure, that I ordered about 4 tons […] of it for experiment + of course I had to send my receipt to a manufacturer to get it prepared. And what think you the ass of a fellow did without telling me. He had a large quantity of caustic soda, which he wished off his hands + he took it [?] the carbonate of soda which [I] had directed. When I received the manure, supposing it prepared according to my directions + began spreading it liberally on my fields to my horror, most of the plants were killed!'. See Munday, 'Justus von Liebig', pp. 208-09.

fertilisers himself, but the early market was cornered instead by John Bennet Lawes and Joseph Henry Gilbert, who formed an amazingly productive and long-lived collaboration at Lawes's Rothamsted farm in Hertfordshire from 1843 to 1900. Profits were immediate, for although the initial intention was never to address Malthusian concerns over population growth, chemical fertilisers found an eager market in a decade of considerable economic and social unrest.[21] As prime-minister Sir Robert Peel opened British farming to foreign competition in 1846 by lifting the protectionist Corn Laws, so famine in Ireland marked the height of the hungry forties in 1848. Progressive farmers were thus primed for the help agricultural chemistry could offer, the new science spreading to the British agricultural community via books on chemical agriculture, the popular press, and meetings of societies such as the BAAS and Royal Agricultural Society of England (RASE).[22]

Agricultural chemistry in the mid-nineteenth century was part of a wider Victorian intensification of British agriculture known as 'high farming'. As P.J. Perry remarks, much of this ethos of agricultural improvement is caught by Tennyson at the end of *The Princess* (1847):[23]

> A great broad-shouldered genial Englishman,
> A lord of fat prize oxen and of sheep,
> A raiser of huge melons and of pine,
> A patron of some thirty charities,
> A pamphleteer on guano and on grain […][24]

Think also of Fred Vincy at the conclusion of *Middlemarch*, writing on 'the "Cultivation of Green Crops and the Economy of Cattle-Feeding"'.[25] High farming generated higher yields across agrarian and livestock production and has generally been seen, in the words of Colin

[21] According to Wolfgang Krohn and Wolf Schäfer, Liebig's chemistry of agriculture was 'provoked by the secular problem of feeding the population'. But as Munday notes, this 'social construction of Liebig' is entirely false; 'Liebig did eventually develop arguments based on these socio-political concerns, but they evolved gradually as he became more obsessed with agricultural chemistry and as he experienced the traumatic events of 1846-48', he writes. See: Wolfgang Krohn and Wolf Schäfer, 'The origins and structure of agricultural chemistry', in *Perspectives on the Emergence of Scientific Disciplines*, ed. by Gerard Lemaine and others (The Hague: Mouton & Co., 1976), pp. 27-52 (32); Munday, 'Justus von Liebig', pp. 149-50.

[22] An 1850 article from *Tate's Edinburgh Magazin*e offers an insight into this process. It was at the Glasgow meeting of 1840 where Johnston's views 'attracted the notice' of certain Scottish agriculturists; 'at their instance', the contributor writes, 'Professor Johnston lectured to the farmers in Paisley, and subsequently repeated his addresses in various parts of Scotland, opening the eyes of the agriculturists to the facts of science, and appealing to the possible increase of profits, against their hereditary prejudices'. Anon., 'High Farming', *Tate's Edinburgh Magazine*, January 1850, pp. 44-49 (47).

[23] P.J. Perry, 'High Farming in Victorian Britain: Prospect and Retrospect', *Agricultural History*, 55.2 (April 1981), pp. 156-66.

[24] Alfred Tennyson, 'Conclusion', *The Princess* (London: Edward Moxon, 1847), ll. 85-89.

[25] Eliot, *Middlemarch*, p. 779.

Duncan, as 'ecologically benign'.[26] Even James Winter – aware of how Britain's 'capacity to lead the rest of Europe in draining resources from less industrially developed parts of the world' acted as a 'domestic conservator' in the nineteenth century – describes a 'highly intensive and, at the same time, sustainable arable farming'.[27] Yet, as my thesis argues, the social and ecological sustainability of food systems within Britain during this period cannot be considered apart from the forces of empire and global capital with which they were enmeshed.[28] In mid-century British agriculture, improvement in farming practice was defined largely in terms of unquestioned and expansionist productionism.

These developments were part of the broader ethos that swept the Victorian world during what Asa Briggs calls the 'The Age of Improvement'.[29] In the context of agriculture, this 'impulse to systematize, rationalize, standardize, innovate and develop', as Winter puts it, emerged through a growing scientific literature and acted on the soils of urban as well as rural environments.[30] Improving urban sanitation was for many a question of moving sewage matter from rapidly expanding towns and cities to ever more distant agricultural land – acting on Viscount Palmerston's observation, quoted widely in the press, that 'Dirt is matter in the wrong place'.[31] As sanitarians worked to improve living conditions for the urban poor, they also sought to foster the improving culture of 'self-help' by which those in the working class might rise to the middle class.[32] Nancy Armstrong has shown how the ethos of improvement acted on the marital home, shaping a bourgeois ideology of the male worker 'as an earner and

[26] Colin A. M. Duncan, *The Centrality of Agriculture: Between Humankind and The Rest of Nature* (Montreal: McGill University Press, 1996), p. 54.
[27] James Winter, *Secure from Rash Assault: Sustaining the Victorian Environment* (Berkeley, CA: University of California Press, 1999), pp. 3, 4.
[28] Even if it were possible to draw an artificial boundary around the domestic experience of high farming, there is reason to believe it was not as 'ecologically benign' as Duncan claims. Consider the fate of the great bustard, one of the world's largest flying birds and the subject of an 1871 article from *The Leisure Hour*: 'once common in this country', the contributor writes, 'high farming has been more fatal to the great bustard than anything else', persecution and loss of habitat entirely extinguishing a once-healthy breeding population. Anon., 'The Great Bustard', *Leisure Hour*, 15 April 1871, pp. 232-34 (232, 234). Great bustards have been reintroduced to Britain in recent years.
[29] Asa Briggs, *The Age of Improvement, 1783-1867* (1959; London: Routledge, 2014).
[30] Winter, *Rash Assault*, p. 5.
[31] Anon., 'Chemical Cleanliness', *Chambers's Journal of Popular Literature, Science and Art*, 14 November 1868, pp. 735-36 (735). See also: 'Nothing Lost', *Chambers's Journal of Popular Literature, Science and Arts*, 20 August 1859, pp. 116-19 (116); 'Sewage of Towns', *The London Review*, 10 September 1864, pp. 286-87 (286). Henry John Temple (Viscount Palmerston) was prime minister between 1855-1858 and again between 1859-1865. His observation pre-empts Mary Douglas's famous description of dirt as 'matter out of place' by more than a century. Mary Douglas, *Purity and Danger: An Analysis of the Concepts of Pollution and Taboo* (1966; London: Routledge, 2001), p. 36.
[32] Samuel Smiles was of course the great exponent of this philosophy. Samuel Smiles, *Self-Help; with illustration of character and conduct* (London: John Murray, 1859).

producer' and the female wife as 'a wise spender and tasteful consumer'.[33] Dickens's fiction is especially full of such characters, Lizzie Hexam and Eugene Wrayburn in *Our Mutual Friend* offering one of several marriages throughout realist fiction of the period to link the economic and domestic worlds of improvement back to the soil. For Brontë, Gaskell, Dickens, and Eliot, the emerging understanding of chemical cultivation offered a discourse to navigate the shifting relations between bodies in the realist marriage plot and to examine the improvement of the human body and self along with the soil.

While my investigation of chemical agriculture addresses a critical neglect within the Environmental Humanities, reading the realist novel alongside organic chemistry also offers an original contribution to the field of Literature and Science. Barri Gold notes that 'the complex relationship between the physical sciences and literature in the Victorian era has, to a surprising degree, been overlooked by literary scholars'.[34] Gold, Tina Young Choi, Allen MacDuffie, and Greg Lynall have all addressed this neglect in the context of energy physics.[35] Nineteenth-century astronomy is another area of the physical sciences to have received considerable scholarly attention.[36] Yet both organic and inorganic chemistry remain little considered, with a book-length study of the nineteenth-century novel and chemistry yet to be written.[37] This is symptomatic of what Mat Paskins has noted to be chemistry's invisibility in modern life – hidden in spite of, or perhaps because of, its status as an enabling science for other fields and industries.[38]

Establishing chemistry in this enabling role was Liebig's central project. As the full title of *Chemical Letters* suggests, (*Familiar Letters on Chemistry: in its relations to*

[33] Nancy Armstrong, *Desire and Domestic Fiction: A Political History of the Novel* (Oxford: Oxford University Press, 1987), p. 59.
[34] Barri J. Gold, *ThermoPoetics: Energy in Victorian Literature and Science* (Cambridge, MA: MIT Press, 2010), p. 27.
[35] Tina Young Choi, 'Forms of Closure: The First Law of Thermodynamics and Victorian Narrative', *ELH*, 74.2 (Summer 2007), pp. 301-22; Allen MacDuffie, *Victorian Literature, Energy, and The Ecological Imagination* (Cambridge: Cambridge University Press, 2014); Gregory Lynall, *Imagining Solar Energy: The Power of the Sun in Literature, Science and Culture* (London: Bloomsbury, 2020).
[36] Pamela Gossin, *Thomas Hardy's Novel Universe: Astronomy, Cosmology and Gender in the Post-Darwinian World* (Aldershot: Ashgate, 2007); Anna Henchman, 'Hardy's Stargazers and the Astronomy of Other Minds', *Victorian Studies*, 51.1 (2008), pp. 37-64; Martin Willis, *Vision, Science and Literature, 1870-1920: Ocular Horizons* (London: Pickering and Chatto, 2011), pp. 57-113.
[37] For articles examining chemistry and the realist novel, all of which seem to focus on Dickens, see: Louise Henson, '"Phantoms Arising from the Scenes of Our Too-Long Neglect": Charles Dickens, Victorian Chemistry, and the Folklore of the Ghost', *Victorian Review*, 26.1 (2000), pp. 6-23; Tyson Stolte, '"Putrefaction Generally": *Bleak House*, Victorian Psychology and the Question of Bodily Matter', *Novel: A Forum on Fiction*, 44.3 (Fall 2011), pp. 402-23; Matthew Ingleby, 'Chemistry versus Biology: Dickens, Malthus, and the Familiarized Doppelgänger', *Victorian Review*, 39.2 (Fall 2013), pp. 97-113.
[38] Mat Paskins, 'Fragile Chemical Forms in Literature and Ethnography', conference paper given at 'Environments of Literature and Science', British Society for Literature and Science Winter Symposium, Cardiff University, 24 November 2018.

Physiology, Dietetics, Agriculture, Commerce, and Political Economy), he saw his science as finding applications across industrial modernity. He believed that chemistry could reform medicine and industry along with agriculture – what Brock calls an 'obsessive determination to make chemistry the fundamental science for modern societies'.[39] And in arguing vehemently that 'chemistry really is the most fundamentally central and useful of all the sciences', he wrote profusely.[40] It was as literature that he brought the discipline of organic chemistry into being and through literature that he advanced the vast range of applications this science has come to find, both in his lifetime and since.

This astounding publication output reflects a desire to write a discipline and a profession into existence. As Liebig recalled in an autobiographical sketch written in later life, when asked at school what he would become, 'I answered that I would be a chemist, [upon which] the whole school […] broke into an uncontrollable fit of laughter, for no one at the time had any idea that chemistry was a thing that could be studied'.[41] While the anecdote is surely exaggerated, the sketch reveals much about how Liebig saw the development of his science. His interest in chemistry was first stimulated by helping his father, a merchant who made paints, varnishes and polishes in 'his small laboratory'.[42] Young Liebig was especially captivated by 'read[ing] the books which guided [his father] in his experiments', and later acknowledged this reading as crucially formative:[43]

> I am quite sure that this manner of reading was of no particular use so far as acquisition of exact knowledge is concerned, but it developed in me the faculty, which is peculiar to chemists more than to other natural philosophers, of thinking in terms of phenomena; it is not very easy to give a clear idea of phenomena to any one who cannot recall in his imagination a mental picture of what he sees and hears, like the poet and artist for example. Most closely akin is the peculiar power of the musician […] There is in the chemist a form of thought by which all ideas become visible to the mind as the strains of an imagined piece of music.[44]

Liebig saw an enduring connection between his science and imagination, an imagination trained and developed by formative reading. This love of reading continued throughout his life and extended far beyond scientific works; he wrote in 1867 that 'I am a friend of English

[39] Brock, *Liebig*, p. 331.
[40] Brock, *Liebig*, p. xi.
[41] Justus von Liebig, 'Justus von Liebig: An Autobiographical Sketch', *The Popular Science Monthly*, 40 (1891-1892), pp. 655-66 (658). It is likely Liebig wrote this sketch in the early 1860s, when he was around sixty, but the manuscript was lost, only to be found and finally published thirty years later, and almost twenty years after Liebig's death in 1873.
[42] Liebig, 'Autobiographical Sketch', p. 655.
[43] Liebig, 'Autobiographical Sketch', p. 655.
[44] Liebig, 'Autobiographical Sketch', p. 656.

literature, and I read almost more English than German works'.[45] My thesis argues for the formative influence of Dickens and Eliot on Liebig's later science. Looking also beyond the influence of individual authors, I draw out how imagination and analogy suffuse his work, arguing that literary form and scientific knowledge-making were imbricated in Liebig's organic chemistry to a remarkable degree.

My next section outlines the ecological methodology my thesis employs for reading chemistry in tandem with literary realism. Beforehand, I would like to close this section by noting that Liebig's commitment to making chemistry the central science for industrial societies existed in tension with something of an ecological sensibility. 'Only relatively recently', Brock writes, 'has come recognition of the significance of [Liebig's] denunciations and warnings concerning *Raubbau,* our prevalent current exploitative system of civilization that pillages Nature and breaks her own chemical laws of recycling'.[46] Munday writes similarly, noting that 'despite the overwhelming success (economically and industrially) of fertiliser factories in Liebig's lifetime, in later years he did not seem fully at ease with the idea. Perhaps he felt guilt over, or had never intended, the wholesale waste of non-renewable resources'.[47]

Yet although both Munday and Brock were writing in the 1990s, Liebig's name is still little known, and his work rarely read, in either the fields of Environmental Humanities or Literature and Science. This is surprising, because his extensive writings on sewage, for example, were a response to what he feared would be the 'complete exhaustion' of Europe's soils by intensifying agriculture and the rapacious use of non-renewable resources.[48] His work stimulated Marx's theorising of metabolic rift, an idea that contemporary scholarship frequently returns to, but rarely with an awareness of the formative role of Liebig's chemistry on Marxist thought.[49] And Liebig's law of the minimum, (his identification that organic growth is limited by the scarcest resource or nutrient), remains a central tenet of

[45] Justus von Liebig, 'Was Lord Bacon an imposter?', *Fraser's Magazine,* April 1867, pp. 482-95, (484). It was Brock's biography that first alerted me to Liebig's love of English literature. Brock, *Liebig*, p. 305.
[46] Brock, *Liebig*, p. xi.
[47] Munday, 'Justus von Liebig', p. 294.
[48] Justus von Liebig, 'Baron Liebig and Alderman Mechi', *The Times*, 23 December 1859, p. 6.
[49] Kohei Saito's work is a notable exception. Kohei Saito, 'Liebig and *Capital*', in *Karl Marx's Ecosocialism: Capital, Nature, and the Unfinished Critique of Political Economy* (New York: New York University Press, 2017), pp. 141-175. I give a full definition of metabolic rift at the start of chapter 2. John Parham puts it like this: 'Related to a decreasing agricultural and increasing industrial and urban population, metabolic rift refers to a carrying away of soil nutrients, most notably in food and fibre production, that strips the land of its "vitality" and fertility and then "destroys the health of the urban worker" once these nutrients end up as waste, putrefying and polluting'. John Parham, 'Biggish data: Fredrich Engels, material ecology, and Victorian data', *European Journal of Culture and Political Sociology,* 6.3 (2019), pp. 344-64 (346).

contemporary ecological science, applied to biological populations and ecosystems. The ecology of literature and science my thesis explores holds two Liebig's in tension, then – an emerging ecological sensibility often contradicting his arguments for chemical industry and vice versa.[50] This ecological method for reading literature and science thus offers a framework for examining fictional and scientific writing in both dialogue and divergence, a non-determinist model to see ecological thought developing in sometimes surprising directions.

Ecologies of Literature and Science

The frameworks by which scholars read literature and science are largely unchanged from the founding of the field in the 1980s. Writing on a 'shared discourse' in *Darwin's Plots*, Beer famously shows that 'the traffic, then, was two way'; her formulation sees 'not only *ideas*, but metaphors, myths, and narrative patterns' shared freely across imaginative fiction and scientific writing.[51] This foundational model for reading literature and science exists alongside George Levine's 'one culture'. Though a necessary counter to C.P. Snow's 'two cultures', Levine emphasises that his formulation 'promises a unity we will not find':[52] 'Indeed, one of the points that needs most elaboration', he writes, 'is the *nature* of the differences between literary and scientific language, and the implication of those differences for our sense of the two enterprises'.[53] Thus, while Beer's two-way traffic and Levine's one culture both model the reciprocal yet dissonant mutual influences of imaginative fiction and scientific writing, they suggest quite different frameworks for reading these texts in tandem. In spite of Levine's assertions to the contrary, the idea of 'one culture' risks making relationships between the two sound overly harmonious, eliding the discordance and uneven power relations that characterise their associations. Two-way traffic has the opposite problem. Though ideas, metaphors and narrative patterns are shown to move across related spheres of work, a distinction drawn between imaginative fiction and scientific writing may be in danger of widening back into two distinct cultures; and it is striking how one-way the traffic often still seems – scientific knowledge frequently seen to impact fiction while the

[50] Paul Young's brilliant chapter on Liebig's meat processing business in South America (an aspect of Liebig's work that my thesis does not touch on) encapsulates some of these tensions. Paul Young, 'The Land that England Lost: W. H. Hudson's *The Purple Land*, Liebig's Extract of Meat Company, and the romance of the outlands', in *Victorian Sustainability in Literature and Culture*, ed. by Wendy Parkins (London: Routledge, 2018), pp. 180-203.
[51] Beer, *Darwin's Plots*, p. 5; emphasis in original.
[52] George Levine, ed., *One Culture: Essays in Science and Literature* (Madison: University of Wisconsin Press, 1987), p. 3.
[53] Levine, *One Culture*, p. 4; emphasis in original.

action of literary form in scientific knowledge-making remains less well examined. Beer would strongly deny any echoes of Snow in her two-way traffic, just as Levine would argue vehemently against an easy sense of unity in his formulation of one culture. Nevertheless, taken as headline statements on the relationship between imaginative fiction and scientific writing, there remains something unsatisfying, I think, in these models for reading literature and science.

Literature and science scholars continue to explore the limits and possibilities of these two models. As Martin Willis writes, 'the paradigm of science and literature as two separate cultures has continued its strong influence', with studies invariably framed to examine 'the use of literary devices in science writing and the influences of scientific ideas on imaginative literature'.[54] For Ralph O'Connor, this problem is inscribed in the name of the field – the 'defining dyad "literature and science" which invites us unconsciously to apportion texts to each category'.[55] Even the best studies struggle to escape this dyadic relationship. Allen MacDuffie, for example, takes both Beer and Levine as his models for reading thermodynamic science and the Victorian novel, noting 'a shared cultural context and a multi-directional traffic' across the two.[56] This, he points out, 'is not to say that the practices of literature and science were indistinguishable to the Victorians, but that they often functioned as complementary forms of knowledge production'.[57] As MacDuffie's study eloquently shows, however, this relationship was as frequently marked by discordance as by complementarity. The line is a fine one, then, between emphasising the interdependence of literature and science while avoiding the sense of a single culture free from discord, and at the same time noting divergence in their reciprocal influences without the sense of two entirely distinct cultures or spheres of work.

It is this line that my thesis aims to tread. Framing my study as an ecology of literature and science, I propose a model for reading imaginative fiction and scientific writing that looks to overcome the possible pitfalls of Levine's one culture and Beer's two-way traffic. Like so much in the field of Literature and Science, my argument takes its cue from Beer herself. 'An ecological rather than a patriarchal model is most appropriate', she writes, 'in studying [Darwin's] work'.[58] Extending this ecological model, my thesis reframes the

[54] Willis, *Vision*, p. 8.
[55] Ralph O'Connor, 'The Meanings of "Literature" and the Place of Modern Scientific Nonfiction in Literature and Science', *Journal of Literature and Science*, 10.2 (2017), pp. 37-45 (38).
[56] MacDuffie, *Energy*, p. 17.
[57] MacDuffie, *Energy*, p. 17.
[58] Beer, *Darwin's Plots*, p. 8.

field's 'defining dyad' by highlighting, as O'Connor puts it, 'the relationships between scientific knowledge and literary form'.[59] Ecologies of literature and science emphasise the messy, uneven, discordant interactions of scientific practice and literary form in the production of knowledge – knowledge production in which both scientific and novelistic writing of course participate. This discordance is allowed to contradict and inflect the complementarity, coherence, and mutually beneficial relationships of which such ecologies are also formed. In other words, to place 'ecologies of' before 'literature and science' opens the nature of the relationships that the 'and' might signify.

Liebig's science is well placed for such a study. Though I suggest no direct link from Brontë and Gaskell to Liebig, my first two chapters together draw out the central place of literary form in *Organic Chemistry*. My final two chapters take a more direct approach, suggesting that Liebig's reading of *Bleak House* influenced how he saw the relations between thermodynamics and chemistry, and arguing that he revised his scientific method in response to Eliot's and Lewes's realist theories of truth and reality. Taken together, my four chapters offer complementary frameworks by which to trace ecologies of literature and science: Brontë's favourite periodicals, Gaskell's place in Manchester's intellectual community, Dickens's and Liebig's mutual admiration and reading, and the friendship that blossomed between Liebig, Eliot and George Lewes – all suggest paths of intellectual exchange. My chapters thus offer varied ecologies of literature and science that move from a shared cultural sphere in chapter 1 and the intellectual culture of a city in chapter 2, to mutual reading in chapter 3 and conversations enjoyed over dinner in chapter 4. In this way, as my thesis progresses, the focus falls evermore tightly on the conceptual crossover and engagement of mid-century chemists and novelists around questions of soil. To borrow O'Connor's words once more, my thesis thus frames '"literature and science" [not] as an implicit dichotomy […] but as two categories which operate at different conceptual levels and thus overlap more intimately'.[60] To trace the action of soils in the foundational practices of both organic chemistry and literary realism is to explore just such a point of overlap.

The term ecology suggests a method, a discipline, and a subject of investigation. By ecologies of literature and science, I refer primarily to networks of knowledge production. Yet it is no coincidence that these networks seek to understand increasing complexity across the human and non-human world at a time when ecology, as a scientific discipline, was

[59] O'Connor, 'Meanings of "Literature"', p. 43.
[60] O'Connor, 'Meanings of "Literature"', p. 43.

emerging. Coined by Ernst Haeckel in 1866, the term appeared in English in 1875.[61] While my study closes during the years when the science of ecology was being defined, 'the *idea* of ecology is much older than the name'.[62] For Donald Worster, '[i]ts modern history begins in the eighteenth century, when it emerged as a more comprehensive way of looking at the earth's fabric of life: a point of view that sought to describe all of the living organisms of the earth as an interacting whole, often referred to as the "economy of nature"'.[63]

Yet the nineteenth century offers not only a nexus in the development of the science, but a challenge to this organicist sense of an interacting whole. Devin Griffiths and Deanna Kreisel make this argument in their recent special issue of *Victorian Literature and Culture*, 'Open Ecologies'. 'If modern ecocriticism has been hobbled by a restrictively organic, harmonious conception of how ecologies work', they argue that 'a return to Victorian interrogations of natural and social collectives can furnish more open, less integrated models for how assemblages operate'.[64] Avoiding an easy historical determinism in the development of ecology, my thesis shows that these interrogations may suggest the subsequent development of the science, or they may diverge from it. Sharing a focus on soils, novelists and scientific practitioners of the mid-nineteenth century formulated knowledge of ecological complexity that is multi-perspectival, often contradictory, and always multivalent. For in the words of Barri Gold, 'art, literature, and science work together to form and reform the world'; Gold's reading of energy transfer in the nineteenth-century novel shows that 'art and literature may even come first', with writers such as Dickens 'upstream' of thermodynamics.[65] The mid-nineteenth-century realist novelists my thesis explores are, in this sense, 'upstream' of ecology.

Openness is integral, then, to both the material ecologies that can be traced through nineteenth-century soils and the ecologies of knowledge production that seek to understand them. These two senses of ecology are not distinct categories in my thesis. Where ideas, metaphors and narrative patterns move in dynamic interrelation across scientific practice and literary form, knowledge of soils is produced that is shaped by, and materially shapes, lived ecologies in the world. Knowledge and matter, in other words, are mutually constituting. As such, I avoid drawing a straightforward distinction between open ecologies in realism and

[61] See Nathan K. Hensley and Philip Steer, eds., *Ecological Form: System and Aesthetics in the Age of Empire* (New York: Fordham University Press, 2018), p. 9.
[62] Donald Worster, *Nature's Economy: The Roots of Ecology* (San Francisco: Sierra Club Books, 1977), p. xiv.
[63] Worster, *Nature's Economy*, p. xiv.
[64] Devin Griffiths and Deanna K. Kreisel, 'Introduction: Open Ecologies', *Victorian Literature and Culture*, 48.1 (2020), pp. 1-28.
[65] Gold, *Thermopoetics*, p. 14.

closed mineral economies of chemical science. The soils of *Middlemarch*, for example, seem to frame exactly this divergence. But considered again, the plot structure of the realist novel can be thought as a closed (narrative) system, while the 'vital force' Liebig allows into his chemical science evinces a radical and unknowable openness in scientific understanding of nature's processes.[66] The relations between these senses of closure and openness evidence, once more, the reciprocal yet disharmonious exchanges taking place within ecologies of literature and science. They are part of, what Griffiths and Kreisel term, 'those messy, contested, and often violent histories through which cultural and natural systems continue to produce each other', and to which I now turn in the context of nineteenth-century soils.[67]

Decolonising Soils

The standard ecocritical account of nineteenth-century soil remains Jonathan Bate's assertion that, as rural populations moved from country to city, local connections to soils were lost. Bate traces this demographic shift in the shifting definitions of the word 'culture', building on Raymond Williams's deconstruction of the term in *Keywords*.[68] The nineteenth century saw the original sense of the word, as in 'a cultivated field or piece of land', supplanted by the newer associations of mental cultivation.[69] As the majority of the British population became urban dwellers in 1851, so 'the association of cultivation with the mind obliterates the old root of the word in the literal earth'.[70]

My thesis traces a parallel reality, one that Bate's argument of disconnection from soil elides. As the forces of British colonialism, capitalism and chemistry networked the world's soil fertility through increasingly intensive and globalised agricultures, so peoples, animals, plants, and soils became – often precisely because of their topographical removal – ever more entangled. To accept the thesis of increasing disconnection from soils risks being complicit in the violences associated with the ways British imperialism acted, both at home and abroad, to isolate soil fertility and to channel it into increasingly intensive models for agricultural production. Bate's argument brings to mind Nathan K. Hensley and Philip Steer's recent comments regarding a 'schism between ecological and postcolonial approaches' in literary criticism, 'one concerned with nonhuman or "natural" actors, stories, and causal accounts and

[66] Liebig, *Chemical Letters*, p. 166.
[67] Griffiths and Kreisel, 'Open Ecologies', p. 7.
[68] Raymond Williams, 'Culture', in *Keywords: A Vocabulary of Culture and Society* (1976; Oxford: Oxford University Press, 2015), pp. 62-66.
[69] Jonathan Bate, *The Song of the Earth* (London: Picador, 2000), p. 3.
[70] Bate, *Song*, p. 16.

the other with human – that is, socio-political – ones'.[71] My thesis contributes to a growing body of work addressing this schism by emphasising the often exploitative, extractive, and uneven connections through which human lives were entangled with soils, and indeed the lives of other humans, animals, and plants, throughout the mid-nineteenth century.[72] Pertinent today, my work resists placing nature and culture in binary opposition in order to emphasise how human health, and indeed the health of all life, is intimately connected to soil health.

My efforts to uncover soil-related violences in the mid-century realist novel are lent impetus by contemporary moves towards decolonisation. For Josie Gill, 'the decolonization movement as a whole questions the integrity of the academy and challenges academics as producers and reproducers of knowledge to consider how that knowledge – and the methodologies adopted for acquiring it – might be exclusionary, exclusive, and indifferent to inequality and injustice'.[73] Reading organic chemistry, I take up Gill's challenge to 'evaluate [and] critique scientific concepts themselves', exposing how the mid-nineteenth-century's chemistry of soils and extractive imperialism were bound together.[74] Nevertheless, reading the nineteenth century's canonical realism may seem an unlikely starting point for scholarship aiming, borrowing Gill's words once more, 'to examine the institutional structures and orders of knowledge that we reproduce in our work, and to understand how this connects to the humans for whom we feel pity but might keep separate from our intellectual thought'.[75]

Yet one way realist novels work to overcome such separation is by showing the violence perpetrated against marginalised populations. The violence I refer to here is largely the 'gradual', 'out of sight', and 'attritional' assaults on human life that Rob Nixon terms 'slow violence'.[76] Consider the passages in *Our Mutual Friend* where Bella Wilfer eats at a

[71] Hensley and Steer, *Ecological Form*, p. 6.
[72] Hensley and Steer perhaps slightly overstate their case. Locus classicus here is Raymond Williams, *The Country and the City* (1973; London: Vintage, 2016). More recent but still foundational studies by Mike Davis, Patrick Brantlinger, and Rob Nixon address exactly this schism between postcolonial and ecological approaches: Mike Davis, *Late Victorian Holocausts: El Nino Famines and the Making of the Third World* (London: Verso, 2001); Patrick Brantlinger, *Dark Vanishings: Discourse on the Extinction of Primitive Races, 1800-1930* (Ithaca, NY: Cornell University Press, 2003); Rob Nixon, *Slow Violence and the Environmentalism of the Poor* (Cambridge, MA: Harvard University Press, 2013). In the last three to five years, scholarship merging postcolonial and ecological approaches has seen a dramatic uptake. See, for example: Kathryn Yusoff, *A Billion Black Anthropocenes or None* (Minneapolis: University of Minneapolis Press, 2018); Elizabeth Hope Chang, *Novel Cultivations: Plants in British Literature of the Global Nineteenth Century* (U of Virginia P, 2019); Emily Waples, 'Breathing Free: Environmental Violence and the Plantation Ecology in Hannah Craft's *The Bondswoman's Narrative*', *Victorian Literature and Culture*, 48.1 (2020), pp. 91-126.
[73] Josie Gill, 'Decolonizing Literature and Science', *Configurations*, 26.3 (2018), pp. 283-88 (284).
[74] Gill, 'Decolonizing', p. 285.
[75] Gill, 'Decolonizing', p. 287.
[76] Nixon, *Slow Violence*, p. 2.

Greenwich restaurant while 'the beggar-boys below the window […] put their heads in the mud'.[77] As my third chapter shows, the novel works to link the horrifyingly intimate relationships these children have with soils to the dinner Bella enjoys above, exposing how chemical agricultures and capitalist trade together make nutrients accessible to some as fine food but inaccessible to others as putrefying mud. Thus the death of Jo in *Bleak House* exposes the disease and malnutrition that extends causally from the 'black mud and corrupt water' where sewage collects in sites such as Tom-all-Alone's or the Thames riverbank – matter that might be valuable in another context as manure.[78] All my chapters reveal similarly hidden yet violent entanglements of soil and people. Plantation agriculture supports the world of *Jane Eyre*, extraction that emerges in the form of Bertha Mason. As 'Parliament' refuses 'to set trade free' by repealing the Corn Laws in *Mary Barton*, the Manchester poor are left 'dying away, for very clemming'.[79] And while Mr Brooke may hope to steer clear of such 'muddy political talk' with Mr Dagley in *Middlemarch*, the rural poor experience the 'depression of the agricultural interest and the sad lack of farming capital' far more keenly than the landowner.[80] The interrelated slow violences of colonial dispossession, malnutrition, and structural inequality inevitably precede the more conventional violence of social unrest. The conflagration that consumes Thornfield Hall, the riots that engulf Thornton and Margaret in *North and South*, and the (admittedly more humorous) interruptions to Brooke's election speech in *Middlemarch* are far from isolated moments in realist narrative. They emerge as the concerted reaction against slow violences traced to the extractive and exploitative treatment of soils and peoples in the mid-nineteenth century.

Yet in making this argument, it would be wrong to collapse the experiences of different populations and soils into a single homogenous narrative. While literary realism exposes violence, the form also perpetrates and extends it. Scholars have long acknowledged that, as realist novels highlight the suffering of disadvantaged populations, their narrative solutions resort to an unsatisfying sense of moral uplift through marriage and education. In Elizabeth Gaskell's novels, for example, the period's cultures of improvement function to suppress the revolutionary implications that emerge from her cross-class studies. I show that *Jane Eyre*, *North and South*, *Our Mutual Friend*, and *Middlemarch* function to varying

[77] Charles Dickens, *Our Mutual Friend*, ed. and intro. by Michael Cotsell (1864-65; Oxford: Oxford University Press, 2008), p. 319; see also p. 670.
[78] Charles Dickens, *Bleak House*, ed. and intro. by Nicola Bradbury, preface by Terry Eagleton (1852-53; London: Penguin, 1996), p. 358.
[79] Elizabeth Gaskell, *Mary Barton*, ed. and intro. by Shirley Foster (1848; Oxford: Oxford University Press, 2006), pp. 86, 64.
[80] Eliot, *Middlemarch*, p. 370.

degrees within a chemical imaginary that subjugates women into a (re)productive capitalism. Fixing characters such as Jane Eyre, Margaret Hale, Lizzie Hexam, and Dorothea Brooke in the roles of wives and mothers, the realist improvement plot acts to release fertility in the service of future economic production. These women are treated like soils, then – as so many fertile natures to be made productive

Thus imbued with the cultures of improvement that defined economic and social life during the period, parallel violences extend within these novels from the marital home to the most distant soils. I refer here not only to the colonial locations that Elaine Freedgood has shown 'underwrite' the worlds of realism, but the lands beyond the Empire that, as Paul Young explains, 'Britain's principal position within a growing and increasingly interconnected world economy' offered access to.[81] Networked by capitalism in remarkably similar ways, peoples and soils both at home and abroad become opportunities for production. When reading realist novels for the social and ecological violences they expose, then, it is vital to uncover the harm that these texts also elide and facilitate.

This is especially important when it comes to the overbearing absence of non-white voices in realist narrative. Edward Said's claim that 'imperialism bears upon the production of literature' and that nineteenth-century novels, in return, serviced 'broadly imperialist view[s] of the world' remains true today.[82] In this way, English literary realism functioned as a part of 'hegemonic systems' by which the Empire maintained control through the globalising forces of capitalism and colonialism.[83]

To explain my intervention here, I need to define how I use the terms 'local' and 'global' in this thesis. Like Anna Tsing, I use them advisedly, referring to the global 'not [as] a claim to explain everything at once' or to offer 'seamless generalisations' through grand theory.[84] Instead, by globalised agricultures, I refer to a chemical model for agricultural production, developed in certain laboratories and fields in Western Europe in the mid-nineteenth century, and translated to various soils across the world. In this respect, chemistry offers an example of, what Tsing terms, 'knowledge that moves across localities and cultures'.[85] The science allowed diverse soils and ecologies to be conceptualised as fertility

[81] Elaine Freedgood, *The Ideas in Things: Fugitive Meaning in the Victorian Novel* (Chicago: University of Chicago Press, 2006), p. 90; Paul Young, 'Dickens's World-System: Globalized Modernity as Combined and Uneven Development', in *The Oxford Handbook to Charles Dickens*, ed. by J.O. Jordan, R. Patten and C. Waters (Oxford: Oxford University Press, 2018), pp. 703-21 (705).
[82] Edward W. Said, *Orientalism* (London: Penguin, 1995), pp. 14, 15.
[83] Said, *Orientalism*, p. 14.
[84] Anna Tsing, *Friction: An Ethnology of Global Connection* (Princeton: Princeton University Press, 2005), pp. ix, xi.
[85] Tsing, *Friction*, p. 7.

and compared quantitively in terms of potential production. By following Donna Haraway in refusing to theorise the world 'in terms of Global Systems', then, I examine how realist narrative works in contradictory ways to distinguish, obscure, and generate an 'earth-wide network of connections' that facilitated this spread of chemical agriculture.[86] By paying attention to 'the local sites that manufacture global structures', as Bruno Latour emphasises, the soil-shaping forces of chemical science can be situated in 'local […] micro place[s]' such as Liebig's Giessen laboratory and Lawes's Rothamsted farm.[87] What is more, when applying Latour's actor-network approach to the worlds of realist narrative, 'each site becomes the result of that action at a distance of some other agency'.[88] It is when these agencies become difficult or impossible to fully account for that an actor-network approach makes the silences of realist narrative, with regard to non-white voices, for example, painfully obvious.

Gaskell's realism offers an example of this silencing in action. When Richard Hale echoes John Thornton in celebrating the 'gravelly soil' of his new Milton home in *North and South*, Gaskell highlights local geological difference as contributing to personal and public health.[89] At the same time, the novel vocalises a universalising belief in land drainage that facilitates a colonial ethic of clearance elsewhere. Jem and Mary's emigration to Canada at the conclusion of *Mary Barton* offers exactly this vision of 'the old primeval tress felled and gone for many a mile around'.[90] While Gaskell's fiction explores questions of sanitation for the urban poor through the chemistry of Manchester's scientific community, her novels unwittingly trace a broader network of knowledge production and translation extending from England to shape soils and ecologies on other continents. Absent from this network are the voices, knowledges, and lives of those who once called 'the old primeval trees' home. An actor-network approach makes colonial dispossession present in realist narrative by its absence. Recognising these absences can help expose, what Leilani Nishime and Hester Williams call, the 'multiple ways in which the neglect of certain kinds of communities reproduces racial categories and how the systematic dispossession of targeted groups is

[86] Donna J. Haraway, 'Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective', *Feminist Studies*, 14.3 (1988), pp. 575-99 (579-80)
[87] Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network-Theory* (Oxford: Oxford University Press, 2005), p. 176.
[88] Latour, *Actor-Network-Theory*, p. 219.
[89] Elizabeth Gaskell, *North and South*, ed. by Angus Easson, intro. by Sally Shuttleworth (1854-55; Oxford: Oxford University Press, 1998), p. 64.
[90] Gaskell, *Mary Barton*, p. 378.

reduced to a naturalized difference'.[91] As in the conclusion of *Mary Barton*, this difference is of course naturalised in precisely those moments where it does not even bear comment. In this way, each of my chapters expose perspectives silenced in the co-developing chemical, colonial and capitalist exploitation of soils. For those resistant to – or deemed to be beyond – the civilising work of improvement lies extinction.[92]

My focus here remains largely on the Atlantic world, specifically the soils and peoples of England, North America, the Caribbean, and West Africa. This is partly a question of space – nineteenth-century histories of subjection under British dominion might well be drawn out through the soils and peoples of India, China, and Australia, for example.[93] But it also recognises the important position of the Atlantic region in supplying 'cheap nature' to support British economic growth during these years. 'The full flower of English industrialization (1840s-1870s) occurred just as the American Midwest became capitalism's newest breadbasket', writes Jason Moore.[94] 'There was a distinctive vortex of nature, capital, and cultivation at the dawn of this new, American-led, agricultural revolution'.[95] In this way, when Job Legh discusses setting trade free in *Mary Barton*, his words extend far beyond industrial Manchester, giving a sense of what Mary Ellis Gibson calls the 'networked local' of the provincial novel.[96] The repeal of the protectionist Corn Laws helped fuel industrial growth, (the domestic violences of which form the subjects of Gaskell's industrial fiction), by networking distant soil fertility into an increasingly global capitalism. As the economies of capital shaped the mineral economies of soil, then, so soils and peoples were together incorporated into an industrial economy. A reading of soil in mid-century realist fiction cannot then ignore either the extinction of indigenous peoples in North America or the transportation of indentured peoples from Africa, genocidal violences that emerge through an expansionist and productionist ethos of improvement applied to people and the land both within and beyond English shores.

---

[91] Leilani Nishime and Kim D. Hester Williams, eds., *Racial Ecologies* (Seattle: University of Washington Press, 2018), p. 5.
[92] For more on this see Brantlinger, *Dark Vanishings*.
[93] Although not focusing specifically on soil, several studies have shown the possibility of such readings. Patrick Brantlinger has examined the extinction of indigenous populations in Australia and the Pacific islands in great detail in *Dark Vanishings*. Elaine Freedgood reads tobacco and aboriginal genocide alongside Dickens's *Great Expectations* in *Ideas in Things*, pp. 81-110. Sukanya Banerjee has recently read *Mary Barton* alongside the Indian cultivation and manufacture of cotton. Sukanya Banerjee, 'Ecologies of cotton', *Nineteenth-Century Contexts*, 42.5 (2020), pp. 493-507.
[94] Jason W. Moore, *Capitalism and the Web of Life: Ecology and the Accumulation of Capital* (London: Verso, 2015), pp. 246-47.
[95] Moore, *Capitalism*, p. 247.
[96] Mary Ellis Gibson, 'Regionalism and Provincialism: Where is the Local?', in *The Routledge Companion to Victorian Literature*, ed. by Dennis Denisoff and Talia Schaffer (London: Routledge, 2019), pp. 449-61 (451).

When Thomas Malthus predicted disaster from exponential population growth at the turn of the nineteenth century, he could not have foreseen how developments in farming would lead to a similarly exponential increase in food production. As MacDuffie writes, 'the astonishing expansion of industry and the development of agricultural chemistry soon increased human productive power to levels Malthus could not have imagined in 1798'.[97] Chemistry and capitalism together networked the world's soil fertility in the service of increasing agricultural and industrial production. Yet even Liebig, instrumental in establishing chemistry's agricultural applications, warned that Western civilisation was likely to end by 1900 unless alternative fertilisers to Peruvian guano were found.[98]

The (as yet) erroneous nature of Malthus's and Liebig's predictions shows the scarcely imaginable increase in crop yields that manufactured chemical fertilisers have made possible. However, as Raymond Williams noted long ago, these increased yields cannot be separated from the violent exploitation and extraction experienced under this same capitalist agricultural system.[99] They form two versions of the same story, versions that realist novels hold in tension. It is increasingly clear that the yields of chemical agriculture, when examined in terms of human history, are likely to mark only a temporary rise in productivity before precipitous and terminal decline – unless alternative farming methods can be found. The ability of novels to hold contradictory perspectives in tension, and in doing so to 'offer […] an examination, and understanding, of science's effects within the human social world', as Willis argues, has never been more vital.[100] To pay attention to soils and science in literary realism is to see the realist novel anew for its interest in matter as well as consciousness, and thus to understand how such narratives generate knowledge of the world that incorporates the human and non-human. As I now outline, it is here that realist narrative remains essential to contemporary efforts to address ecological crises.

Realism in Ecological Crisis

Literary realism is founded on representationalism. As Levine writes, realism 'always implies an attempt to use language to get beyond language, to discover some non-verbal truth out there'.[101] Pam Morris expands on this point, stating that 'the project of realism is founded upon an implicit consensual belief that realities do exist "out there" beyond linguistic

[97] MacDuffie, *Energy*, p. 3.
[98] Liebig, 'Baron Liebig and Alderman Mechi', p. 6.
[99] Williams, *Country and the City*, p. 52.
[100] Willis, *Vision*, p. 8.
[101] George Levine, *The Realistic Imagination: English Fiction from Frankenstein to Lady Chatterley* (Chicago: University of Chicago Press, 1981), p. 6.

networks and that we can use language to explore and communicate our always incomplete knowledge of that ever-changing historical materiality'.[102] In representing but never mirroring the world in this way, literary realism is associated with realism in the sciences, as Ian Hacking has noted.[103] He summarises traditional 'scientific realism' as the belief 'that the entities, states and processes described by correct theories really do exist'.[104] In other words, scientific theories are (provisionally) correct when they (are agreed to) represent reality truthfully. Adelene Buckland shows how a representationalist realism emerges across literature and the sciences over the same years during the nineteenth century.[105] Similarly, Peter Garratt demonstrates the ways empiricist discourse acts across the philosophical, scientific and novelistic writing of the Victorian period in providing access – and also probing literature and science's claims – to truth about reality.[106] Garratt's argument thus builds on Levine's acknowledgment that 'the epistemology that lay behind realism was empiricist'.[107]

Brontë, Gaskell, Dickens, and Eliot all foreground an empirical reality so as to distinguish their writing from the more speculative energies of earlier literary forms. They bring the focus of the novel, in this sense, down to earth. To be near to the soil, to represent the dirt of lived experience, is for each to have a faithful understanding of the world – this is the mid-century realist project as I understand it here.

At the same time, however, differences inhere through this earthy realist aesthetic that probe at the boundaries of an empirically verifiable material world. For Brontë in *Jane Eyre*, a commitment to realism exists in tension with the Gothic, supernatural processes which present a challenge to the realist novel as a knowable world that follows laws of structure and sequence. Gaskell's fictions offer an almost sociological account of life in the industrial city, where generating sympathy for the working-class poor involves tracing human bodies and soils in close contact – yet in *Mary Barton* and *North and South*, as these contacts proliferate, they press at the bounds of the novel form, disturbing a unifying sense of narrative closure.

---

[102] Pam Morris, *Realism* (London: Routledge, 2003), pp. 93-94.
[103] Ian Hacking, *Representing and Intervening* (Cambridge: Cambridge University Press, 1983), p. 26.
[104] Hacking, *Intervening*, p. 21. Hacking is actually challenging this traditional understanding of scientific realism. He defines scientific realism in terms of intervention rather than representation. For Hacking, realism in science is based on the ability of scientists to experiment with entities to find out other things – an electron is his example. In order to use an electron to discover other material properties, a scientist must be a realist about the electron's existence.
[105] Adelene Buckland, *Novel Science: Fiction and the Invention of Nineteenth-Century Geology* (Chicago: University of Chicago Press, 2013), p. 26.
[106] Peter Garratt, *Victorian Empiricism: Self, Knowledge, and Reality in Ruskin, Bain, Lewes, Spencer and George Eliot* (Madison: Fairleigh Dickinson University Press, 2010).
[107] Levine, *Realistic Imagination*, p. 18.

Bleak House and *Our Mutual Friend* approach an irrealism that offers insights into the hidden workings of global capital, even as Dickens becomes, in George Eliot's words, 'transcendent in his unreality' when representing the 'psychology' of London's poor.[108] And Eliot herself, perhaps the most self-reflective of all mid-century realists, shapes a novel experiment in *Middlemarch* where the world of Loamshire seems to be forever slipping just beyond her narrator's perspective. As empiricist epistemology forms the superstructure of literary realism, then, so mid-century realists also reflect on their capacity to know the world. In gathering these authors together, I draw out how their varieties of realism, while following a broad epistemological project in proximity to soil, also diverge in their presentation and understanding of the material world.

This work continues a long tradition of reading literary realism as a protean and acutely self-reflective mode of writing. Levine, for example, points to 'nineteenth century writers always self-conscious about the nature of their medium', questioning 'simple faith in the correspondence between word and thing'.[109] Morris also finds 'doubt and ambivalence at the heart of British realism', identifying a tradition that 'question[s] the nature of reality'.[110] As Srdjan Smajić notes, 'the novels we commonly think of as realist have a remarkably liberal understanding of reality'.[111] Nineteenth-century literary realism has been seen by many to question a naive empiricism, then, and each of the novelists I read here have complex and subtly different relationships to truth in soil.

Across literature and the sciences, theories of realism and materialism have always been, as Hacking puts it, 'mixed up'.[112] In recent years, theories of matter and agency put forward by various new materialist thinkers have begun to challenge representationalism as the basis for realism in science. Bruno Latour describes matter as having agency, forming shifting assemblages of human and non-human 'actors'.[113] Stacy Alaimo understands the human body as 'always intermeshed with the more-than-human world', a state of being encapsulated by her term 'trans-corporeality'.[114] These ideas coalesce in Karen Barad's 'agential realism'. 'Matter', Barad writes, 'is agentive, not a fixed essence or property of

[108] George Eliot, 'The Natural History of German Life', *The Westminster Review*, July 1856, pp. 51-79 (55).
[109] Levine, *Realistic Imagination*, pp. 4, 12.
[110] Morris, *Realism*, pp. 80, 86.
[111] Srdjan Smajić, 'Supernatural Realism', *Novel: A Forum on Fiction*, 42.1 (Spring 2009), pp. 1-22 (16).
[112] Hacking, *Intervening*, p. 24. See also Morris, *Realism*, p. 3.
[113] Latour, *Actor-Network-Theory*.
[114] Stacy Alaimo, 'Trans-Corporeal Feminisms and the Ethical Space of Nature', in *Material Feminisms*, ed. by Stacy Alaimo and Susan Hekman (Bloomington, Indianapolis: Indiana University Press, 2008), pp. 237-64 (238).

things', but 'a congealing of agency'.[115] She uses the term 'intra-action' – over interaction – to emphasise the ongoing causal agencies acting across human and non-human entities in the continuous formation of the world.[116] Intra-actions are the foundation of her agential realism, and they make easy distinctions between natural and social, material and discursive, and human and non-human actors impossible. Knowledge of reality here results from intra-acting agencies of matter and measurement. Viewed in this light, there can be no inherent divide between 'objects-in-themselves' and their representations, for both are mutually constituting.[117] Agential realism thus challenges, to borrow Barad's words, 'representationalism's construal of matter as a passive and blank slate awaiting the active inscription of culture whereby the relationship between materiality and discourse is figured as one of absolute exteriority'.[118]

Although these words are primarily meant as a critique of scientific realism, Barad's argument presents a simultaneous challenge to the division of description and reality at the heart of nineteenth-century literary realism. If the form is interested in soil, as I am claiming, then the implication of Barad's critique is that this interest remains passive, soil description serving as what Roland Barthes describes as a reality effect.[119] Seen like this, rather than functioning as part of an open investigation into a dynamic and agential materiality, earth, dirt, and mud all appear in realist fiction so as to give a generic sense of a real and familiar world.

It follows that literary realism, apparently failing to portray the agency of the material world, is inherently unsuited to apprehending ecological crises – an argument put forward recently by Amitav Ghosh. As a literary form 'radically centered on the human', Ghosh views realism as ill-suited to exploring the 'renewed awareness of the elements of agency and consciousness that humans share with many other beings'.[120] He argues that realism's focus on the everyday presents a problem in 'the Anthropocene', where events that seem wildly improbable become common. The increasing frequency of 100-year storms, Ghosh contends, necessitate narrative strategies that realism has long since discarded. He presents epic narratives, de-centred from the human and conceptualising 'universes of boundless space and

[115] Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Durham, NC: Duke University Press, 2007), pp. 137, 151.
[116] Barad, *Meeting the Universe Halfway*, p. 33.
[117] Barad, *Meeting the Universe Halfway*, p. 128.
[118] Barad, *Meeting the Universe Halfway*, p. 150.
[119] Roland Barthes, 'The Reality Effect', in *The Rustle of Language*, trans. by Richard Howard (1984; Berkeley, CA: University of California Press, 1989), pp. 141-48.
[120] Amitav Ghosh, *The Great Derangement: Climate Change and the Unthinkable* (Chicago: University of Chicago Press, 2016), pp. 66, 63.

time', as the literary form to apprehend contemporary ecological crises, where 'forces of unthinkable magnitude […] create unbearably intimate connections over vast gaps in time and space'.[121]

This leaves three related problems for any reading of nineteenth-century literary realism in dialogue with ecological crisis to address. First, that the form's anthropocentric focus elides how matter, discourse, human and non-human life may mutually shape each other. Second, that the everyday scales of realism are ill-suited to apprehending vast ecological crises that make these entanglements of human and non-human agency critical in their long formation and bearing. And third, that narrative closure offers a reductive fantasy to know the world in totality, allowing unforeseen harm to spread elsewhere as agency extends beyond the provincial and anthropocentric bounds of the realist novel. These problems are at once both ontological, challenging a representationalism centred on the human, and epistemological, questioning how realist novels can offer knowledge of the world that can be considered truthful in the Anthropocene.

In response to these challenges, I approach the mid-nineteenth-century novel as an exploration of earth matter as well as human consciousness. As shared ideas of growth and cultivation relate to the character of both soils and people, so to read soils in nineteenth-century English realism is to be confronted with agencies that span both the human and non-human. Soils and peoples are constituted together within the world of the novel in ways that challenge easy distinctions between subject and object, word and thing. My focus thus augments the common conception of a psychological realism by showing how explorations of character in realist narrative encompass matter as well as mind. The form is not as anthropocentric, I suggest, as has been claimed.[122]

Within the novel as representation, meaning may thus be made in ways that challenge divisions between language and reality seen as implicit in a representationalist account of the world. By approaching the novel as an investigation of human development that extends in dynamic relation to the non-human, my thesis exposes moments when the worlds of realist fiction track towards an agential understanding of imbricated human and non-human agencies. My second chapter, focusing on the intra-actions of soils, bodies, and discourse in

[121] Ghosh, *Great Derangement*, p. 63.
[122] A similar claim has been made by scholars in recent years with regards to *Bleak House*. See: John Parham, 'Bleak intra-actions: Dickens, turbulence, material ecology', in *Victorian Writers and the Environment: Ecocritical Perspectives*, ed. by Laurence W. Mazzeno and Ronald D. Morrison (London: Routledge, 2017), pp. 114-29; Jesse Oak Taylor, *The Sky of Our Manufacture: The London Fog in British Fiction from Dickens to Woolf* (Charlottesville: University of Virginia Press, 2016), pp. 21-43.

Mary Barton and *North and South*, develops this argument most fully, but each chapter presents similar instances in different forms: in chapter 1, I show how mind, matter and analytical practice are co-constituted in *Jane Eyre*; chapter 3 reads the soils and bodies of *Bleak House* and *Our Mutual Friend* as shaped by – and shaping – entangled flows of nutrients and capital; and my final chapter exposes how Eliot situates knowledge-making in and through the soils of Loamshire. In each case, it is not that nineteenth-century realist writers somehow anticipate an agential ontology, but that the material-discursive entanglements of contemporary socioecological crises are present too in the social and environmental issues of the period as explored in realist fiction.

The long presents of socioecological breakdown, as scholars such as Jesse Oak Taylor and Liz Miller have recently argued, extend two centuries into the pasts that produced them.[123] Far from being unable to grasp the temporal and topographic scales of ecological collapse, nineteenth-century realism offers the foundational tensions and contradictions of contemporary socioecological challenges refracted back through the lenses of distance and unfamiliarity. If the planetary scales of Ghosh's epic draw attention to climate breakdown's visually arresting disasters (he focuses on tornados and hurricanes), the everyday focus of the realist novel accounts for, what Nixon terms, 'disasters that are slow moving and long in the making'.[124] It must be remembered that global heating intersects too with the spread of disease, famine, and soil degradation, forming cumulative slow violences that disproportionately affect the physical and mental health of certain populations. This addresses the second of the three challenges ecological breakdown presents realist narrative – that the everyday temporalities of realism are unsuited to examining socioecological crises – and points the way to the third, how realist fiction may generate truthful knowledge of those 'unbearably intimate connections' that dictate life in the Anthropocene.

My thesis frames realist novels as situated knowledges of humans in soil. I noted above 'the earth-wide network of connections' that realist narrative may work both to reveal and obscure, and it is Haraway's conception of 'partial, locatable, critical knowledges' that offers a way into realism's capacity to at once apprehend and occlude networked agency.[125] As Haraway emphasises, 'the only way to find a larger vision is to be somewhere in particular', words that speak to George Eliot's focus in *Middlemarch*; 'all the light I

[123] Taylor, *London Fog*, p. 70; Elizabeth Carolyn Miller, 'Drill, Baby, Drill: Extraction Ecologies, Open Temporalities, and Reproductive Futurity in the Provincial Realist Novel', *Victorian Literature and Culture*, 48.1 (2020), pp. 19-56 (33).
[124] Nixon, *Slow Violence*, p. 3.
[125] Haraway, 'Situated Knowledges', p. 584.

command must be concentrated on this particular web', her narrator famously explains, 'and not dispersed over that tempting range of relevancies called the universe'.[126] It is no coincidence that Eliot situates her novels in Loamshire, a region named for a soil that contains plenty of organic matter; as Dorothea Brooke discovers, acting responsibly becomes a question of understanding the relations in which her being is enmeshed and that together coalesce to form the networked lives of the novel.[127] Yet Dorothea is far from the only female protagonist in mid-century realism for whom action is tied to navigating a partial perspective situated within the community and the soil she inhabits. As Margaret Hale discovers and must learn to negotiate, the knowing self is enmeshed within a soiled material world. For Jane Eyre and Esther Summerson, giving a reliable narrative account thus hinges upon knowing this world from a situated perspective. '[T]he knowing self is partial in all its guises, never final, whole, simply there and original', writes Haraway, and the female protagonists of nineteenth-century realism all exhibit subjectivity unfolding in dynamic relation to soil and the material world.[128] Esther's pox-marked face bears the visible scars of a perspective situated within an agential materiality that Jane Eyre, Margaret Hale, and Dorothea Brooke must also, in their own ways, learn to negotiate and assimilate into their being.

But if situatedness is a state of being for realism's female protagonists, surely the realist novel as a whole, where narrative closure serves as what J. Hillis Miller calls 'an enterprise of totalization', is predicated on complete knowledge.[129] The violences perpetrated against these women may then be approached epistemologically – the result of an inability to transcend partial perspective by enacting the masculinist 'god trick', as Haraway calls it, of total knowledge.[130] As realist novels unfold, this is precisely the perspective realist narrators have traditionally been understood to occupy. In this way, realist authors achieve closure, as explained above, by resorting to the governing ideologies of their time – safely containing the revolutionary energies of characters such as Jane Eyre and Lizzie Hexam, for example, in the domestic confines of the marital home.

Elizabeth Ermarth explains that realist novels function by a process of repetition and comparison whereby, as the narrative progresses, 'the details which formerly were understood as discrete cases now come to be understood as partial expressions of hidden

[126] Haraway, 'Situated Knowledges', p. 590; Eliot, *Middlemarch*, p. 132.
[127] Loam denotes a soil that contains roughly equal parts sand, silt, and clay.
[128] Haraway, 'Situated Knowledges', p. 586.
[129] J. Hillis Miller, 'Optic and Semiotic in *Middlemarch*', in *The Worlds of Victorian Fiction*, ed. by Jerome H. Buckley (Cambridge, MA: Harvard University Press, 1975), pp. 125-45 (125). Miller is referring to *Middlemarch* specifically, but his words speak to the mid-nineteenth-century realist project as a whole.
[130] Haraway, 'Situated Knowledges', p. 581.

wholes'.[131] In Ermarth's reading, these wholes refer to truths about human nature and experience, truths that 'are independent of any particular form of visual apprehension or, as in the novel, of apprehension by a single consciousness in a single moment'.[132] So if realist narratives are akin to Haraway's situated knowledges in moving from 'somewhere in particular' to develop 'a larger vision' of the world, the difference, Ermarth would point out, is that through many examples and viewpoints, realist novels purport to offer complete rather than partial knowledge of this world.[133] Viewed in this way, the unifying form of a novel such as *Bleak House*, with an omniscient narrator that portends to be 'everywhere and so nowhere', enacts precisely what Haraway warns against – 'the god trick of seeing everything from nowhere'.[134] Indeed, as Haraway states in her critique of science, her situated approach 'is not a version of "realism", which has proved a rather poor way of engaging with the world's active agency'.[135]

Yet the worlds of realist narrative, unfolding in dynamic relation to soils, are not only explorations of human nature and experience. The 'hidden wholes' of realism, I propose, are disrupted by the networked action of non-human agency. As Caroline Levine explains, 'literary forms have a power […] to set forms against one another in disruptive and aleatory as well as rigidly controlling ways'.[136] The network is an example, Levine explains, of a form that 'cannot be grasped all at once' and thus a form, in the realist novel, that unsettles the 'bounded whole' of narrative closure.[137] I agree with Ermath on how realist novels make knowledge, then, but disagree that realist narrative achieves a unified and totalisable world. As Levine puts it, helpfully using *Bleak House* as her example, 'in order to represent a world of networks, the text must refuse totality' (a reading of Dickens's novel I further at the end of chapter 3). A tension thus opens, seen repeatedly throughout my thesis, between realism's desire for closure and the realisation that, for narrative closure to succeed, the economic and ecological webs realist novels reveal must remain uncontrollably, indeed unknowably, open.

At the point of narrative closure, the harm realist novels oppose escapes along networks that must remain open. Tracing the action of soils in mid-century realism reveals open discord between narrative closure and networked agency across the worlds of realist

[131] Elizabeth Deeds Ermarth, *Realism and Consensus in the English Novel* (Princeton: Princeton University Press, 1983), p. 16.
[132] Ermarth, *Realism*, p. 16.
[133] Haraway, 'Situated Knowledges', p. 590.
[134] Haraway, 'Situated Knowledges', pp. 590, 581.
[135] Haraway, 'Situated Knowledges', p. 593.
[136] Caroline Levine, *Forms: Whole, Rhythm, Hierarchy, Network* (Princeton: Princeton University Press, 2015), pp. 129, 39.
[137] Levine, *Forms*, p. 129.

fiction: Jane and Rochester can only hope to raise a family at Ferndean if wealth continues to be extracted from plantation agriculture; Margaret Hale and John Thornton may only feed Milton's labouring poor if the exploitation of people and soil in North America remains undisturbed; and the continuing prosperity that allows Bella Wilfer and John Harmon to raise their 'inexhaustible baby' depends on the ongoing extraction of nutrient wealth from across the globe.[138] In each case, apparently domestic harmony cannot exist without human and non-human processes remaining active in and through soils on other continents. Novels such as *Jane Eyre*, *North and South*, and *Our Mutual Friend* are in this way typical of realism; they achieve domestic harmony, and so reconcile internal tensions within both the marital home and the nation, at the continuing cost of violence to soils and peoples on other continents. To place the improving ideology of realism alongside the longue durée of socioecological crises, then, begins to show how realist narrative fractures along recurring fault lines between domestic and foreign, internal and external, open and closed.

Realist novels thus reveal a truth about twenty-first century natures under neoliberalism as well as their formative nineteenth-century incarnations under liberalism. Within a network that is radically and unknowably open, simplistic closed solutions will always cause unforeseen harm elsewhere. As realism offers unsatisfactory narrative closure, the form's fractures are generative in revealing how, as socioecological crises extend from the nineteenth century into the present, simple and unifying solutions are unlikely to grasp the complex mix of agencies that bear on the flourishing of human and non-human life into the future. Counterintuitively, literary realism offers a way to embrace partial perspective as a necessary condition of knowing socioecological crises, and thus gives insights into how to act responsibly when enmeshed within crises that are impossible to know in totality.

Realist narratives remain situated within ecological and economic networks that mutually shape each other as they expand beyond the text. The novels I read here inhabit the contradictions and tensions at work in the emergence of industrial modernity. These extend as socioecological crises into our present. Building on Georg Lukács's *Theory of the Novel*, Frederic Jameson has written in recent years of 'realism as a historical and even evolutionary process, in which the negative and the positive are inextricably intertwined'.[139] I approach the contradictions of realism through an ecological lens. These novels are realist because they capture life within the enmeshed human and non-human processes of industrial modernity –

[138] Dickens, *Our Mutual Friend*, pp, 755, 756, 766, 774.
[139] Frederic Jameson, *The Antinomies of Realism* (London: Verso, 2013), p. 8.

lives lived within a closed system that turns out, with destructive and terrifying results, to be open. In this, they offer the most devastatingly truthful knowledge of life in the Anthropocene.

Summary of Chapters

Chapters 1 and 2, encompassing questions of farming and health, trace ecologies of literature and science that develop through discourses shared via the periodical press and within particular locations. The burgeoning scientific agriculture evident in 1840s Yorkshire forms the focus of my first chapter, '"We are not to conform to nature": Sustaining Improvement in *Jane Eyre* and the Science of Agriculture'. Here I draw out broad links between novel form and networked soil, showing how the period's ethos of improvement acted on both the human and the land. As Charlotte Brontë harnesses the new analytical techniques of organic chemistry to isolate the botanical figuration of women in *Jane Eyre*'s marriage plot, Jane's intellectual development situates knowledge-making practice so as to deny the totalising perspectives of both botany and chemistry. But as intra-actions between selfhood and soil extend from Yorkshire to the Caribbean plantation, human and land are subjected to terrible violence, exploitation that sustains Brontë's realist improvement plot.

Chapter 2, 'Sympathy for the Soiled: Mud, Metaphor, and Metabolic Rift in Gaskell's Industrial Fiction', turns from Yorkshire to the intellectual culture of 1840s Manchester. My focus shifts from agriculture to public health as I trace the importance of Liebig's chemical pathology in the work of Elizabeth Gaskell and the city's sanitarians. I reveal the important role metaphor and analogy held in Gaskell's and Lyon Playfair's efforts to trace the action of sewage on Manchester's disadvantaged populations. Where *Mary Barton* details the terrible effects of malnutrition and disease spread by putrefying yet potentially fertile matter, *North and South* reconciles metabolic rift by reuniting the soils of the country with the soils of the city in the symbolic marriage of Margaret Hale and John Thornton. Yet the sympathy Gaskell develops between classes within England can only be achieved by cultivating lands abroad, and thus depends on extinguishing those indigenous peoples on other continents deemed to be beyond improvement. Once more, a closed narrative system can only be achieved with a logic of unbounded extraction.

The ecologies of literature and science I examine in chapters 3 and 4 centre upon mutual reading and shared friendship. Chapter 3, 'World-ecology "among the mud": Soil Exhaustion and the Chemical Economy in Dickens's London', uses Jason Moore's concept of world-ecology to trace the assimilation of the globe's soils into a rapacious mid-century

capitalism. As Liebig's science sought to quantify soils chemically as capital, (even as reading *Bleak House* contributed to his growing unease about the implications), Dickens examined this logic in his fiction, revealing what was inaccessible to everyday observation – the workings of global capital through soils and peoples around the world. *Bleak House* offers an examination of soil exhaustion whereas, in *Our Mutual Friend*, the marriage plot serves as a narrative of soil restoration. Yet, as the latter novel is unable to eliminate the global violence that Dickens seeks to resist in London, in *Bleak House* this tension opens as a fracture between two narrative wholes, an omniscient narrative that aspires to total apprehension of the world and a situated account, relayed by Esther Summerson, that accepts partiality as a necessary condition of knowledge.

In chapter 4, 'Between the Ideal and the Real: Laboratory and Field in the Vital Soil of Eliot's Loamshire', I focus on this pervasive tension between closed knowledges and open networks. Beginning with the months Liebig, George Eliot, and George Lewes spent together in Munich in 1858, I examine epistemic relations between deduction and induction as they recur across their writing by placing the ideal conditions of the closed laboratory experiment in tension with the open contingencies of the field experiment. This lab/field culture, I show, is examined throughout *Middlemarch*. Thematically, the novel's science navigates tensions between theoretical science and practical art that coalesce around the relations between scientific inquiry and the capitalist economy. At a structural level, Eliot employs a biochemical discourse to examine and resolve relations between bodies in the novel's marriage plot. In a narrative network where vitality is found to inhere through the webbed connections that extend between beings, *Middlemarch* questions whether the sum of relations that make up the whole of Loamshire's web can ever be fully known. As Dorothea Brooke must learn, acting well in the unknowable web involves acknowledging the prospect of doing harm. An extended conclusion, 'Dirty Realism', offers a final word on both the chapter and the thesis, capturing the achievements and contradictions of the mid-nineteenth-century realist novel in its proximity to soils.

Chapter 1. 'We are not to conform to nature': Sustaining Improvement in *Jane Eyre* and the Science of Agriculture

> 'MY LORD YARBOROUGH AND GENTLEMEN, – It is a striking circumstance, in connexion with vegetable growth, that some plants are seen to thrive on one kind of soil, or one geological formation only. You meet with them in abundance in one country or district of Europe – where chalks, or marls, or limestones, or similar sandy or salt-bearing soils occur – while in the rest of Europe you seek for them in vain. But the grasses on which herbivorous quadrupeds thrive, are seen on soils of almost every kind, if the climate favour them; and the corn-bearing plants on which man lives find their support on every geological formation.
>
> Is it illogical to perceive in this striking fact an evidence of design? – to infer from it that the Deity wills that man and his domesticated races should subdue and people the whole earth?
>
> But on inquiring into this fact more nearly, we make two further observations: first, that the corn and herbage do not grow with equal luxuriance on all soils, or give an equal return; and second, that on the same soils on which, when left to themselves, they grow in an unhealthy manner, they prosper greatly when tended and cared for by human skill.
>
> Is it illogical, again, from these facts, to conclude that the Deity intends the soil to be tilled, not only with the sweat of the brow, but by the efforts of the intellect of man? If it yield most abundantly to the thoughtful and instructed cultivator, is not the purpose of the Deity manifest – that mental should combine with bodily industry in making the most of the universal proneness of the earth, everywhere, to produce the means of sustaining human life?'
>
> James Finlay Weir Johnston, 'The Present State of Agriculture in its Relations to Chemistry and Geology', 11 July 1848.[1]

With these words, delivered in York to the Royal Agricultural Society of England (RASE), agricultural chemist and geologist James Finlay Weir Johnston captured a spirit of improvement sweeping British agriculture in the 1840s. To understand the relations between soils and plants, and the impacts of soil variation on plant growth, agriculture required chemical and geological investigation, he explained. While harvests varied depending on these as-yet unknown variables, yields were undoubtedly increased 'when tended and cared for by human skill'. Such a result was proof enough of providential design, supporting agricultural cultivation as imperial expansion that might 'subdue and people the whole earth'. While similar colonial mindsets had long been underwritten by Providence, Johnston's argument that 'the thoughtful and instructed cultivator' might improve agricultural

[1] James Finlay Weir Johnston, 'The Present State of Agriculture in its Relations to Chemistry and Geology. A Lecture delivered before the Society at the Meeting in York', *Journal of the Royal Agricultural Society of England*, 9 (1848), pp. 200-36 (200).

production captured the new and revolutionary application of science to 1840s farming.[2] As Justus von Liebig had written at the start of the decade, 'a rational system of agriculture cannot exist' until 'the composition of a fertile soil' and 'the components of substances used as manure' are 'satisfactorily determined'.[3] Applying scientific investigation to agriculture, Johnston and Liebig advanced a globalising ethos of improvement uniting, as the motto of the RASE proudly stated, 'Practice with Science'.[4] To combine 'mental' and 'bodily industry' thus promised to improve yields and satisfy Providence by 'making the most of the universal proneness of the earth, everywhere, to produce the means of sustaining human life'.

My opening chapter reads this emerging science of agriculture alongside *Jane Eyre*, published in 1847. '[A] novel *of* and *about* empire', as Alan Bewell emphasises, Charlotte Brontë's novel offers insights into the impacts of agricultural improvement both at home and abroad.[5] *Jane Eyre*'s examination of this developing science plays out at the levels of metaphor and structure, influencing the marriage plot, the development of Jane's intellect and character, and Brontë's realist aesthetic. Unlike in future chapters, where direct links can be traced from Gaskell, Dickens, and Eliot to the emerging chemistry of agriculture, here my investigation takes shape around shared cultures of improvement, as applied to both soils and people during the 1840s. Sally Shuttleworth's *Charlotte Brontë and Victorian Psychology* is an important touchstone for my reading, as is Justine Pizzo's more recent work on Brontë and early meteorology.[6] Both these scholars show a writer whose fiction is immersed in the scientific cultures of her time, examining sciences that gain clear definition, like the science of agriculture, through the 1840s.[7] I argue that, as a new chemical language of soils and plants gains prominence in this decade, *Jane Eyre* applies analytical investigation to the conventional marriage plot, long seen in terms of botanical figuration. Brontë's novel does not simply map scientific inquiry onto the novel form but examines science's construction

[2] On longer history of interconnected providential and colonial mindsets see: Alan Bewell, *Romanticism and Colonial Disease* (Baltimore: Johns Hopkins University Press, 1999); Richard Grove, *Green Imperialism: Colonial Expansion, Tropical Island Edens, and the Origins of Environmentalism, 1600-1860* (Cambridge: Cambridge University Press, 1995).
[3] Justus von Liebig, *Organic Chemistry in its Application to Agriculture and Physiology*, trans. by Lyon Playfair (London: Taylor and Walton, 1840), pp. 139, 141.
[4] This motto was displayed prominently on the cover of the RASE's journal from its second volume in 1841.
[5] Bewell, *Romanticism*, p. 285; emphasis in original.
[6] Sally Shuttleworth, *Charlotte Brontë and Victorian Psychology* (Cambridge: Cambridge University Press, 1996); Justine Pizzo, 'Atmospheric Exceptionalism in *Jane Eyre*: Charlotte Brontë's Weather Wisdom', *PMLA*, 131.1 (2016), pp. 84-100.
[7] Brontë 'incorporated into the novel contemporary psychological discourse', Shuttleworth writes of *Jane Eyre*. *Victorian Psychology*, p. 3; Pizzo argues that 'Brontë's sensitivity to the weather was not an idiosyncratic trait but rather a testament to the widespread study and popularization of meteorology – which became a formal and state-funded discipline in the 1840s'. 'Atmospheric Exceptionalism', p. 85.

and real-world effects; as I show, the novel critiques contemporary standards of scientific truth to offer a realism that celebrates personal experience in knowledge-making practice. In so doing, *Jane Eyre* works to reveal the violence implicit in the agricultural improvement of global natures, even as the novel succeeds, not in eliminating such violence, but in exporting it elsewhere.

Following Shuttleworth's foundational study, I trace Brontë's knowledge of this contemporary science to the periodical press. The science of agriculture was a frequent topic of discussion in her 'favourite periodical', *Blackwood's Edinburgh Magazine*, where it is likely she came across articles written by Johnston.[8] With his many works of agricultural science published by William Blackwood, he wrote numerous pieces on agricultural topics for *Blackwood's Magazine* during the 1840s.[9] These sometimes referenced Liebig's work, though rarely in complimentary terms, as I explain below. Liebig's science had a more favourable reception, however, in another of Brontë's favourite periodicals, *Chambers's Edinburgh Journal*, where *Organic Chemistry, Animal Chemistry* and *Chemical Letters* all received glowing reviews.[10] Such was Liebig's fame that in 1845 *Chambers's* even published a brief account of his 'head and character'.[11] In the suggestion that Liebig's talents might have been better 'cultivated' at school, the article's metaphor of education is informed by the applications Liebig's chemistry found in improving the cultivation of soils and crops.[12] As I

[8] Shuttleworth, *Victorian Psychology*, p. 174. As Margaret Smith describes in her edited *Letters of Charlotte Brontë*, *Blackwood's* held an important place in the Brontë home. The Brontë children created parody editions filled with reviews, poetry and stories (pp. 4, 113n). Poetry discussed in *Blackwood's* provided the template for Charlotte's 1831 poem, 'The trumpet hath sounded', and she referenced the magazine in letters dated May 1832, December 1840, and May 1846 (pp. 129n, 112, 239, 470). Her sister Emily, in a diary entry for 30 July 1841, writes that 'Aunt […] has just been reading Blackwood's magazine to papa' (pp. 262, 474n.). In addition to subscribing to the magazine themselves, the Brontës had access to the publication through the Keighley Mechanics Institute library. Charlotte Brontë, *The Letters of Charlotte Brontë*, ed. by Margaret Smith, 3 vols (Oxford: Clarendon Press, 1995-2000).

[9] James Finlay Weir Johnston, 'Practical Agriculture', *Blackwood's Edinburgh Magazine*, March 1845, pp. 298-314; 'The Practice of Agriculture', *Blackwood's Edinburgh Magazine*, April 1843, pp. 414-32; 'Science and Agriculture', *Blackwood's Edinburgh Magazine*, June 1842, pp. 738-55; 'Things of the Day: English Agriculture', *Blackwood's Edinburgh Magazine*, March 1842, pp. 406-14; 'Things of the Day: The Corn Laws', *Blackwood's Edinburgh Magazine*, March 1842, pp. 414-16. All anonymously published in *Blackwood's Edinburgh Magazine* and attributed to Johnston by *The Wellesley Index*.

[10] Brontë references *Chambers's Journal* in *Shirley*, published in 1849; 'Had *Chambers's Journal* existed in those days, it would certainly have formed Miss Helstone's and Farren's favourite periodical. She would have subscribed for it, and to him each number would duly have been lent; both would have put implicit faith and found great savour in its marvellous anecdotes of animal sagacity'. *Shirley*, intro. and notes by Sally Minogue (1849; Ware: Wordsworth, 1993), p. 330. For reviews of Liebig's works see: Anon., 'Liebig's Organic Chemistry', *Chambers's Edinburgh Journal*, 15 May 1841, pp. 131-32; 'Liebig's Animal Chemistry', *Chambers's Edinburgh Journal*, 27 August 1842, pp. 253-54; 'Familiar Letters on Chemistry. First Article', *Chambers's Edinburgh Journal*, 16 December 1843, pp. 378-79; 'Familiar Letters on Chemistry. Second Article', *Chambers's Edinburgh Journal*, 23 December 1843, pp. 386-87.

[11] Anon., 'Liebig When A Boy', *Chambers's Edinburgh Journal*, 15 March 1845, p. 176

[12] 'Liebig When A Boy', p. 176.

show below, the agricultural improvement of the soil and the bourgeois improvement of the individual were mutually supporting in the 1840s.

Although rarely examined through the context of agriculture, many studies have considered education as improving cultivation from a horticultural perspective. Scholars including Amy King, Deirdre Lynch, Theresa Kelley, and Elizabeth Hope Chang have drawn out the multifaceted associations of improvement directing the cultivation of plants and particular versions of femininity in the eighteenth and nineteenth centuries.[13] Blanche Ingram's introduction of 'botany' in Thornfield's drawing room stands as a jarringly prominent mention of science in *Jane Eyre*, yet for all the illuminating readings of plants and women in Victorian novels, botanical figuration in Brontë's fiction has so far escaped sustained critical attention.[14] Examining the novel's soils, plants, and people, I uncover a work of fiction torn between 'epistemic virtues'; approached via Lorraine Daston and Peter Galison's work on objectivity, Brontë can be seen to hold two different standards of scientific truth in dialogue in *Jane Eyre*, ways of doing science at stake in botany and the emerging science of agriculture.[15]

In offering an original reading of the novel, this chapter also furthers research on the nineteenth-century application of science to agriculture. As Robin Bud notes, though 'internationally well-known' in the 1840s, today Johnston's name is 'obscure even to most historians of science'.[16] Book-length studies by William Brock (of Liebig) and E. John

---

[13] Amy King, *Bloom: The Botanical Vernacular in the English Novel* (Oxford: Oxford University Press, 2003); Deidre Shauna Lynch, '"Young Ladies are Delicate Plants": Jane Austen and Greenhouse Romanticism', *ELH*, 77.3 (Fall 2010), pp. 689-729; Theresa M. Kelley, *Clandestine Marriage: Botany and Romantic Culture* (Baltimore: Johns Hopkins University Press, 2012); Elizabeth Hope Chang, *Novel Cultivations: Plants in British Literature of the Global Nineteenth Century* (Charlottesville: University of Virginia Press, 2019).

[14] Charlotte Brontë, *Jane Eyre*, ed. and intro. by Stevie Davies (1847; St Ives: Penguin, 2006), p. 200. (All further references to *Jane Eyre* are to this edition and are given parenthetically in the body of the chapter.) This is not to say that the presence of botanical figuration in Brontë's fiction has not been noted. Lynch and Kelley both reference Brontë in their studies, though not at length. Chang's recent reading of *Villette* (1853) in *Novel Cultivations* is the most detailed reading of Brontë's fiction in terms of plant life. Chang argues that, '[b]y revisiting and parodying older gothic conventions within a newly expanded global environment, *Villette* posits plant relations that engulf the main character' (52); 'at minimum, it proposes that Lucy is herself a kind of plant of tree, whose maintenance and tending within the confines of the urban environment requires particular care' (64). While not examining *Jane Eyre* in detail, she does note that the novel 'uses environmental detail as material grounds for psychic dissolution, repression, and (however limited) liberation. […] [T]hese damaging effects are narrated by a female protagonist but experienced most forcefully by representatives of English manhood attacked by a problematic and alternate femininity – wild and malignant in Brontë's case'. *Novel Cultivations*, p. 113; I consider Bertha Mason's position in the novel in relation to soil at the end of this chapter.

[15] Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone, 2007), p. 111. Where botany aspired to what Daston and Galison term 'truth-to-nature', abstracting the plant from the soil to depict an idealised image of the species in watercolour, the science of agriculture, examining plants in their relations to soils, adhered to an emerging standard of 'objectivity' that prioritised particulars rather than ideals.

[16] Robert Bud, 'Applied Science in nineteenth-century Britain: public discourse and the creation of meaning, 1817-1876', *History and Technology*, 30.1 (2014), pp. 3-36 (9).

Russell (of agricultural science in Great Britain) are two notable exceptions, offering insights into Johnston's work and his disagreements with Liebig.[17] As Brock writes, he became 'a powerful opponent of Liebig in […] the great controversy between Liebig and Lawes and Gilbert over nitrogen fixation in the 1850s', a dispute that is considered later in my thesis.[18] It has yet to be noted, however, that this debate began with Johnston questioning Liebig's science in *Blackwood's* in 1842. The disagreement is of interest here because it reveals tensions over truth and faithful representation that Brontë engages in her realism. As noted in my thesis introduction, my first chapter traces this 'ecology of literature and science' through the popular periodical press, but it would be a mistake to see such networks of engagement as confined solely to print. Liebig and Johnston both visited Yorkshire in the 1840s to speak on the relations between science and agriculture, and the scientific-society meetings they attended were also vitally important loci of dissemination for the new science.

My chapter is organised into four sections. The first, 'Defining "the Science of Agriculture"', reads Liebig's and Johnston's writings to show how they developed a new chemical language of soils and the methodological project for a concerted agricultural science in the 1840s. 'Analysing the Greenhouse Marriage in *Jane Eyre*' then reveals how Brontë uses the analytical techniques of this new science to challenge the conventions of the novelistic marriage plot, specifically the dominant representation of women in terms of ideal botanical form. Section three, 'Attaining "the real"', demonstrates that as Brontë negotiates botanical and chemical standards of scientific truth, Jane's intellectual development highlights the centrality of personal experience in knowledge-making practice, in turn suggesting a realism where partial knowledge forms the basis for claims to truth. My final section, 'Soil and Self amidst Global Natures', draws on Karen Barad to show the ways soils, human selves, and ideas of improvement are mutually constituting in *Jane Eyre*.[19] Departing from existing studies of the novel, which emphasise Jane's affinities with atmospheric airs, I uncover the important place soil has in shaping her character.[20] This reading suggests a

[17] William H. Brock, *Justus von Liebig: The Chemical Gatekeeper* (Cambridge: Cambridge University Press, 1997); E. John Russell, *A History of Agricultural Science in Great Britain* (London: George Allen & Unwin, 1966).

[18] Brock, *Liebig*, p. 154. Brock also notes that Johnston became a thorn in Liebig's side during 'the squabble over protein', considered in chapter 4 of my thesis, where I describe how George Henry Lewes questioned Liebig's theories of nutrition.

[19] Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Durham, NC: Duke University Press, 2007).

[20] Pizzo's reading of Jane's 'atmospheric exceptionalism' stands in a long line of scholarship linking Jane's construction with atmospheric airs. As Alan Bewell puts it: 'The heroine of the novel, then, is not just a person but the embodiment of an ecological myth, linking English places with English people: she is, indeed, Jane Air'. *Romanticism*, p. 288. And as Sandra Gilbert and Susan Gubar memorably write, Jane 'is invisible as air, the heir

messier conception of how knowledge is made, how the world is shaped, and where the human is situated within it, than has traditionally been attributed to representationalism as the basis for literary realism. My final section concludes with a reading of Bertha Mason, tracing the devastating effects of cultivation framed as improvement when transposed onto distant ecologies.

Defining 'the Science of Agriculture'

With the publication of *Organic Chemistry* in 1840, Justus von Liebig offered an exclusively chemical method and discourse with which to understand agriculture. His most revolutionary ideas concerned soil: 'A fertile soil', he wrote, 'ought to afford to a plant all the inorganic bodies indispensable for its existence'.[21] This inorganic mineral theory rejected existing conceptions concerning the importance of soil's organic matter, known as humus. Theories of humus stated that plants derived their carbon and nitrogen directly from soils containing the decaying matter of dead plants and animals. In the vitalist terms of *Naturphilosophie*, death was believed to stimulate life. Liebig questioned the work of botanists and physiologists for whom 'carbonic acid, ammonia, acids, and bases, are sounds without meaning, words without sense, terms of an unknown language'.[22] Explaining soil through this chemical discourse, Liebig isolated the constituent components of humus and dismissed them as of little importance for plant growth: 'The humus of chemists is a product of the decomposition of humus by alkalies', he stated, 'it does not exist in the humus of vegetable physiologists'.[23] In Donna Haraway's words on scientific reductionism, Liebig offered 'one language' to understand soils and plants, with his organic chemistry presented 'as the standard for all the translations and conversions' across the related sciences of botany and physiology.[24] The result of this exclusively chemical frame, as William Brock notes, was a 'bank balance' approach to soils and living systems, with Liebig claiming that fields could be kept in 'a constant state of fertility by replacing every year as much as we remove from them in the form of produce'.[25] In this way, Liebig redefined soils as collections of chemical elements in various molecular combinations.

---

to nothing, secretly choking with ire'. Sandra Gilbert and Susan Gubar, *The Madwoman in the Attic: The Woman Writer and the Nineteenth-Century Literary Imagination* (New Haven: Yale University Press, 1984), p. 342.

[21] Liebig, *Organic Chemistry*, p. 169.

[22] Liebig, *Organic Chemistry*, p. 35.

[23] Liebig, *Organic Chemistry*, p. 46.

[24] Donna J. Haraway, 'Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective', *Feminist Studies*, 14.3 (1988), pp. 575-99 (580).

[25] Brock, *Liebig*, p. 191; Liebig, *Organic Chemistry*, p. 182.

By perfecting methods of analysis for organic compounds and applying them to plants and humus, Liebig thus offered a new chemical framework with which to understand soils and plants. *Organic Chemistry* used literary comparisons to cement these new ideas as well as undermine those of others. Liebig positioned his new chemistry as 'a foreign literature', unknown and 'despise[d]' by those working in other sciences 'in exact proportion to their ignorance of it'.[26] He also made literary comparisons to reject work unable to explain the 'mysterious' and 'enigmatic,' dismissing Karl Burdach's early-nineteenth-century physiology, for example, as 'poetry, but not sober philosophical inquiry'.[27] The errors of the poetic mind, prone to speculative and therefore un-scientific theorising, were embodied, for Liebig, in existing conceptions of humus:

> All the erroneous opinions concerning the *modus operandi* of humus have their origin in the false notions entertained respecting the most important vital functions of plants; analogy, that fertile source of error, having unfortunately led to the very unapt comparison of the vital functions of plants with those of animals.[28]

As David Knight notes, such 'animal-plant analogies' were typical of biological investigation in the eighteenth century.[29] Liebig presented structures of literary reasoning as part of science's past, and unsuitable to the 'sober' investigations he deemed necessary for its future development.[30] Writing in German, he went so far as to label humus 'an imaginary substance […] which exists in their imagination [of agriculturists and plant physiologists] in a form that occurs in no type of soil'.[31] By deriding what he saw as poetic imaginings, Liebig sought to distance his work from, as he believed, the speculative nature of Romantic science.

While rejecting *Naturphilosophisch* ideas of humus, echoes of Romantic-era science remained in Liebig's references to a 'vital principle' or 'vital processes'.[32] Vitalism was a tradition Liebig rejected in its associations with soil, but retained throughout his career in his understanding of animal and plant physiology.[33] As he explained in *Organic Chemistry*, 'the

[26] Liebig, *Organic Chemistry*, p. 35.
[27] Liebig, *Organic Chemistry*, p. 110.
[28] Liebig, *Organic Chemistry*, p. 26.
[29] David Knight, 'Agriculture and Chemistry in Britain around 1800', *Annals of Science*, 33.2 (1976), pp. 187-96 (195).
[30] There is some irony in this considering the central role analogy played in Liebig's chemical pathology, as I examine in chapter 2.
[31] Justus von Liebig, 'Der Zustand der Chemie in Preussen' (1840), trans. by Pat Munday, in 'Sturm und Dung: Justus von Liebig and the Chemistry of Agriculture' (unpublished doctoral thesis, Cornell University, 1990), p. 177. In the third section of this chapter, I uncover a similar politics of imagination in knowledge production in *Jane Eyre*.
[32] Liebig, *Organic Chemistry*, p. 166.
[33] For Liebig's rejection of *Naturphilosophie* and arguments against vitalist theories of humus see Munday, 'Justus von Liebig', pp. 175-177, 188-197. For vitalism in Liebig's physiology see Timothy O. Lipman, 'Vitalism and reductionism in Liebig's physiological thought', *Isis*, 58 (1967), pp. 167-85.

expression "vital principle" must […] be considered as of equal value with the terms specific or dynamic in medicine: everything is specific which we cannot explain, and dynamic is the explanation of all which we do not understand'.[34] But though the secrets of life's processes were not yet understood, Liebig was convinced chemistry offered the tools to reveal them: 'We should not permit ourselves to be withheld, by the idea of a vital principle, from considering, in a chemical point of view, the process of transformation of the food, and its assimilation by the various organs'.[35] Liebig ascribed such 'transformations', not to a 'vital principle', but 'to a disturbance in the attraction of the elements of a compound, […] a purely chemical process'.[36] As with soil, his chemical discourse framed a reductionist investigation of vital processes. But at the same time, as Pat Munday has shown, this approach was not a 'Godless materialism'.[37] '[T]he life of plants is closely connected with that of animals […] for a wise and sublime purpose', Liebig wrote, with Providence implicit in much of his science.[38] Liebig's investigations can be seen, therefore, as 'transitional' between the vitalism of the eighteenth- and early-nineteenth centuries and the materialism that would characterise later science.[39]

Liebig viewed his organic chemistry as transcending earlier science in method as well as theory, embodying 'the triumph of mind over empiricism'.[40] He situated *Organic Chemistry* in an illustrious lineage following Humphry Davy's *Elements of Agricultural Chemistry* (1813), praising Davy for following 'the path of true philosophical inquiry, which promises to lead us to truth'.[41] Liebig's chemistry of agriculture was in reality quite different, however, suggesting new theories of soil and plant nutrition and utilising new methods of analysis.[42] The rejection of knowledge derived from 'superficial observation', as Liebig described it, was at the heart of his efforts to define 'the fundamental principles of agriculture'.[43] In this way, *Organic Chemistry* developed, what Wolfgang Krohn and Wolf Schäfer describe as, Davy's 'paradigmless agricultural chemistry' (33).[44] Liebig's rejection

[34] Liebig, *Organic Chemistry*, p. 58.
[35] Liebig, *Organic Chemistry*, p. 56.
[36] Liebig, *Organic Chemistry*, pp. 56-57.
[37] Munday, 'Justus von Liebig', p. 144.
[38] Liebig, *Organic Chemistry*, p. 21.
[39] Munday, 'Justus von Liebig', p. 143.
[40] Liebig, *Organic Chemistry*, p. vi.
[41] Liebig, *Organic Chemistry*, p. ix. For more on Davy's science see Russell, *Agricultural Science in Great Britain*, pp. 67-76.
[42] David Knight, 'Agriculture and Chemistry', pp. 194-95.
[43] Liebig, *Organic Chemistry*, p. 139.
[44] Wolfgang Krohn and Wolf Schäfer, 'The origins and structure of agricultural chemistry', in *Perspectives on the Emergence of Scientific Disciplines*, ed. by Gerard Lemaine and others (The Hague: Mouton & Co., 1976), pp. 27-52 (33).

of empiricism was in fact cemented on a visit to York in 1844, where he attended that year's meeting of the British Association for the Advancement of Science (BAAS). He was 'dissatisfied with the way geologists seemed to run the whole show', Brock writes, 'deplor[ing] the empirical approach of British geologists and the way they were hailed as great authorities without seemingly knowing any physics or chemistry'.[45] With his chemistry of agriculture, Liebig thus provided 'a strict experimental method', as Uschi Schling-Brodersen explains, aimed at 'free[ing] the subject from the confusion of contradictory empirical evidence'.[46] And in a similar vein, *Organic Chemistry* described 'botany' as limited by its 'examination of form and structure', arguing that only once chemistry is 'allowed to sit in council upon the explanation of the most simple processes' can 'true knowledge' be acquired.[47] At the heart of Liebig's science was this belief that analysing constituents provided a more truthful conception of the world than the observation of exterior form, a belief suggested too in Brontë's analysis of the greenhouse marriage in *Jane Eyre*, detailed in my next section.

Liebig's theoretical approach, aimed at transforming the empirical practice of farming into a science, brought him into long-running conflicts with several members of the British agricultural community. One of the first to highlight problems with Liebig's work was Scottish agricultural chemist, James Finlay Weir Johnston. Johnston had become reader in chemistry and mineralogy at the University of Durham in 1833, (a position he held until his death in 1855), and his course in agricultural chemistry, taught between 1848 and 1852, was one of the very first to be offered in England.[48] Born in Paisley and educated at the University of Glasgow, Johnston was instrumental in the Highland and Agricultural Society (founded in 1784) and consulting chemist to the newly established Agricultural Chemistry Association of Scotland from 1843. John Russell notes that he performed 242 analyses of fertilisers for Scottish farmers in his first year in the post; as Johnston reported himself in 1848, after four and a half years he had performed 'upwards of two thousand'.[49] These analyses sought to identify what Johnston called 'fraudulent manures' from among the large numbers of manufactured fertilisers flooding the market in the early years of the chemical

[45] Brock, *Liebig*, p. 100.
[46] Uschi Schling-Brodersen, 'Liebig's role in the establishment of agricultural chemistry', *Ambix*, 39 (1992), pp. 21-31 (26).
[47] Liebig, *Organic Chemistry*, p. 35.
[48] Paul Brassley, 'Agricultural Science and Education', in *The Agrarian History of England and Wales, vol. 7, 1850-1914*, part 1, ed by E. J. T. Collins, 8 vols (Cambridge: Cambridge University Press, 2000), pp. 594-649 (621).
[49] Russell, *Agricultural Science in Great Britain*, p. 131; Johnston, 'Present State of Agriculture', p. 226.

fertiliser industry.[50] Yet his greatest impact on agriculture was through his writing and lecturing. The most popular of his books was *Catechism of Agricultural Chemistry and Geology* (1844), which went through thirty-three editions in his lifetime.[51] This short text encapsulated his *Elements of Agricultural Chemistry and Geology* (1842), itself a condensed version of his *Lectures on Agricultural Chemistry and Geology* (1843), which stretched to over a thousand pages.[52]

Johnston is largely remembered today for his role in establishing the BAAS. It was Johnston who urged the inaugural meeting take place in York in 1831 having begun the discussion about forming such a society following a visit to the BAAS's German forerunner.[53] It has yet to be noted, however, that this organisation offered impetus to the scientific investigation of soils and agriculture through the 1830s. At the second meeting of 1832, geologist William Buckland recommended 'adding to the geological committee of the Association a section to be devoted to the improvement of agriculture'.[54] But the BAAS instead stimulated agricultural investigation, unwittingly, in the field of chemistry. When Liebig attended his first meeting in 1837, his paper on uric acid, read by Michael Faraday, made quite an impression. The council commissioned Liebig to produce reports on 'organic chemistry' and 'isomeric bodies'.[55] These reports, however, were never completed. Instead, Liebig attempted to pass off his *Organic Chemistry* as fulfilling the BAAS's request – 'the honourable task of preparing a report upon the state of organic chemistry', as he described it in his book's preface.[56] Left to smooth over a potentially awkward situation at the BAAS meeting of 1840, William Gregory described Liebig's book as 'in the highest degree important, as being the first attempt to apply the newly created science of Organic Chemistry to Agriculture'. '[T]he British Association had just reason to be proud of such a work', he concluded, 'as originating in their recommendation'.[57] As for the report on isomerism, it was

[50] Johnston, 'Present State of Agriculture', p. 218.
[51] Russell, *Agricultural Science in Great Britain*, p. 131; James Finlay Weir Johnston, *Catechism of Agricultural Chemistry and Geology* (London and Edinburgh: William Blackwood, 1844).
[52] James Finlay Weir Johnston, *Elements of Agricultural Chemistry and Geology* (London and Edinburgh: William Blackwood, 1842); *Lectures on Agricultural Chemistry and Geology* (London and Edinburgh: William Blackwood, 1843).
[53] See A. D. Orange, 'The Origins of the British Association for the Advancement of Science', *British Journal for the History of Science*, 6 (1972), pp. 152-76.
[54] Anon., 'British Association for the Advancement of Science', *Literary Gazette*, 30 June 1832, pp. 408-09 (409).
[55] *Report of the Seventh Meeting of the British Association for the Advancement of Science, held at Liverpool in September 1837* (London: John Murray, 1838), p. xvi.
[56] Liebig, *Organic Chemistry*, p. vi.
[57] Anon., 'Tenth Meeting of the British Association for the Advancement of Science', *Athenaeum*, 3 October 1840, pp. 767-81, (774). For more on this see William H. Brock and Susanne Stark, 'Liebig, Gregory and the British Association, 1837-1842', *Ambix*, 37 (1990), pp. 137-47.

left to Johnston to complete. The Scotsman was, it seems, not best pleased, and would become a firm opponent of Liebig during the 1840s and 50s.

To appreciate the nature of Johnston's attacks on Liebig, it is important to understand where they differed in terms of method. At the Yorkshire Agricultural Society (YAS) dinner in 1841, Johnston stated that '[t]he sciences of geology, chemistry, and botany, were ready to aid the farmers in the establishment of [scientific] principles'.[58] Where empirical geology was derided by Liebig, geological investigation made empirical observation central in Johnston's science. In an 1838 lecture on coal, given to the Geological and Polytechnic Society of the West Riding of Yorkshire (GPS), Johnston praised the 'local observations' of the GPS which, once connected to 'similar observations [in] other districts', promised to lead to 'a general identification of the strata' across the country.[59]

This focus on observation was part of a new method of scientific inquiry sweeping British geology in the 1830s, whereby Johnston advised that becoming 'acquainted with the general principles of geology' would allow the society's members to interpret 'the phenomena immediately under their eye'.[60] These words alluded to Charles Lyell's recently published *Principles of Geology* (1830), which put forward the argument that processes acting in the present had remained constant in both form and rate throughout geologic time.[61] Understanding the geologic past, and indeed future, therefore required meticulous observation of the present; this is the essence of uniformitarianism, which necessitates strict empirical observation. Michelle Geric has argued that this discourse of uniformity provided 'a superior, rational and refined style of thinking' for scientific knowledge-making in general.[62] This is the message Johnston emphasised in his address to the GPS, and Geric's thesis certainly holds true for Johnston's science of agriculture, where the empirical method of uniformitarianism would be central.

Johnston used uniformitarian principles to distinguish his *Elements of Agricultural Chemistry and Geology* from Davy's foundational *Elements of Agricultural Chemistry*. The distinction he sought to draw is clear from a comparison of two images, both meant to depict the influence of rock type on soil variation. Figure 1.1 is from Davy's earlier work.

[58] Anon., 'Yorkshire Agricultural Society: Meeting at Hull', *Hull Packet*, 6 August 1841, pp. 4-5 (5).
[59] James Finlay Weir Johnston, *The Economy of a Coal-Field: an exposition of the objects of the Geological and Polytechnic Society of the West Riding of Yorkshire* (Durham: Andrews, 1838), pp. 12, 14.
[60] Johnston, *Geological and Polytechnic*, p. 37.
[61] Charles Lyell, *Principles of Geology* (London: John Murray, 1830).
[62] Michelle Geric, *Tennyson and Geology: Poetry and Poetics* (London: Palgrave, 2017), p. 83.

Figure 1.1. Humphry Davy, 'a general idea of the appearance of rocks and veins', 1813.[63]

This imagined composition is influenced by Romantic landscape aesthetics, with the jagged peaks and cliffs invoking the sublime. Each of the exposed strata in the fore- and mid-ground depict a different rock and soil type, presented here in an artificial proximity unlikely to be realised in nature. Although Johnston, like Liebig, viewed Davy as an important forerunner, he was clear that Davy's science 'belongs rather to the history of the progress of knowledge than to the condition of existing information'.[64] This is apparent from the contrasting method of presentation that Johnston used to depict the very same influence of rock type on soil composition.

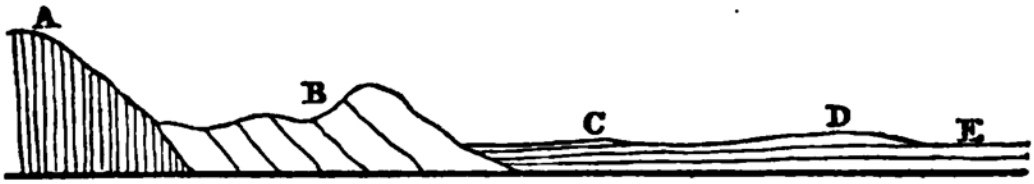

Figure 1.2. James Johnston, Section showing influence of rock strata on soils, 1842. [65]

Unlike Davy's sublime image, Johnston's section flattens the landscape. Removing any suggestion of a subjective perspective, his method of presentation embodies the principles of uniformitarian empiricism. As he wrote in *Elements*, 'geology […] supplies […] the principles by which we can predict the general quality of the soil and subsoil'.[66] In this effort to classify soils, Johnston defined his work in stark opposition to Davy, who explicitly stated that to attempt such a general classification of soils 'with scientific accuracy, would be a vain

[63] Humphry Davy, *Elements of Agricultural Chemistry, in a course of Lectures for the Board of Agriculture* (London: Longman, 1813), n.p.
[64] Johnston, *Lectures*, p. 10.
[65] Johnston, *Elements*, p. 74.
[66] Johnston, *Elements*, p. 68.

labour' such was their variation.[67] In this way, Johnston framed his science of agriculture in terms of a uniformitarian discourse of empiricism that Liebig firmly rejected.

Part of the reason for Johnston's and Liebig's different methodologies was that they were looking to achieve different things with their science. Pat Munday describes how Liebig was 'not interested in actual practice or the day-to-day concerns of farmers', but rather 'the chemical principles of plant growth'.[68] In a letter sent to Lyon Playfair in 1840, he was at pains to distinguish his 'chemistry of agriculture' from the practical concerns of 'agricultural chemistry'.[69] *Organic Chemistry* even deplored an agricultural community 'which recoils with seeming distrust and aversion from all means of assistance offered it by chemistry, and which does not understand the art of making a rational application of chemical discoveries'.[70] For Johnston, however, agricultural science was practical and participatory, with farmers central to future research. As he noted in the preface to his *Lectures*, the contents were first 'addressed to a Society of practical agriculturists';[71] in his 1841 address to the YAS, he emphasised 'that every agriculturist, by experiments, had the power of improving their art, and thus becoming pioneers to science'. In this way, his books encouraged farmers to conduct their own analyses, outlining the 'several steps […] to be taken in examining a soil with the view of so far determining its constituents as to be able to precisely to name and classify it'.[72] Johnston even wrote that Liebig's disparaging remarks must apply to the German agricultural community alone, for he had always found even 'the remotest agricultural districts [in Britain …] anxious for information, and eager for improvement'.[73]

In Johnston's science, this idea of agricultural improvement transcended a focus on the cultivation of soils to direct the improvement of people. In his speeches and writing, uniformitarian discourse framed a participatory science, disseminating principles by which farmers might develop their scientific observation and reasoning skills. In his 1848 York address, he reiterated to 'the practical man' the importance of 'experiments' for improving agricultural practice.[74] But he also praised 'experimental research', prosecuted 'in connexion

[67] Davy, *Agricultural Chemistry*, p. 174.
[68] Munday, 'Justus von Liebig', p. 127.
[69] Quoted in Munday, 'Justus von Liebig', p. 205.
[70] Liebig, *Organic Chemistry*, p. 161.
[71] Johnston, *Lectures*, p. 5. The society to which Johnston first addressed his *Lectures* was the Durham County Agricultural Society and Durham Farmers' Club.
[72] Johnston, *Lectures*, p. 343.
[73] Johnston, *Lectures*, p. 8.
[74] Johnston, 'Present State of Agriculture', p. 228. Johnston did emphasise, however, how experience had since told that field experiments, 'as a source of those sure and indisputable data, by which science is to be carried forward', ought to be entrusted to 'the professional experimenter'. I will return to these tensions between field and lab, practice and expertise, in chapter 4, where I explain that Liebig was uninterested in practical concerns,

with rural economy', for its ability 'to introduce more careful habits of observing and recording – to awaken new thought, and thus gradually to impart a higher tone to the minds of the rural population'.[75]

As I will argue in my next section, Liebig's organic chemistry, analysing the constituents of plants and soils, offered Brontë a discourse with which to analyse the contemporary botanical figuration of women. But in its shared applications of improvement to soil and human intellect, Johnston's participatory science offered Brontë a way to redefine education as cultivation that goes beyond the botanical marriage plot. His suggestion that scientific inquiry might simultaneously shape soil and the human mind is echoed in the construction of Brontë's novel which, as my third and fourth sections will show, calls into question a representationalism splitting word from thing, human subject from known object, to arrive at a realism where world and knowledge-making practice may be mutually constituting.

Before I turn to *Jane Eyre*, however, it is important to emphasise the similarities that Johnston's and Liebig's science shared, despite some obvious differences. Johnston's geological focus should not obscure how both were integral in establishing chemistry as foundational to understanding soils and plants, with particular bearing on the progress of agriculture. As Johnston emphasised in York in 1848, although many agriculturists were 'ridiculing the pretended value of chemistry' ten years earlier, 'chemical nomenclature' had since come 'within the easy comprehension of almost every farmer'.[76] Johnston and Liebig were together central in disseminating this chemical discourse. They communicated chemistry's applications to agriculture to the British farming community through their books, their writing in popular periodicals and specialist journals, their speeches at meetings of scientific societies, and, in Johnston's case, by lecturing to farmers and analysing the manures they were using on their farms. A popular venue for meetings of peripatetic groups such as the BAAS and RASE, and home to thriving regional organisations such as the YAS, Yorkshire and its farmers were at the heart of these changes. I now show that the ideas and methods of the emerging science of agriculture offered Brontë a discourse of analysis and

---

and disparaging of field experiments, whatever their aim. As Munday details in his excellent doctoral study of Liebig's chemistry of agriculture, Liebig drew attention to the possibilities of agricultural chemistry, from which 'the field took off independently, combining Liebig's emphasis on chemical principles with field research. This work, performed at newly founded agricultural stations, revealed a complex web of additional theoretical and empirical considerations, neither of which Liebig was prepared to deal with'. 'Justus von Liebig', pp. 2-3. It is fair to say that Liebig's importance in framing a new chemical language for agriculture is thus more conceptual than practical.

[75] Johnston, 'Present State of Agriculture', pp. 207-08.

[76] Johnston, 'Present State of Agriculture', p. 205.

observation that shaped her depiction of life in the north of England in *Jane Eyre*. My reading of the novel begins by showing how Jane learns to apply the analytical eye of organic chemistry to the greenhouse marriage plot, undermining the botanical figuration of women as delicate plants to be taken care of in marriage.

Analysing the Greenhouse Marriage in *Jane Eyre*

Thornfield Hall's drawing room offers a strikingly botanical setting. As the room is prepared for the arrival of Rochester's high-society friends, Jane looks on as 'vases of exotics' cut from Thornfield's hothouses are arranged 'bloom[ing] on all sides' (193). She describes how the eligible upper-class ladies of Rochester's party, soon arranged amidst this riot of plant life, themselves stand 'fair as lilies' (199). Botanical associations between flower and femininity reach their height as Jane overhears Blanche Ingram discussing botany, as she describes here with typically acerbic wit:

> Genius is said to be self-conscious: I cannot tell whether Miss Ingram was a genius, but she was self-conscious – remarkably self-conscious indeed. She entered into a discourse on botany with the gentle Mrs Dent. It seemed Mrs Dent had not studied that science: though, as she said, she liked flowers, 'especially wild ones;' Miss Ingram had, and she ran over its vocabulary with an air. I presently perceived she was (what is vernacularly termed) *trailing* Mrs Dent; that is, playing on her ignorance: her *trail* might be clever, but it was decidedly not good natured. (200-01; emphasis in original)

Elizabeth Hope Chang has recently shown how 'the plants that surrounded Victorians were often transported from foreign soil and almost always modified by human action to form a second, cultivated, nature'. Similar senses of cultivation can be perceived here in Blanche's speech.[77] Unlike the 'wild' flowers enjoyed by Dent, Blanche seems to prefer the exotic cultivars that surround her. Jane fastens one of these flowers to Adèle's dress, 'pour completer ma toilette' (198), as Rochester's daughter says, further blurring distinctions between flower and femininity. In this way, the specialist vocabulary Blanche's discourse evokes, triggered as she 'examine[s] the flowers' (199) that frame both her knowledge and appearance, in turn suggests the second, cultivated, nature of education. The passage thus opens the botanical associations linking the cultivation of plants and young women for inquiry within the novel.

I show in this section how *Jane Eyre* interrogates contemporary botanical culture. '[B]otany becomes a discourse of female sexuality in eighteenth-century literature', writes

[77] Chang, *Novel Cultivations*, p. 1.

Sam George, associations that are part of a longer 'iconographic tradition' that, as Theresa Kelley notes, became yet more 'emblematically coded in the Victorian era'.[78] Although the exact contents of Ingram's discourse are not revealed, the contrast between her scientific 'vocabulary' and Dent's 'vernacular' understanding offers an allusion to Linnaeus's Latinate taxonomies, whereby plants were classified according to their sexual organs. As Amy King has shown, 'Linnaeus's system made sexual courtship […] a legitimate study for representation [in the nineteenth-century novel]', and by making such coded sexual references in the drawing room, Brontë implies, Ingram not only 'trails' the unsuspecting Mrs Dent but courts Rochester.[79] Where studies by King, George, Chang and Kelley all examine 'the edge of hazard, authority, and petty cruelty that attended making women into flowers', I show that Brontë interrogates this representational – and sometimes physical – violence in *Jane Eyre*.[80] Her novel exposes the botanical associations of flower and femininity by drawing on a different way of knowing plants and soils in terms of constituents rather than external form. The novel's courtships plots are structured upon Jane's resistance to botanical figuration, I argue, with the unequal male-female relations such representations support isolated by a discourse of analysis that borrows from 1840s organic chemistry.

Brontë's botanical artwork offers valuable insight into how contemporary scientific and artistic pedagogy supported the botanical framing of women. 'Pink Begonia', painted in 1832 when she was aged sixteen and striving towards a career as a professional artist, offers a window into a contemporary standard of scientific truth.[81]

[78] Sam George, *Botany, sexuality and women's writing: From modest shoot to forward plant* (Manchester: Manchester University Press, 2007), p. 2; Kelley, *Botany*, p. 4.
[79] King, *Bloom*, p. 4.
[80] Kelley, *Botany*, p. 90.
[81] I use the titles of these paintings given by Christine Alexander and Jane Sellars in their edited collection, *The Art of the Brontës* (Cambridge: Cambridge University Press, 1995). For Brontë's artistic education at Roe Head School see Alexander and Sellars, *Brontës*, pp. 40-44. For more information on Brontë's artistic training and knowledge see Jane Kromm, 'Visual Culture and Scopic Custom in *Jane Eyre* and *Villette*', *Victorian Literature and Culture*, 26.2 (1998), pp. 369-94 (370, 374).

Figure 1.3. Charlotte Brontë, 'Pink Begonia', 1832.[82]

Brontë's painting suggests a way of knowing plants described by Lorraine Daston and Peter Galison as 'truth-to-nature'.[83] The essential aspects of the begonia are here clearly represented, with both the front and back of the leaves shown at different stages of growth. The flowers are depicted similarly from contrasting angles, in bud and full bloom, identifying incremental stages in the development of the blossom. Painted in perfect abstraction from the soil, Brontë's begonia is thus idealised as an example of the typical form of the species. Romantic botany thus attained 'truth-to-nature' through ideal illustrations developed from the close consideration of actual specimens, images that in turn offered the standard from which to identify and classify flora. Native to South America, the begonia shows how this botanical epistemology supported and was sustained by the expansion of empire. 'Truth-to-nature' offered the epistemological structures by which the plant life of diverse and often exotic ecologies could be understood and classified.

It seems unlikely, however, that Brontë painted her begonia from an actual specimen. As Christine Alexander and Jane Sellars describe, her artwork follows the contemporary artistic tradition of 'from nature', a term that actually denotes a painting copied from an

[82] Alexander and Sellars, *Brontës*, p. 86.
[83] Daston and Galison, *Objectivity*, pp. 55-113.

artistic copybook.[84] Dierdre Lynch writes that Jane Austen's *Mansfield Park* 'aligns the second nature of education with the florist's flowers of the greenhouse', and Brontë's painting evidences an identical process.[85] Learning to paint plants in the 'from nature' tradition was seen as an appropriate female accomplishment, with delicate exotics such as the begonia in turn offering powerful metaphors of female development. Faithfully copying hundreds of such images thus trained women in 'from nature' painting while framing an ideal form of delicate and submissive femininity. As Theresa Kelley explains, this 'iconographic tradition […] rendered women as passive flowers in need of care (or abuse)'.[86]

It is from Lynch's reading of Austen's fiction that I develop the concept of the greenhouse marriage in *Jane Eyre*. Lynch builds on King's reading of botany and novel form by placing the eighteenth- and nineteenth-century iconography of botanical femininity in a specifically imperial frame. For Lynch, Austen's novels associate women with flowers through a discourse of artificial growth and bloom, such that the play of courtship in the country-house drawing room is akin to the artificial climate of the greenhouse. As with Blanche Ingram above, eligible young women are thus literally and figuratively 'located […] amidst the ornamental plants bred up in the Regency's increasingly numerous greenhouses, hothouses, hotbeds, hot-stoves and forcing houses'.[87] Lynch encapsulates this iconography under the term 'Greenhouse Romanticism', whereby upper-class women might care for plant life, perhaps even study botany, but in so doing themselves be seen as delicate and exotic blooms to be artificially cultivated for the marriage market.[88]

With her artistic training shaped by this botanical iconography, Brontë seems to have been well aware of the associations linking the cultivation of plants and the education of young women. Responding by letter to George Henry Lewes's review of *Jane Eyre*, published in *Fraser's Magazine* in 1848, and specifically to his claim that Austen and Fielding were the greatest English novelists, she defended her novel by dismissing *Pride and Prejudice* as 'a carefully-fenced, highly cultivated garden with neat borders and delicate flowers'.[89] Where for Lynch, quoting these words, Brontë's comments contribute to a study

[84] Alexander and Sellars, *Brontës,* pp. 51-52. See also Daston and Galison, *Objectivity,* p. 99. In botany, this artistic training functioned alongside scientific knowledge-making by preparing a discerning scientific eye for the isolation and depiction of ideal botanical form. As Daston and Galison demonstrate, botanists and illustrators of the early nineteenth century thus worked together to portray plants in ideal illustrations developed from the close consideration of actual specimens. *Objectivity,* p. 104.
[85] Lynch, 'Greenhouse Romanticism', p. 719.
[86] Kelley, *Botany*, p. 93.
[87] Lynch, 'Greenhouse Romanticism', p. 694.
[88] Lynch, 'Greenhouse Romanticism', p. 692.
[89] Quoted in Lynch, 'Greenhouse Romanticism', p. 709.

of Austen's botanical marriage plots, for me they lead to an examination of how *Jane Eyre*, as Brontë seems to stress to Lewes, resists the cultures of botanical femininity so prominent in earlier fiction.

Long before Ingram's 'discourse on botany', the botanical associations of the greenhouse marriage are introduced across the opening chapters of *Jane Eyre*. The novel begins with Jane examining the plates in *Bewick's History of British Birds* (1797): 'Each picture told a story', she describes, 'mysterious often to my undeveloped understanding and imperfect feelings, yet ever profoundly interesting' (11). Developing this understanding by learning to execute 'beautiful paintings of landscapes and flowers' (30) is one of the chief attractions Jane finds at Lowood School. Much as Brontë's begonia evidences interrelated scientific and artistic cultures, Jane's 'paintings of butterflies hovering over unblown roses, of birds picking at ripe cherries, of wrens' nests inclosing pearl-like eggs' (88), are influenced by her formative perusal of scientific literature as well as her artistic training. But in cultivating her artistic ability through 'ideal drawings' (88) of plants and birds, Jane is figured as a plant to be cultivated into an ideal form herself. Mrs Reed, Jane's begrudging guardian, looks forward to 'uprooting' her 'bad propensities' (25), cultivating Jane as she would her 'hothouse vines' and 'conservatory' 'plants' (18). Jane is soon admitted for further 'cultivation' (41) into Lowood' school, described by the school's supervisor, Mr. Brocklehurst, as 'that nursery of chosen plants' (42). Lowood's object, as Brocklehurst repeatedly stresses, is to cultivate qualities such as 'humility' (41) and 'grace' (76) in young women; as he reprimands Miss Temple, who has just informed him that a student's hair 'curls naturally', these girls are 'not to conform to nature' (76). In this way, the development of Jane's intellect and character begin to be framed in terms of the cultivated hothouse exotic.

Jane does not accept this framing passively. Where botanical illustration looks to abstract and depict ideal form, Jane often engages in the close observation of particulars. She references these instances of detailed observation from the novel's first chapter, describing how she 'mused on the disgusting and ugly appearance' of John Reed (13), 'scrutinised the face' of apothecary, Mr Lloyd (23), 'examined' and 'perused' Mrs Reed's 'figure' and 'features' (43). Jane focuses each time on particular rather than ideal form. For Kelley, 'Jane's quirky reading and painterly practices' seem to suggest 'a rebelliousness' to botanical figuration, and while *Jane Eyre* is not the focus of Kelley's study, the rebelliousness she identifies is yet more pronounced in Jane's observation and understanding of the world.[90] It is

[90] Kelley, *Botany*, p. 111.

in discussion with Mr Lloyd where Jane first describes her careful examination in terms of analysis: 'How difficult it was to frame any answer! Children can feel, but they cannot analyse their feelings; and if the analysis is partially effected in thought, they know not how to express the results of the process in words' (29). For Jane, analysis here describes isolating the constituent components of individual character and expressing the result in words. As for Blanche and botany, science becomes discourse, but Jane's analysis adheres to a very different way of knowing plants and soils stemming from science's applications to agriculture.

For Liebig, the analysis of character was a central component of agricultural investigation. '[C]hemistry', he wrote, 'teaches the mode of investigating the composition and of studying the characters of the different substances from which plants derive their nourishment'.[91] Soil may thus be defined 'according to the different external characters and chemical properties which it presents'.[92] *Chambers's Journal* echoed this discourse in reviews of Liebig's work: *Organic Chemistry*, an 1842 article described, 'referred to the chemistry of vegetable life; that is, the character of those elementary bodies which went to the formation of vegetables'.[93] And this discourse of character was not confined to chemistry. Focusing on geology in 1832, Buckland had drawn attention to 'the dependence of the character of the soil upon the condition of the subjacent strata'.[94] Such references to geological and chemical character are common across Johnston's science. Lecturing to the GPS in 1838, he urged 'the discovery of characters, fossil or mineralogical, by which [strata] may readily be identified'.[95] Writing in *Blackwood's Magazine* in 1842 he stated that 'the general agricultural character of every district is dependent on the stratified or unstratified deposits on which the district rests'.[96] Although 'soil tak[es] its general character from the subjacent rock', however, 'this intimate and direct relation [is not] to be observed' everywhere, with 'the chemical constituents of the minerals' also having a bearing on soil composition.[97] A soil thus 'derive[s] its character' from rock and mineral, 'peculiar properties', as Johnston described them in *Elements*, requiring 'the united application of geological and chemical knowledge' to identify.[98] This discourse of character, common

[91] Liebig, *Organic Chemistry*, p. vii.
[92] Liebig, *Organic Chemistry*, p. 5.
[93] Anon., 'Liebig's Animal Chemistry', p. 253.
[94] Anon., 'British Association', 30 June 1832, p. 409.
[95] Johnston, *Geological and Polytechnic*, p. 14.
[96] Johnston, 'Science and Agriculture', p. 751.
[97] Johnston, 'Science and Agriculture', p. 751.
[98] Johnston, 'Science and Agriculture', p. 751; Johnston, *Elements*, p. 111.

across agricultural science of the period and defining the constituent components of plants and soils rather than their ideal forms, thus united empirical observation with internal analysis. Detailed in journals with which Brontë was familiar, it offered her a method by which to isolate the botanical associations of Greenhouse Romanticism.

As Jane soon describes, she has a 'turn […] for analysis' and a propensity 'to question' (93). Arriving at Thornfield as governess to Adèle, Jane increasingly turns her analysis to character: 'But has he no peculiarities?', she asks Mrs Fairfax of Mr Rochester, 'What, in short, is his character?' (124). Jane is disappointed by the reply – that Rochester's 'character is unimpeachable' – and notes that '[t]here are people who seem to have no notion of sketching a character, or observing and describing salient points, either in persons or things' (124). Jane's analysis isolates these salient particulars from within any generalised ideal, probing, for example, Fairfax's suggestion of Rochester's 'unimpeachable' character. On meeting Rochester, she realises his 'character' remains 'beyond my penetration' – or rather, 'beyond its present reach' (162), for she continues to hone her analytical method. Just as Amy King has shown that natural history's 'twinned reverence for minute details and for the commonplace finds it cognate expression in literary realism', so chemistry and geology here offer Jane, (and Brontë's realism, as I come to later), a methodological framework to isolate and describe details and particulars.[99] In this way, Jane can isolate 'excellent materials' (172) in Rochester as well as learn 'the character of […] landscape' (487) surrounding Thornfield. By persistently 'analys[ing] […] peculiarities of person and character' (280), her method applies a structure of analysis, borrowed from agricultural science's focus on soil and plant character, to isolate the components of character across both the human and non-human world.

Infused with the geological observation and chemical analysis of agricultural science, Jane thus develops a method aimed at identifying the granularities and particularities of her surroundings, not the abstracted ideals of Romantic botany. These epistemologies purport to understand plant life in very different terms and, as they meet in *Jane Eyre*, plants and their associated cultures become an inevitable site of conflict. It is in the woods surrounding Lowood that Jane notes her 'turn for analysis', and on arriving at Thornfield soon applies analytical investigation to flora:

[99] Amy M. King, 'Reorienting the Scientific Frontier: Victorian Tide Pools and Literary Realism', *Victorian Studies*, 47.2, Papers from the Second Annual Conference of the North American Victorian Studies Association (Winter 2005), pp. 153-63 (159).

> I walked slowly to enjoy and to analyse the species of pleasure brooding for me in that hour and situation. […] I was a mile from Thornfield, in a lane noted for wild roses in summer, for nuts and blackberries in autumn, and even now possessing a few coral treasures in hips and haws, but whose best winter delight lay in its utter solitude and leafless repose. If a breath of air stirred, it made no sound here; for there was not a holly, not an evergreen to rustle, and the stripped hawthorn and hazel bushes were as still as the white worn stones which causewayed the middle of the path. Far and wide, on each side, there were only fields, where no cattle now browsed; and the little brown birds, which stirred occasionally in the hedge, looked like single russet leaves that had forgotten to drop. (131)

Unlike Brontë's 'Pink Begonia', Jane identifies plant life in terms of seasonal variation rather than full-blooming summer ideal. She does so from a position immersed in the agricultural landscape, among 'fields, where no cattle now browsed', rather than closeted in the drawing room. As Chang has identified of nineteenth-century genre fiction, environmental description is here an 'opportunit[y] to make meaning' rather than a 'gap or break from regular narrative work'.[100] Botany's classificatory structures begin to break down as birds become leaves, plants become stone; organic and inorganic nature may be approached together via analysis of the agricultural environment. Avoiding Ingram's botanical terminology, Jane presents plants in more vernacular terms. Her analysis of people and plants, like Johnston's analysis of soil, is meant to be accessible, (or at least far more so than the botany Ingram is permitted to study because of her class position), for Jane does not classify plants as species according to a learned Linnaean taxonomy, but analyses plant life as the 'species of pleasure' she, and anyone else, might 'enjoy'. This message will be reiterated later in the novel, as Jane's friendship with Diana and Mary Rivers is solidified across class boundaries through a shared appreciation of the 'moss', 'heath-bell', 'flower-sprinkled turf', 'brilliant bracken, and mellow granite crag' surrounding Marsh End. 'These details were just to me what they were to them', Jane explains, 'so many pure and sweet sources of pleasure' (403).

Brontë thus presents a schism between divergent understandings of soils and plants. While botany's Latin taxonomies remain the preserve of those wealthy and leisured enough to learn them, uniformitarian discourse suggests that knowing the natural world, (and particularly soils, as Johnston urged), may be the preserve of all.[101] Similarly, where the botanist observes a particular specimen to abstract an ideal form of the species in

[100] Chang, *Novel Cultivations*, p. 9.
[101] Elizabeth Gaskell's depiction of the working-class naturalist Job Legh in *Mary Barton*, (a novel I consider in chapter 2), offers clear evidence that botany was not only the preserve of the wealthy. Yet botany is presented in *Jane Eyre* as an exclusively upper-class pursuit, aligning with Brontë's attempts to challenge the botanical figuration of women in the country-house marriage plot.

watercolour, the organic chemist, as Liebig explained, analyses this same specimen to understand not 'form' and 'structure', but constituents and 'process'. In *Jane Eyre*, the idealising traditions of botany, in the form of Blanche Ingram, are soon isolated by Jane's analysis:

> [Blanche] was very showy, but she was not genuine: she had a fine person, many brilliant attainments; but her mind was poor, her heart barren by nature: nothing bloomed spontaneously on that soil; no unforced natural fruit delighted by its freshness. (215-16)

Jane here apprehends the botanical associations of the greenhouse marriage with an analysis of character located in the drawing room, the site of Ingram's 'discourse on botany'. The 'forced' and unnatural growth of the hothouse is aligned with the cultivation of 'brilliant attainments' and 'fine person' (216) in young women.[102] Removed from such artificial conditions, pared from her education and training, Jane isolates Ingram as a 'barren' 'soil' incapable of 'spontaneous', 'natural' growth. Like the 'exquisite flowers' (198) which decorate the drawing room, these cultivated characters are 'not genuine', Jane realises, for they adhere to an idealised and thus artificial understanding of female accomplishment. In this way, Jane successfully 'analys[ses] the mingled sounds' (196) of drawing-room conversation to isolate the components of Ingram's botanical 'discourse' (200). By aligning human, soil, and vegetable character, her analysis uncovers the components of Ingram's impressive botanical form, and with it the artifice supporting the cultures of Greenhouse Romanticism in the mid-nineteenth century.

For all her success analysing Ingram's character, however, analysing Rochester presents Jane with a problem. As she visits Thornfield's library to hear from a fortune teller, (soon revealed to be Rochester in disguise), the novel parodies the difficulties of objective analysis, considered at length in my next section. Jane has just been told, by the disguised Rochester, that his true self must seem 'grateful' for the admiration Blanche has been showing him:

> 'Grateful! I cannot remember detecting gratitude in his face.'
> 'Detecting! You have analysed, then. And what did you detect, if not gratitude?'
> I said nothing.
> 'You have seen love: have you not? – and, looking forward, you have seen him married, and beheld his bride happy?'
> 'Humph! Not exactly. Your witch's skill is rather at fault sometimes.' (231)

[102] For more on 'forcing' see Lynch, 'Greenhouse Romanticism', pp. 703-04.

As earlier in the novel, when in the company of Mr Lloyd, Jane is invited to describe her analysis in words. Once more, she struggles to do so. Given her penetrating account of Ingram, evidently the problem is no longer an inability to 'analyse [her] feelings' or 'express the results of the process' (29). Yet the same challenge of transcending subjective 'feelings' to generate supposedly objective knowledge via analysis is evident as Jane struggles, or perhaps refuses, to identify Rochester's courtship of Ingram in terms of Greenhouse Romanticism. While she does not 'detect' love in his face, she cannot trust her analysis, for the feelings bound up in her 'throbbing heart' betray any claims to an objective perspective (218): 'It had formerly been my endeavour to study all sides of his character', she describes, '[n]ow I saw no bad' (218). Idealising Rochester in this way inevitably clouds her analysis of Ingram, who she believes 'happy, because one day she might look into the abyss [of Rochester's character] at her leisure, explore its secrets and analyse their nature' (218). Renouncing her analysis of particulars for a vision of the ideal, Jane in turn loses sight of the epistemological structures associated with Ingram's botany, incapable as they are of any such granular analysis.

If Rochester's 'trickery is a source of power' in this scene, as Gilbert and Gubar identify, then in terms of the greenhouse marriage plot this power seeks to conceal the abuse such botanical unions may perpetrate.[103] While Jane struggles to turn her analysis on Rochester's character, the novel is clear that his views of women align with the conventions of Greenhouse Romanticism. His manipulation of Ingram and Jane, courting the former to 'render' the latter 'madly in love' (303), offer the visible manifestations of far worse violence that Bertha Mason endures at his hands, largely on the novel's margins. My fourth section will deal with this in detail, but it is important to note here how Rochester's abusive treatment of women is figured through botanical association, such as in the following passage where he is describing his former lover, and Adèle's mother, Celine Varens:

> I have been green, too, Miss Eyre – ay, grass green: not a more vernal tint freshens you now than once freshened me. My Spring is gone, however, but it has left me that French floweret on my hands, which, in some moods, I would fain be rid of. Not valuing the root whence it sprang; having found that it was of a sort which nothing but gold dust could manure, I have but half a liking to the blossom, especially as it looks so artificial as just now. (163-64)

Rochester here uses the artifice of the exotic cultivar to frame Celine's affair. Describing a plant 'which nothing but gold dust could manure', Rochester frames her falsity in terms of

[103] Gilbert and Gubar, *Madwoman in the Attic*, p. 354.

the artificial cultivar, aligning his former lover with the 'fumes of conservatory flowers' which 'stifle' her apartment (166). He attempts to distance daughter from mother by 'transplant[ing]' Adèle from the 'slime and mud of Paris […] to grow up clean in the wholesome soil of an English country garden' (170). Cultivated on the English estate rather than in the corrupting 'mud' of Paris, this 'French floweret' is to be 'train[ed]' akin to one of the English climbing roses that fill Thornfield's gardens. But even as he attempts to distance Adèle in this way from the 'artificial' hothouse exotic she appears to resemble, his actions betray a damaging belief that frames daughter and mother as 'blossom' and 'root'. This figuration defines Adèle once more within the cultures of Greenhouse Romanticism, as a plant to cultivate, care for, or perhaps abuse.

Botanical iconography thus enacts structures of patriarchal power, and Jane tries to resist Rochester's attempts to define her as a similarly passive and submissive plant. '[D]on't crown me with roses' (301), she warns him, 'I will not be your English Celine Varens' (311). Rochester ignores her: '[I] would yet set you glistening like a parterre' (309), he says, defining Jane as an ornamental flower border and the passive recipient of male cultivation. Rochester pronounces her 'fair as a lily' (331) on the morning of her wedding, evoking the same genus used earlier to describe Ingram as a 'lily-flower' (206). She is, he tells her, 'fresh, healthy, without soil and without taint' (252). While his description is meant to evoke the verb form of 'to soil', as in 'to make dirty' or 'tarnish', it offers an analogical alignment with the epistemological structures of botany. Where the botanical illustrator looks to abstract the ideal of species form in watercolour, Rochester mirrors the process by abstracting Jane as an example of untainted perfection from any possible associations with soil. Despite her protestations, Rochester thus enacts their courtship within the paradigms of botanical greenhouse culture that direct his earlier relationships with women.

As Gilbert and Gubar explain, Jane 'yearns to escape entirely from drawing rooms and patriarchal mansions', and while she is unable to do so her granular analysis of botanical forms unsettles the structures of patriarchal power enacted through the greenhouse marriage.[104] If young women are flowers to be cultivated through education, then woman-as-plant may be analysed to reveal a complex constitutive character such education would seek to efface. Jane thus learns to isolate and reject the iconography that would view her education in terms of delicate hothouse growth by learning a different epistemology of soils and plants. With 'surveillance and interpretative penetration form[ing] the groundworks of Jane and

[104] Gilbert and Gubar, *Madwoman in the Attic*, p. 338.

Rochester's erotic struggles', as Shuttleworth's reading of phrenology in the novel reveals, chemical analysis offers Jane a method that understands character in terms of constituents rather than the external appearances of botany.[105]

Rejecting the idealising episteme of botany is a structural component of Brontë's realism, as my next section shows. Amy King explains how 'the complex, non-naïve relation of Victorian realists to "truth" […] emerges from a rational and empirical model of knowledge, one less tempered by Romanticism than usually credited'.[106] Where Jane's way of knowing the world goes beyond Romantic botany, Brontë's realism also interrogates empirical analysis by exposing the role of the subjective self at the heart of knowledge-making practice. *Jane Eyre*'s conception of truthful knowledge is located within bodies and environments, developed from partial perspectives, and mediates between object and knowing subject. Jane's narrative thus suggests something of Donna Haraway's situated knowledges, an understanding that shines new light on questions of genre and form that have long occupied scholars of Brontë's novel.

Attaining 'the real'

In this section I develop my reading of Jane's analysis by examining her knowledge-making practices in connection with empiricism. Jane famously passes much of her time 'watching and thinking' (58). In this, she is unlike her schoolfriend, Helen Burns, who has 'no method' (67), as she informs Jane, and whose thoughts are prone to 'wander […] into a sort of dream' (68). This distinction between watching and dreaming, suggesting a controlled analytical reasoning on the one hand and thoughts that pass unchecked into imagination on the other, is there in the following passage as Jane attempts to relay a 'most correct' account of her childhood to Miss Temple:

> I resolved in the depth of my heart, that I would be most moderate – most correct; and, having reflected a few more minutes in order to arrange coherently what I had to say, I told her the story of my sad childhood. Exhausted by emotion, my language was more subdued than it generally was when it developed that sad theme; and mindful of Helen's warnings against the indulgence of resentment, I infused into the narrative far less of gall and wormwood than ordinary. Thus restrained and simplified, it sounded more credible: I felt as I went on that Miss Temple fully believed me. (84)

Relaying a believable account here involves restraining the personal feelings which have, thus far, 'infused' Jane's accounts of her childhood with 'resentment' and bitterness. To

[105] Shuttleworth, *Victorian Psychology*, p. 171.
[106] King, 'Victorian Tide Pools', p. 157.

borrow George Levine's words on self-abnegation in the work of science, Jane for the first time offers 'a willingness to repress the aspiring, emotion-ridden self and everything merely personal […] that might get in the way of acquiring knowledge'.[107] Her 'subdued' and 'moderate' language parallels an act of emotional restraint, whereby Jane realises the need to repress a potentially unreliable self so as to offer 'credible' knowledge of her past life. 'Restrained and simplified' in this way, Jane's account is 'fully believed' by Miss Temple – at least, so Jane 'felt'. For as Peter Garratt's work on Victorian empiricism shows, scientific knowledge was increasingly seen to derive from 'felt experience' in this period, with 'the contingent self […] conceived simultaneously as the route towards knowledge and its obstacle'.[108] Jane's account is, after all, 'whatever [her] memory suggests as true' (84). Hence her narrative might be inflected with subjective feelings yet considered in terms of objective truth, simultaneously 'exhausted by emotion' and 'most correct'. Truthful knowledge can only be accessed through personal experience, it would seem, embedding a paradox that Brontë's realism examines through Jane's intellectual development, as this section will explain.

Before tracing how Jane develops her analytical method so as to negotiate this paradox, Johnston's writing offers further insight into how science negotiates the centrality of felt experience in the production of knowledge. The following passage, taken from Johnston's *Elements*, presents a knowledge-making narrative, one George Levine identifies elsewhere underpinning the work of science:

> Chemical analysis is a difficult art, – one which demands much chemical knowledge, and skill in chemical practice (manipulation, as it is called), and calls for both time and perseverance – if valuable, trustworthy and *minutely correct* results are to be obtained. I believe it is only by aiming after such minutely correct results that chemical analysis is likely to throw light on the peculiar properties of those soils which, while they possess much general similarity in composition and in physical properties, are yet found in practice to possess very different agricultural capabilities.[109]

Requiring time, perseverance and skill to attain, generating classificatory structure from endless variation, and leading from ignorance of soils to knowledge of their 'peculiar properties', Johnston's methodology bears the hallmarks of narrative. Levine's argument that the construction of objective knowledge follows a 'narrative of scientific epistemology' that

[107] George Levine, *Dying to Know: Scientific Epistemology and Narrative in Victorian England* (Chicago: University of Chicago Press, 2002), p. 2.
[108] Peter Garratt, *Victorian Empiricism: Self, Knowledge, and Reality in Ruskin, Bain, Lewes, Spencer and George Eliot* (Madison: Fairleigh Dickinson University Press, 2010), pp. 29, 15.
[109] Johnston, *Elements*, pp. 110-11; emphasis in original.

effaces the subjective self fits neatly here.[110] Johnston details a movement from personal experience, where 'soils' are 'found in practice to possess very different agricultural capabilities', to objective truth, those 'valuable, trustworthy and *minutely correct* results'. 'To be objective', as Daston and Galison write, 'is to aspire to knowledge that bears no trace of the knower'.[111] 'Chemical analysis' does not simply transcribe the composition of a soil, then, but requires the dedication of a skilled practitioner, whose work, if done successfully, effaces its own production as truthful 'chemical knowledge' is 'obtained'.

If the figure of the scientist were to become visible in the production of this knowledge, questions would be raised about the status of that knowledge as a claim to truth. Writing in *Blackwood's Magazine*, Johnston questioned Liebig's science by suggesting that theories in *Organic Chemistry* did not successfully efface Liebig's subjective beliefs. Liebig had come to argue that plants received nitrogen in sufficient quantity from ammonia in the atmosphere, making the application of nitrogenous manures unnecessary.[112] This conflicted with both practical experience and the results of experiments conducted in the field, prompting the following attack from Johnston in June 1842:

> It *is* proved that ammonia is very useful to vegetation, and ought never to be wasted in good husbandry, but then it is *assumed* by Liebig to be the only source of nitrogen to living vegetables. We are the more peculiar in insisting upon this, because the writer, borne away by his own belief, expresses himself as if he really had deduced his opinion from legitimate premises, and because we have seen many notices of his book, in which, what is merely an opinion of the writer, is really supposed to be proved.[113]

Liebig's theory of nitrogen assimilation by plants was not 'deduced […] from legitimate premises', Johnston claimed, because it advanced a personal opinion. Understood in terms of Levine's narrative of scientific epistemology, Johnston suggests that Liebig abandons the processes of objective chemical analysis in favour of a subjective assumption. He is 'borne away by his own belief' from the actual role of nitrogen in plant growth and, most damagingly, from a reliable scientific method. 'We should be sorry to think that such an opinion was capable of proof', Johnston concluded, 'for we are quite sure that it does not truly represent the ordinary procedure of nature'. [114]

[110] Levine, *Dying to Know*, p. 268.
[111] Daston and Galison, *Objectivity*, p. 17.
[112] This position developed between the first (1840) and third (1842) editions of *Organic Chemistry*. See: Brock, *Liebig*, pp. 159-60, 166-67; Munday, 'Justus von Liebig', pp. 225-26.
[113] Johnston, 'Science and Agriculture', p. 746; emphasis in original.
[114] Johnston, 'Science and Agriculture', p. 746.

As Johnston defines scientific truth in terms of theories that 'truly represent the ordinary', his words point to a representationalism at work across science and the novel. In *Jane Eyre*, moments of crisis are often figured in terms of negotiating relations between subject and object to form a representation of reality that may be considered truthful. This is the case in the following passage, as Jane receives 'information' that Rochester and Ingram are likely to marry:

> I reviewed the information I had got; looked into my heart, examined its thoughts and feelings, and endeavoured to bring back with a strict hand such as had been straying through imagination's boundless and trackless waste, into the safe fold of common sense. (186)

Jane believes she has 'rejected the real, and rapidly devoured the ideal' (186), by failing to control her imaginative speculations. This has led her to misrepresent Rochester's conduct towards her, or so she believes. As Levine notes, while 'a self-denying surrender to the reality of the real' offers the grounds for objective knowledge, it also implies 'an imaginative imposition of the self on the world'.[115] If science is understood 'as a particularly organized, developed and rigorous application of common sense', Jane's 'reason' thus aims to return her to an objective position on the information at her disposal.[116] That she once again fails to understand Rochester's actions, (which are in fact aimed at manipulating her feelings), reinforces the sense that gaining an objective perspective on reality is fraught with difficulty and contradiction. For as Liebig misrepresents the fact that 'ammonia is very useful to vegetation' by assuming it to be plants' 'only source of nitrogen', Jane struggles to negotiate similar relations between subject and object to arrive at truth. In this way, as Johnston points out an error that suggests some of the difficulties of truthfully representing reality common also to Jane, his words are indicative of a representationalism at work across a spectrum of realist writing, encompassing nineteenth-century novels and scientific texts.

Truth may therefore be defined in terms of the faithfulness with which any representation depicts the subject of investigation. But this is complicated in *Jane Eyre* because the truth-to-nature of botany and the objectivity of organic chemistry aspire to different standards of scientific truth. (As Ruth Yeazel has noted, attaining 'the real' and attaining truth are not necessarily aligned in the novel.)[117] Both of these epistemes discipline a subjective imagination, but for very different ends, and Brontë examines their differences as

[115] Levine, *Dying to Know*, p. 40.
[116] Garratt, *Victorian Empiricism*, p. 23.
[117] Ruth Bernard Yeazel, 'More True Than Real: Jane Eyre's "Mysterious Summons"', *Nineteenth-Century Fiction*, 29.2 (September 1974), pp. 127-43 (128).

Jane paints portraits of herself and Ingram. She begins with a self-portrait in an effort to return from 'the ideal' to 'the real': 'place the glass before you, and draw in chalk your own picture, faithfully, without softening one defect', she directs, 'omit no harsh line, smooth away no displeasing irregularity' (187). Where Daston and Galison's objectivity aims at 'minimizing intervention, in hopes of achieving an image untainted by subjectivity', Jane resists any imaginative imposition that might 'smooth away' her defects.[118] The resulting image defines truth in terms of a 'faithful' representation of 'irregularity' as it appears in 'the glass'.

The processes Jane uses to depict Blanche, explained in the following passage, are strikingly different. At this point in the novel, she has yet to meet her rival in person:

> [D]elineate carefully the loveliest face you can imagine; paint it in your softest shades and sweetest hues, according to the description given by Mrs Fairfax of Blanche Ingram: remember the raven ringlets, the oriental eye; – What! you revert to Mr Rochester as a model! Order! No snivel! – no sentiment! – no regret! I will endure only sense and resolution. Recall the august yet harmonious lineaments, the Grecian neck and bust; let the round and dazzling arm be visible, and the delicate hand, omit neither diamond ring nor gold bracelet; portray faithfully the attire, aërial lace and glistening satin, graceful scarf and golden rose. (187)

Painting 'the loveliest face you can imagine' by emphasising 'harmonious lineaments', Jane harnesses her imagination to capture an ideal form. As Daston and Galison identify, images in the truth-to-nature tradition offer 'as much an emblem of a whole class of objects as a portrait of any one of them', and Jane's painting of Blanche as 'Grecian' beauty seeks 'to render not merely the typical but the perfect'.[119] Jane may have never met her rival, but this does not stop her 'recalling' her beauty. Where she calls for 'order', 'sense and resolution' to banish dreams of Rochester, imagination is not disciplined by omission, (as it was in the construction of her self-portrait), but controlled so as to translate only those features typical of the perfect form ('according to the description' given by Mrs Fairfax) into an idealised image. The different mediums, with Blanche depicted in watercolour and Jane in chalk, further serve to emphasise different ways of knowing. These differences play out, in the novel, between botanical feminine ideal (Blanche as 'golden rose') and particulate soil and plant (Jane as composite character). Yet for all their differences, both portraits are described as 'faithfully' representing their subject. Jane Kromm, reading Jane's portraits in terms of artistic realism, suggests that 'Brontë's handling of these portrait images in effect minimises

[118] Daston and Galison, *Objectivity*, p. 43.
[119] Daston and Galison, *Objectivity*, p. 70.

claims to objectivity in appearance'.[120] When approached through the procedures of contemporary science, however, in aspiring to objectivity on the one hand and truth-to-nature on the other, both portraits may be constructed very differently while showing equal fidelity to truth.

Brontë examines these scientific viewpoints through her protagonist's intellectual development. In seeking to understand the world, Jane is frequently caught between the idealisation of forms and an analysis of particulars. These ways of knowing offer different 'epistemic virtues', as Daston and Galison describe them, that Jane has to negotiate and qualify, for as Brontë emphasises, both lead to extreme positions when followed absolutely.[121] For instance, as Rochester becomes Jane's 'idol' over 'God', she experiences his proposal as a 'dream' in which it is impossible to 'be certain of the reality' (297). With the novel's courtships forming 'competitive exercises in interpretative penetration', as Shuttleworth explains, Jane here renounces the analysis of particulars for an untempered vision of an ideal future.[122] Such an unqualified perspective is misleading and dangerous, the novel emphasises; on learning that Rochester is already married to Bertha, Jane realises that love has left her 'blind' to reality (341). Having abandoned any attempt at analytical investigation, however, visions of the ideal continue to crowd her vision. Once she has escaped Thornfield and found refuge at Moor House, she sees Rosamond Oliver in terms of the 'pure hues of rose and lily', as an 'earthly angel' that 'realised the ideal of beauty', as 'a youthful, graceful form […] as ever the temperate climes of Albion moulded' (418). St John Rivers's appearance is akin to that of 'antique models', Jane suggests, framing both him and Rosamond as specimens of the ideal rather than particulate characters. As St John himself identifies, when left unregulated, Jane's 'tastes' have a propensity to 'lean to the ideal' (407). When unqualified by any more particulate focus, her representations of reality align with the idealising traditions of Romantic-era botany that she elsewhere firmly rejects.

St John's and Jane's courtship offers a series of 'struggles […] played out on the field of knowledge', writes Shuttleworth.[123] As these struggles are detailed in the latter stages of the novel, St John advances the epistemic virtue of objectivity, embodying the dangers of such a necessarily impersonal perspective. 'Reason, and not feeling, is my guide (423), he states, as his 'ever watchful blue eye' (456) is equated with the 'eye of science' (461). This

[120] Kromm, 'Visual Culture', p. 383.
[121] Daston and Galison, *Objectivity*, p. 111.
[122] Shuttleworth, *Victorian Psychology*, p. 149.
[123] Shuttleworth, *Victorian Psychology*, pp. 176-77.

eye isolates Jane's 'constitution' as 'calculated to endure variations of climate', variations that St John would subject Jane to as his missionary wife. Jane comes close to accepting his proposal, despite perceiving that this action will result in her death: 'mine is not the existence to be long protracted under an Indian sun' (466), she pleads, reiterating shortly afterwards that 'I should not live long in that climate' (471). St John offers another 'pillar of patriarchy', and as with the patriarchal structures of the hothouse marriage, Jane is once more subjected to a framing that sees her existence dangerously close to exotic plant life.[124] Only now, rather than Rochester placing female bodies within the stifling confines of the hothouse (or attic) on the English country estate, Rivers's belief in Jane's 'constitution' would enact a concomitant violence that would see her removed from England altogether. There are parallels here with Bertha's extraction from her home to a different land and climate, detailed more fully in my next section. Seen in terms of the conventions of Greenhouse Romanticism, the application of St John's unqualified objectivity to the female body may permit just as much violence as the idealising traditions of truth-to-nature.

Jane's analysis of particulars must therefore fall between these two poles of truth – the ideal and the objective. Having begun to perceive 'elements within' (396) St John's idealised form, she comes to understand a character that 'could not bond all that he had in his nature […] in the limits of a single passion' (424). Once more, analysis is achieved at a moment of crisis, with Jane struggling to resist St John's loveless proposal of marriage:

> How much of him was saint, how much mortal, I could not heretofore tell: but revelations were being made in this conference: the analysis of his nature was proceeding before my eyes. I saw his fallibilities: I comprehended them. I understood that, sitting where I did, on the bank of heath, and with that handsome form before me, I sat at the feet of a man, erring as I. The veil fell from his hardness and despotism. Having felt in him the presence of these qualities, I felt his imperfection, and took courage. I was with an equal – one with whom I might argue – one whom, if I saw good, I might resist. (469)

For Levine, 'plots turn on the power of the protagonist to develop the proper temper and state of mind to allow realistic confrontation with the object'.[125] As Jane's analysis identifies hidden 'imperfection', she gains the agency to 'resist' St John's will and reject his proposal of marriage. While her analysis of St John's ideal 'form' reveals 'fallibilities' within, however, Jane's method does not offer her 'truth through objectivity' as Levine would understand it.[126] She recalls instead how she 'felt in [Rivers] the presence' of 'hardness' and

[124] Gilbert & Gubar, *Madwoman in the Attic*, p. 366.
[125] Levine, *Dying to Know*, p. 149.
[126] Levine, *Dying to Know*, p. 149.

'despotism', through which she 'felt his imperfection', equating analysis as a process akin to Garratt's identification of empiricism. As the ideal form is isolated by analysis as 'felt experience', Levine's 'object' eludes any totalising objective perspective, with 'qualities' instead perceived, or rather 'felt', indirectly.[127] Personal experience is thus presented as both the route and obstacle to truthful knowledge, with relations between knowing subject and known object a question of negotiation rather than abnegation.

As Brontë qualifies the idealisation of truth-to-nature in the greenhouse marriage, she thus also qualifies and mediates any objective perspective. This is how the novel ends, with Jane describing the world to a symbolically blind Rochester from a position 'buried in a wood' (496, 516). Far from the botanical feminine ideal of Thornfield's drawing-room, Jane and her husband are situated conspicuously within plant life rather than abstracted from it. 'At Ferndean, a manor-house on a farm' (495), she becomes Rochester's eyes in a formulation which centres personal experience in knowledge-making practice:

> I was then his vision, as I am still his right hand. Literally, I was (what he often called me) the apple of his eye. He saw nature – he saw books through me; and never did I weary of gazing for his behalf, of putting into words, the effect of field, tree, town, river, cloud, sunbeam – of the landscape before us; of the weather round us […]. (519)

Jane here occupies a mediating position between a world inaccessible to Rochester and its representation. If St John's 'eye of science' offers what Donna Haraway would term 'the sensory system […] used to signify a leap out of the marked body and into a conquering gaze from nowhere', then Jane's perspective is conspicuous here for being 'buried' (496, 516).[128] Considered in terms of Haraway's situated knowledges, as visual perception is mediated 'through' Jane, the abstracted 'view[s] from nowhere' of truth-to-nature and objectivity are rejected for an 'embodied objectivity' that is necessarily partial.[129] Thus analysis as 'felt experience' does not automatically deny the possibility of objectivity. 'Positioning is […] the key practice in grounding knowledge organized around the imagery of vision', Haraway emphasises, and as Rochester learns to see again, 'bending his sightless eyes to the earth' (516), the novel closes with an altogether more grounded relationship of care than those proposed by either the botanical framing of ideal womanhood or St John's 'cold' (458) objective gaze.[130] As Rochester comes to see through Jane's situated perspective, the marital

[127] Garratt, *Victorian Empiricism*, p. 29.
[128] Haraway, 'Situated Knowledges', p. 581.
[129] Haraway, 'Situated Knowledges', p. 590.
[130] Haraway, 'Situated Knowledges', p. 587.

'equality' that scholars have long seen realised in this scene can thus also be read in epistemological terms.[131]

Yet with 'vision […] always a question of the power to see – and perhaps of the violence implicit in our visualizing practices', Haraway would rightly point out the problems with this reading of *Jane Eyre*.[132] As I consider in my next section, the novel never addresses the treatment and perspective of Bertha, or indeed the wider colonial structures of power that allow Brontë to close the novel with Jane and Rochester shut away in apparent 'isolation' from the world.[133] But it is worth considering beforehand how Jane's arrival at something akin to 'objectivity as positioned rationality', as Haraway might understand it, relates to questions of genre and form in Brontë's novel.[134] As scholars have long found, *Jane Eyre* is notoriously difficult to classify. Shuttleworth, for example, calls into question the developmental progression of the novel as *Bildungsroman*, arguing that 'Jane, as child, presents the same psychological formation as Jane in adulthood'.[135] As I have also been arguing, the novel stages 'a series of moments of [epistemological] conflict', but I would suggest that these moments offer growth by detailing Jane's intellectual, rather than psychological, development.[136] This methodological refinement underpins Brontë's realism, for as Jane examines, scrutinises, and watches, her repeated efforts at analysis gradually penetrate something of what Elizabeth Ermarth has described as the 'depth' of the world.[137] 'The realist says that the object can be grasped in any one instance only in aspect', Ermarth explains, 'and that fuller apprehension depends on the reductive comparisons made from a series of instances'.[138] In this way, Jane's repeated attempts to analyse character offer the means by which Brontë 'can project from a limited number of cases to general laws of relationship or sequence'.[139] The novel as narrative-told-in-retrospect thus details the processes of its own construction as the protagonist refines the appropriate method to understand the world and thus construct a realistic sequence of events. The passage where

[131] On Jane and Rochester's marriage at Ferndean as an equal relationship see, for example: Yeazel, 'More True Than Real', pp. 137-141; Gilbert and Gubar, *Madwoman in the Attic*, p. 354.
[132] Haraway, 'Situated Knowledges', p. 585.
[133] Gilbert and Gubar, *Madwoman in the Attic*, p. 369.
[134] Haraway, 'Situated Knowledges', p. 590.
[135] Shuttleworth, *Victorian Psychology*, p. 159.
[136] Shuttleworth, *Victorian Psychology*, p. 159.
[137] Elizabeth Deeds Ermarth, *Realism and Consensus in the English Novel* (Princeton: Princeton University Press, 1983), p. 36.
[138] Ermarth, *Realism*, p. 34.
[139] Ermarth, *Realism*, p. 21.

Jane attempts to be 'most correct' as she narrates her past life to Miss Temple might be taken for the novel in microcosm.

What then of those 'Gothic interludes', described by Nancy Armstrong, that 'tear a hole in the fabric of realism'?[140] Realism necessitates 'that the same conditions hold everywhere in space', Ermarth explains, and that 'objects have an invariant structure that does not change with position'.[141] The 'supernatural' (516) voice that calls Jane to Rochester towards the novel's conclusion is an obvious example where *Jane Eyre* breaks these bounds of 'normative perception'.[142] It is far from the only such moment: on the night of Rochester's proposal, for instance, Jane professes to 'experience[ing] no fear and little awe' (296) as the 'cataract-like' storm rages above. With Jane denying sublimity even as the novel invokes the height of pathetic fallacy, the broader Gothic resonances with which these Romance traditions are associated come to the fore as lightning strikes 'the great horse-chestnut' in Thornfield's grounds, leaving 'half of it split away' (296). In an uncanny presentiment of Rochester's injuries, Jane and Rochester's separation, and the destruction of Thornfield Hall, this symbolism suggests powers at work beyond the known procedures of nature. But the storm also has more prosaic effects, leaving 'the dust [of fields] well laid' and plants 'glistening green and rain refreshed' (308); as Johnston wrote in *Blackwood's*, 'plants derive a large […] portion of their nitrogen' as 'nitric acid' is formed 'by the passage of electricity through the atmosphere', leaving plant life especially 'invigorated by the fall of a thunder-shower'.[143] Brontë's 'well laid' earth may be a reference to the latest agricultural science or, perhaps more likely, a common turn of phrase, but what is certain is that her novel describes the storms empirically observable effects on soil while also conjuring its unknowable supernatural elements. 'When novels banish Gothic phenomena', argues Armstrong, the narrative aims 'to unify a world', creating a plain of experience that is coherent and homogenous in the ways Ermarth explains.[144] This is not the case in *Jane Eyre*, however, where the prosaic and the paranormal appear side by side.

This uneasy presence of the Gothic in Brontë's realism relates to *Jane Eyre*'s negotiation of subject and object. If 'Gothic fiction sees realism as too narrowly focussed on whatever a readership can know about the world', as Armstrong explains, then the

[140] Nancy Armstrong, 'A Gothic History of the British Novel', in *New Directions in the History of the Novel*, ed. by Patrick Parrinder, Andrew Nash, and Nicola Wilson (New York: St Martin's Press, 2014), pp. 103-20 (106).
[141] Ermarth, *Realism*, p. 21.
[142] Armstrong, 'Gothic History', p. 106.
[143] Johnston, 'Science and Agriculture', p. 746.
[144] Armstrong, 'Gothic History', p. 106.

possibilities of the form align with Brontë's conception of realist narrative as necessarily partial knowledge.[145] Gothic interludes highlight what is known by a process of negation. By introducing unexplained processes to realist narrative, such interludes break the bounds of normative perception; in so doing, they suggest knowledge that the novel-as-representation might be unable to access or fully account for. *Jane Eyre*'s Gothic interludes are important for Brontë's realism in the same way as the positioning of Jane's personal experience in the creation of knowledge; they highlight the limits of the known at the expense of any totalising perspective to arrive at a conception of reality that might be taken as truthful. For as she hears Rochester's voice, Jane frames 'superstition' as 'the work of nature', whereby unknown processes are 'roused, and did – no miracle – but her best' (483). As Srdjan Smajić explains:

> The "spectre" of superstition is laid to rest instantly, and what does the job is not Jane's incredulous attitude toward superstition but her unwavering faith in the extraordinary range of natural phenomena. At "her best" nature is not miraculous but wondrously manifold and inexhaustible. What are called laws of nature, Brontë suggests, are at best working hypotheses, at worst premature conclusions based on insufficient evidence and limited experience.[146]

Just as scholars have reconciled an 'over-contrived' ending with the novel's overall structure, Brontë's Gothic interludes are consistent with the way of knowing the world that her realism advocates, from a 'buried' and partial perspective.[147]

While Jane's 'discrete cases' of analysis form 'partial expressions of hidden wholes' in ways that align with Ermarth's conception of realism, the novel as an 'act of rationalization' does not entirely succeed.[148] As *Jane Eyre*'s Gothic interludes remain unexplained, Brontë refuses to offer a fully coherent and closed narrative system. The novel's famous 'lack of unity' points to the epistemological limits of a text where 'partiality' rather than 'universality' offers the basis for truth – or 'rational knowledge claims', as Haraway would have it.[149]

I now turn to the ways Jane defines her selfhood and the soils that constitute much of her character – both those local to northern England and those of colonial lands. In showing the ways that soils constitute Jane's subjective self, I trouble distinctions between subject and

[145] Armstrong, 'Gothic History', p. 104.
[146] Srdjan Smajić, 'Supernatural Realism', *Novel: A Forum on Fiction*, 42.1 (Spring 2009) pp. 1-22 (15).
[147] William Peden, quoted by Thomas A. Langford, 'Prophetic Imagination and the Unity of *Jane Eyre*', *Studies in the Novel*, 6.2 (Summer 1974), pp. 228-35 (228). Langford is arguing for the novel to be read instead as an 'intricate unit' (235). Also see: Yeazel, 'More True Than Real', p. 142; Gilbert and Gubar, *Madwoman in the Attic*, pp. 364-70.
[148] Ermarth, *Realism*, pp. 16, 21.
[149] Langford, 'Prophetic Imagination', p. 228; Haraway, 'Situated Knowledges', p. 589.

object, culture and nature, that in turn have implications for the construction of the novel. Drawing on Karen Barad's theories of materialism, I suggest that meaning is made in *Jane Eyre* such that, as discourses of cultivation shape material soils, the materiality of soils shapes the novel's discourses of selfhood. This allows me to trace how a violent ethos of land clearance and soil improvement is translated from the soils of northern England to the colonial plantations that, as Elaine Freedgood has demonstrated, sustain Rochester's domestic holdings at Thornfield and Ferndean.[150] Where Freedgood reveals 'deforestation, colonization, and [the] implementation of plantation slavery' in the novel via the mahogany furniture that fills the English country house, I trace the violent imperial history of soil improvement through the discourse in which Jane and St John Rivers define their selfhood.[151] Yet it is Bertha Mason, the one character presented as beyond improving cultivation in *Jane Eyre*, who in fact captures the true nature of the improvement ethos, her violent death on the novel's margins belying the centrality of her traumatic experience to the imperial extraction that sustains the novel's world.

Self and Soil amidst Global Natures

For Karen Barad, 'the representationalist belief in the power of words to mirror preexisting phenomena' offers 'the metaphysical substrate' of traditional realism.[152] As I have been showing, however, *Jane Eyre* is not based on a naïve belief in the possibility of apprehending through language a given reality perfectly or completely. Jane's intellectual development approaches instead what Barad's terms 'a performative account', which 'insists on understanding thinking, observing, and theorizing as practises of engagement with, and as part of, the world in which we have our being'.[153] This section shifts attention from Jane's intellectual development to her developing selfhood. The moment when Jane takes chalk to her self-portrait figures as a prominent – and by no means the only – example where earthy materials become intrinsic to acts of self-fashioning. My reading departs from existing studies of the novel to show how Jane's emerging selfhood is constituted in terms of earth as well as air. Defining her 'diverse rugged […] character' to Rochester as 'naturally hard – very flinty' (315), Jane delineates her identity in a discourse that borrows from soil so as to identify in terms of particulars rather than the botanical feminine ideal. As for the

[150] Elaine Freedgood, *The Ideas in Things: Fugitive Meaning in the Victorian Novel* (Chicago: University of Chicago Press, 2006), pp. 34-35.
[151] Freedgood, *Ideas in Things*, p. 32.
[152] Barad, *Meeting the Universe Halfway*, p. 133.
[153] Barad, *Meeting the Universe Halfway*, p. 133.

particularities of soil composition, so the particularities of the subjective self, with truthful knowledge defined in terms of the faithful depiction of 'irregularity' (187). But as this section will show, Jane's selfhood suggests a relationship between the analysis of human character and soil character that moves beyond analogical representation. '[H]umans enter not as fully formed, pre-existing subjects', Barad explains, 'but as subjects intra-actively co-constituted through the material-discursive practises they engage in'.[154] As Jane seeks to delimit her selfhood in terms of soil, her practices simultaneously shape human subject, the soils the human seeks to understand, and the language and ideas through which this knowledge is made and communicated.

The following passage presses at the neat divisions between knowledge and reality, subject and object, seemingly implicit in the novel's analogies between human and soil. As Jane escapes Thornfield for the moors of Northern England, she comes into contact with soils with an immediacy that threatens her corporeal existence:

> What a golden desert this spreading moor! Everywhere sunshine. I wished I could live in it and on it. I saw a lizard run over the crag; I saw a bee busy among the sweet bilberries. I would fain at the moment have become bee or lizard, that I might have found fitting nutriment, permanent shelter here. But I was a human being, and had a human being's wants: I must not linger where there was nothing to supply them. […] Hopeless of the future, I wished but this – that my Maker had that night thought good to require my soul of me while I slept; and that this weary frame, absolved by death from further conflict with fate, had now but to decay quietly, and mingle in peace with the soil of this wilderness. (374)

The passage begins by placing Jane within the intermeshed relationships of soil and plant, insect and animal, sunshine and moorland environment. She imagines herself as one of the creatures living not just 'on' the moor, but 'in' the flows of matter and energy that sustain it. This glimpse of coexistence is immediately denied, however, as Jane distinguishes herself from other moorland beings as 'a human being' with 'a human being's wants'. As her words refer to practical questions of nourishment, so human society also presses on her brief vision of moorland existence as she remembers her Protestant ethics – that she must strive to make the best of her material existence while 'life' is 'yet in [her] possession' (374). This understanding of duty to God is predicated upon the division of 'soul' from body. While this separation may be so obvious as to hardly need stating, it has important consequences here, for with spirit and material seen to be ontologically distinct, Jane must refuse the opportunity 'to […] mingle in peace with the soil'. The demarcation of soul from body thus functions to

[154] Barad, *Meeting the Universe Halfway*, p. 168.

deny Jane's entanglement within the moorland's intra-actions, even as her material coexistence within them is affirmed through processes of 'decay' that would see her become 'fitting nutriment' for bilberries and other plants.

With Barad showing that the 'division between nature and culture' needs to be 'actively configured and reconfigured', Jane's near-death experience on the moor at once challenges and enacts a version of its artificial construction.[155] Before she finds shelter at Moor House, Jane's contact with moorland soils continues to challenge distinctions between nature and culture. She passes through a 'bog' (380) which leaves her as 'as white as clay or death' (386), a linguistic formulation that worries easy distinctions between material and spirit. The moor is here repeatedly described in terms of soil and plant, 'green where rush and moss overgrew the marshes; black, where the dry soil bore only heath' (380). As a dwelling in the heart of the moor, the dual names given to Moor House, or 'Marsh End' (377), invoke both these boggy and arid earths. Once inside the household, however, all 'traces of the bog' are removed from Jane and her clothes. '[N]o speck of dirt' remains and, with it, she describes, 'no trace of the disorder I so hated, and which seemed so to degrade me' (391). From dreaming of a life and death amidst moorland soil to despising this earthy matter as a mark of disorder and degradation, as Jane passes the threshold of the home, soil becomes dirt only once 'wilderness' (374) is defined against the culture of civilisation. In the home, soil thus becomes dirt in a way conveyed accurately by Mary Douglas as 'matter out of place'.[156] But if culture is also understood in its older connotations of tillage, this reading risks obscuring a second sense where soil may be dirt while remaining part of the moorland's natural processes outside the home – as matter, as it were, very much in place. For in the fields surrounding Moor House, 'almost […] as unproductive as the heath from which they were scarcely reclaimed' (379), soils come to be constituted as dirt for a perceived lack of agricultural productivity. Where Barad argues that reality is 'produced through complex intra-actions of multiple material-discursive practices', Jane's passage from heath to human society is enabled by the differential articulations of culture against nature embedded as soil becomes dirt.[157]

The distinction between soil and dirt, defined by the presence or absence of certain fertile constituents, shapes an ethos of improvement that structures the closing stages of the

[155] Barad, *Meeting the Universe Halfway*, p. 136.
[156] Mary Douglas, *Purity and Danger: An Analysis of the Concepts of Pollution and Taboo* (1966; London: Routledge, 2001), p. 36.
[157] Barad, *Meeting the Universe Halfway*, p. 140.

novel. As Jane receives a frosty reception from Hannah, the housekeeper of Moor House, she meditates on 'prejudices […] most difficult to eradicate from the heart whose soil has never been loosened or fertilised by education: they grow there, firm as weeds among stones' (391). Having come into contact with the unproductive soils of the moor, Jane constitutes the human subject in identical terms. Garratt's words on Victorian empiricism are relevant here, for Jane's experience 'modifies the contours of the knowing subject by being assimilated into its emergent identity'.[158] Placing Hannah beyond education framed as cultivation, Jane's metaphor betrays the mutual associations constituting human and soil as either receptive to or beyond improvement. Like Johnston arguing that soil should be tilled through physical and mental labour, with the prosecution of science 'impart[ing] a higher tone to the minds of the rural population', the logic that frames soils as potential production, assimilated by Jane on the moor, here dictates the improving cultivation of human character. Sure enough, as she begins teaching students from the farms surrounding Morton, Jane finds young girls with 'character […] disposed for improvement' (422). Arguing contrary to received criticism of the novel, Pizzo states that Jane's mental and bodily life do not oppose each other.[159] This is certainly true here, but where Pizzo traces these links through air, in this case it is the materiality of earth that shapes Jane's conception of her selfhood and that of others, with soil dictating the improvement of the human.

St John Rivers brings an identical ethos to the cultivation of soil and the soul. As he explains to Jane, he undertakes missionary work with the aim of 'turning [his] original materials to the best account'. Describing how he has 'cultivated' himself by 'pruning and training nature' (433), the improvement of plant and soil in the novel constitutes the development of selfhood once more. St John's faith embeds '[h]umility' as 'the ground-work of Christian virtues', as he describes a little later, words that betray an ironic and intimate connection to soil, suggesting what Robert Pogue Harrison terms 'a mode of being on the earth that rests on humic foundations'.[160] For St John can only find purpose in being 'redeemed from the earth' (521), redemption that ensures, paradoxically it would seem, that he experiences 'earth [as] no longer a void' (520). Yet to trace the associations of 'humility' and 'ground' that St John's faith conjures is to find shared etymological roots in the soil; 'humility' comes from the Latin 'humilis', meaning 'lowly, humble', literally 'on the

[158] Garratt, *Victorian Empiricism*, p. 33.
[159] Pizzo, 'Atmospheric Exceptionalism', p. 85.
[160] Robert Pogue Harrison, *The Dominion of the Dead* (Chicago: University of Chicago Press, 2003), p. 34.

ground'.[161] As the logic of improvement constitutes the 'dust and ashes' (464) of which Rivers believes his body to consist, it also cleaves a redeemable soul from the dirt of corporeal existence, betraying the artificial construction of another division between culture and nature.

St John's missionary work traces the route by which this improvement is translated to global natures – transposed from the earths of Morton onto the earth as world. The son of a farmer, he rejects the cultivation of land surrounding Moor House, detesting what he views to be an existence 'buried in morass' (394). As a missionary in India, however, he 'hold[s] that the more arid and unreclaimed the soil where the Christian labourer's task of tillage is appointed him […] the higher the honour' (407). Rejecting the 'unproductive' (379) soils of his homeland to 'reclaim' yet less promising soils abroad, St John's actions are thus shaped by the material constituents that define the productive potential of land – the same logic of soil against dirt, culture against nature. Far from an escape from the 'moorish soil[s]' he so despises, his emigration as 'pioneer' (407) is a translation of their improvement to lands far beyond England. Transplanted from the soils of Northern England to 'Madagascar', 'the Cape', or 'India' (429), to 'the Himalayan ridge, or Caffre bush, even the plague-cursed Guinea Coast swamp' (453-54), cultivation as providential duty constitutes diverse peoples and soils in identical terms – as so many natures requiring improvement.

Where intra-actions between soil and selfhood delimit the boundaries and properties of each, a world is articulated where both human and earth are made subject to improvement constituted through material applications of culture. The novel closes with a vision of Rivers, articulating once more this mutual constitution of self and world:

> A more resolute, indefatigable pioneer never wrought amidst rocks and dangers. Firm, faithful, and devoted, full of energy, and zeal, and truth, he labours for his race; he clears their painful way to improvement; he hews down like a giant the prejudices of creed and caste that encumber it. (520-21)

As Jane celebrates St John's missionary work, the passage suggests some of the destructive effects of these cultures imposed on soils far beyond England. Recalling the 'prejudices' Jane finds growing 'firm as weeds' among the 'soil' of the heart, St John as pioneer 'hews down' both native vegetation and indigenous beliefs that 'encumber' improving cultivation. 'Rivers […] transplant[s] the bourgeois ideology of self-improvement into an imperial exercise in

[161] 'Humility', in *The Oxford English Dictionary* [online], < https://www.oed.com/view/Entry/89375> [Accessed 11 May 2021].

control', Shuttleworth explains.[162] The colonial violence implicit in the novel's 'eye of science' thus identifies soils and peoples for exploitation framed as the 'painful way to improvement'. Where 'spiritual victory for St John […] flow[s] from martyrdom', as Terry Eagleton identifies, violence enacted upon the corporeal body, here sacrificed in death, extends to the material natures forcibly altered to ensure the soul's redemption.[163]

In death, St John thus embodies the translation of a violent ethic of improvement across the globe – imperial violence that will be seen again in Gaskell's, Dickens's and Eliot's fiction. Soils are here seen as either potential productivity or worthless dirt, an ethic constituted through the soils of England and shaping the materiality of distant lands in identical terms. Whether the aim is to provide souls for a Christian God or resources for imperial exploitation, however, the resonances of cultivation that Brontë draws on to join the improvement of selfhood and soil are of course far older than the work of Liebig and Johnston. Yet in a novel suffused with the analytical investigations of chemistry applied to soil, Brontë's metaphors are lent an urgency via the burgeoning applications of science to agriculture.

The world-building power of agricultural chemistry to shape a new, globalising language of cultivation is evident in both Liebig's and Johnston's writing. Both men analysed guano from Peru, isolating extraordinary fertilising properties in its constituents of '*urate, phosphate, oxalate,* and *carbonate of ammonia*'.[164] Such analyses depended on colonial networks, extending to soils themselves, with Liebig, for instance, analysing 'six different samples of soils from the island of Cuba, in which tobacco is grown'.[165] Of the agricultural chemists of the mid-nineteenth century, however, Johnston perhaps did more than any other to export the new science beyond Europe. As *Blackwood's Magazine* reported in 1851, 'his high reputation as an agricultural chemist' saw him commissioned to give lectures to the Agricultural Society of New York and employed 'by the Government of New Brunswick to examine and report on the agricultural capabilities of that province'.[166] Translating 'the true principles of the all-important science of agriculture' to North America, Johnston's work, *Blackwood's* reported, offered 'multiplied proofs of the zealous and intelligent spirit of

[162] Shuttleworth, *Victorian Psychology*, p. 180.
[163] Terry Eagleton, *The English Novel: An Introduction* (2005; Oxford: Blackwell, 2013), p. 131
[164] Liebig, *Organic Chemistry*, p. 82; emphasis in original.
[165] Justus von Liebig, 'On some points in Agricultural Chemistry', *Journal of the Royal Agricultural Society of England*, 17 (1856), pp. 284-326 (286).
[166] Anon., 'Johnston's *Notes on North America*', *Blackwood's Edinburgh Magazine*, December 1851, pp. 699-718 (699).

improvement which is extending rapidly all over the North-Eastern States'.[167] *Jane Eyre*'s concluding paragraphs, then, capture the direction of the science, suggesting the translation from soils at home to ecologies abroad of an extractivist chemical model for agricultural production.

As the closing paragraphs of this section now show, the novel functions both to elide and reveal the violence inherent in this process. The ethic of improvement impacts diverse ecologies across the world via imperial networks as common to Liebig and Johnston as to Rivers, or indeed Rochester. As Mrs Fairfax informs Jane when she arrives at Thornfield, 'all the land in this neighbourhood […] has belonged to the Rochesters time out of mind' (124). '[L]abourers' later seen 'making hay in Thornfield's meadows' (281) offer a rare sight of the agricultural labour that sustains the country house, work largely hidden at the novel's margins. Rochester also owns 'a small estate of two or three farms […] some thirty miles off' (318), distance and scale itself dwarfed by the Caribbean plantations which are the true source of his wealth. As Raymond Williams notes of Jane Austen's fiction, in *Jane Eyre* the country house signifies exploitation continued both at home and abroad.[168] Marrying Bertha secures the 'thirty thousand pounds' that Bertha's father, 'a West India planter and merchant' (351), provides as a dowry. This marriage ensures that Thornfield's 'estate' (351) will not be divided between Rochester and his elder brother. Distant imperial extraction here sustains (and is sustained by) the logic of colonialism turned inward on the enclosed land surrounding the English country house, land that Jane earlier describes (around Gateshead Hall) as 'the plantation' (46). Processes of land clearance and enclosure, as Freedgood explains in her reading of deforestation in the novel, extend from Thornfield, to Madeira, and on to the Caribbean.[169] Brontë's novel can be approached in this way as an insight into the distributed effects of plantation ecology, described by Haraway as 'the devastating transformation of diverse kinds of human-tended farms, pastures, and forests into extractive and enclosed plantations, relying on slave labor and other forms of exploited, alienated and usually transported labor'.[170] The 'cleared meadows' (286) surrounding Thornfield and the 'clear[ance]' (521) St John subjects upon the indigenous peoples of India are, in this way, mutually constituting. Rochester's extractive relationship to Jamaica cannot be separated from an exploitative relationship to soils (and peoples) at home. Hence the 'riots' the novel

[167] Anon., 'Johnston's *Notes*', p. 704.
[168] Raymond Williams, *The Country and the City* (1973; London: Vintage, 2016), pp. 150-72.
[169] Freedgood, *Ideas in Things*, p. 41.
[170] Donna J. Haraway, 'Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin', *Environmental Humanities*, 6 (2015), pp. 156-65 (163).

briefly notes taking place in an unnamed 'large town' in Northern England (418), suggesting something of the stark inequalities that occupy Gaskell's industrial fiction, examined in my next chapter.

The logic of improvement ensures that if soils may be deemed beyond the remedy of culture and thus as dirt incapable of production, certain peoples might be deemed incapable of improvement and thus as less than human. This is how Rochester views Bertha, having come to believe she is beyond improving cultivation. Perceiving 'her cast of mind common, low, narrow, and singularly incapable of being led to anything higher, expanded to anything larger' (353), she descends into a beast in his eyes. This is the substance of Jane's account, where 'demoniac laughter' (173) and 'a snarling, snatching sound, almost like a dog' (241), prefigure Bertha's appearances as 'a tigress' (245) and a 'clothed hyena' (338). In a novel suffused with metaphors of horticultural and agricultural cultivation, Bertha is conspicuously placed beyond such improvement.

Yet any differences between Jane and Bertha bely parallels that, as Shuttleworth notes, are 'insistent'.[171] As Gilbert and Gubar identify, Bertha is 'an avatar of Jane'.[172] Where improvement configures productive soils along with Jane's bourgeois self, Bertha's descent into madness may be glimpsed, not only as 'the product of unrestrained passion', as scholars have long argued, but as improvement's corollary – the manifestation of diseased ecologies and debilitating health problems for the people who live in them.[173] The daughter of a 'creole' woman (377), she is placed as a 'hybrid' body between Western Europe and the colonial lands that sustain it.[174] Bertha's body becomes 'the site of colonial conflict in the text', Bewell writes, 'and her madness expresses that conflict'.[175] Driven to insanity, transported across an ocean, and confined in a single room, her extraction from Jamaica to England embodies the pervasive violence purported against distant populations in the name of improvement that supports the provincial world of the novel.

[171] Shuttleworth, *Victorian Psychology*, p. 168.
[172] Gilbert and Gubar, *Madwoman in the Attic*, p. 359. Gilbert and Gubar also describe Bertha as 'Jane's dark double' (360) and 'her own secret self' (348). Nancy Armstrong describes Jane and Bertha 'as more and less sublimated versions of the same kind of sexual desire'. Nancy Armstrong, *Desire and Domestic Fiction: A Political History of the Novel* (Oxford: Oxford University Press, 1987), p. 203.
[173] Yeazel, 'More True than Real', p. 135.
[174] Bewell, *Romanticism*, p. 291. For further discussion of race in *Jane Eyre* see Patricia McKee, 'Racial Strategies in *Jane Eyre*', *Victorian Literature and Culture*, 37.1 (2009), pp. 67-83.
[175] Bewell, *Romanticism*, p. 291.

Placed on the novel's margins, Bertha's experience testifies to the 'slow violence' of improvement, 'attritional', 'gradual', and largely 'out of sight', as described by Rob Nixon.[176] *Jane Eyre*'s estate gardens, however, function to bring this violence into focus. As Chang has recently noted, '[p]lants, when they appear in such globally expansive novel plots, link the distant and the near in ways that supplement the limits of human perception'.[177] What distinguishes *Jane Eyre* from the genre fiction of the later nineteenth century, (the focus of Chang's study), is that native rather than exotic cultivars fill Thornfield's beds with 'laurels', 'horse-chestnut', 'jasmine', 'pink' and 'rose' (287). The garden links 'the distant and near' by merging far-flung ecologies in other ways, such as by contrasting a passing moth reminiscent 'of a West Indian insect' with a native 'lady-clock' (289), a dialect term for ladybird. It is the scent of Rochester's 'cigar' (286) that leads to Jane finding him in the garden shortly before his proposal; as the 'perfume increases' (287), so do the resonances of colonial extraction that his 'Havannah incense' (166) signifies. Caribbean tobacco on the English estate betrays the plantation wealth that sustains, what Nixon terms, 'the kinds of gardens that prevail in a literature written predominantly by those remote from the soil perspectives of the labouring poor'.[178] The Spanish Town garden that Rochester remembers on a 'fiery West Indian night' (354) is another example of such a garden, 'lush with assumed access'.[179] Both gardens are off-limits to Bertha, of course, who is confined high up on Thornfield's third floor in a potent signification of wealth extracted from colonial lands. Where the English country garden is linked to the Caribbean, so the colonial garden traces these links in the opposite direction, with Rochester enjoying the 'wind from Europe' (355) that follows the 'tempest' (355) of a tropical 'hurricane' (354). As Bertha's distance from the soil is overcome in the moment of her death, when she crashes to the ground from the 'roof' of the burning country house (493), so the parallel 'tempest' (297) that prefigures this coming violence by shattering Thornfield's horse-chestnut may be read as embodying the distributed effects of plantation logic on far-flung ecologies.

This slow violence manifests in the novel in other ways too. The interrelated health of human and environment is powerfully demonstrated at Lowood school. This 'seat of contagion' (92) is created as a 'forest dell', 'the cradle of fog and fog-bred pestilence' (91), intra-acts with human bodies and Brocklehurst's destructive attempts at improving

[176] Rob Nixon, *Slow Violence and the Environmentalism of the Poor* (Cambridge, MA: Harvard University Press, 2013), p. 2.
[177] Chang, *Novel Cultivations*, p. 16.
[178] Nixon, *Slow Violence*, p. 28.
[179] Nixon, *Slow Violence*, p. 28.

cultivation. Where religious beliefs lead Brocklehurst to limit the access children have to warmth and food, ideology and material intra-act to render human bodies, 'starved and frozen into Christian submission', susceptible to the typhus the environment sustains.[180] The deaths of Bertha Mason and the girls at Lowood may be read together as socioecological effects following from attempts to improve life so as 'not to conform to nature' (76). As with the fate of these children, Bertha's death and the destruction of Thornfield Hall insist to be read as, what Nixon terms, 'the socioenvironmental fallout from developmental agendas whose primary beneficiaries lie elsewhere'.[181] When Rochester threatens to rape Jane in one of the novel's rare eruptions of physical 'violence' (318), his actions reveal the pervasive slow violence taking place on the novel's margins in the rape and plunder of soils (and peoples) across and beyond the Atlantic world.

Conclusion: Sustaining the Improvement Plot

Jane Eyre is built upon these violent relationships. Jane becomes an 'heiress' (440) upon inheriting 'twenty thousand pounds' (441) after her uncle, John Eyre, dies in Madeira. Introduced to the novel as 'an island thousands of miles off, where they make wine' (109), narrative progression depends on action that takes place in such distant European colonies. A 'wine merchant' (110) and 'Funchal correspondent of [Mr Mason's] house' (339), John Eyre warns Mason of Rochester's impending marriage to Jane having received a letter from his niece while Mason passes through on his return home to the Caribbean. Plot turns on these imperial networks, betraying the shared ethos by which Mason's, Rochester's, and Jane's wealth is generated via the improvement and extraction of global soil fertility. When Blanche Ingram plays charades using a 'turban of some gold-wrought Indian fabric' (200), or St John decides to 'leave Europe for the East' (417) for a purpose only to be found 'under a tropical sun' (429), or Rochester makes cruel jokes about 'bargaining for so many tons of flesh and such an assortment of black eyes' (310) in Istanbul, or suggests that 'hiring a mistress' is like 'buying a slave' (359), or travels to the Caribbean to secure a fortune by marrying Bertha, *Jane Eyre* is structured upon colonial extraction. This extraction is facilitated by imperialism, a burgeoning laissez-faire British capitalism, and a worldview that frames exploiting the earth's apparently limitless fertility as providential duty; it is dependent on the hidden labour of people and ecologies in distant parts of the globe, labour that sustains the world of the novel but is largely elided in its construction. As will be seen again and again in the worlds of

[180] Gilbert and Gubar, *Madwoman in the Attic*, p. 344.
[181] Nixon, *Slow Violence*, p. 18.

realist fiction, the improvement plot largely depends on exporting the ethos of improvement to distant soils and importing from them the wealth this improvement generates.

Dictating the isolation and extraction of diverse peoples and natures, homogenised as potential production, soil improvement acts across the agricultural science and realist novel of the mid-nineteenth century. It is also at work, as my following chapters will show, in the novels of Gaskell, Dickens, and Eliot. Yet where the realist novel can be seen to differ from the science is in also working to expose some of the violence inherent in this ethos. *Jane Eyre* is thus emblematic of tensions that recur throughout my thesis. The novel suggests that the destructive effects of improvement are linked across environmental and human health, both mental and physical. As Jane resists abusive marriages to Rivers and Rochester, so logics of improving cultivation, whether articulated in terms of agricultural science's objectivity or the botanical ideals of Greenhouse Romanticism, are called into question. The novel's conclusion thus seems to offer a model of love and care founded on equality, noted by many scholars. Life that has been damaged or destroyed though the productivist practices of modern agriculture may be healed, such an argument might run, through female care and restoration.

Yet readings of equality ignore that any harmonious relationship at Ferndean depends on exporting harm to ecologies elsewhere. This tension plays out between the new life that Jane and Rochester create at the novels' conclusion and the extraction that makes their retreat to Ferndean possible in the first place, framing their apparent 'isolation' as a dangerous illusion of love and care.[182] Rather than ending the novel 'isolated from society but flourishing in a natural order of their own making', as Gilbert and Gubar have argued, Jane and Rochester flourish on wealth extracted from the artificial and improved natures of distant lands.[183] In a motif that recurs throughout the novels examined in my thesis, apparently local harmony begets and elides distant violence and disorder. This also points to a common burden in the worlds of realist fiction placed on female characters to reproduce and renew life in marriage. Where Pizzo's reading of *Jane Eyre* uncovers 'the female body's sensual alliance with the surrounding air', I would emphasise Jane's reproductive alliance with the earth.[184] In terms of the novel's slow violence, and in light of the recurrence of such violence throughout the realist novels of the mid-nineteenth century, this alliance might be more accurately thought of in terms of coercion.

[182] Gilbert and Gubar, *Madwoman in the Attic*, p. 369.
[183] Gilbert and Gubar, *Madwoman in the Attic*, p. 370
[184] Pizzo, 'Atmospheric Exceptionalism', p. 87.

As for the emerging science of agriculture, the new chemical language that Liebig and Johnston were central to developing altered soils in a number of ways. Chemistry helped to open the world's soil fertility for imperial exploitation. Although this process was underway long before the mid-nineteenth century, by reducing seemingly infinite soil variations to comparable systems of interacting elements, the new science helped to network the world's soil fertility on a scale not before seen. Chemistry thus effected a conceptual shift that saw soils move from mysterious vital spaces to combinations of chemical elements, making them receptive to improvement at the molecular level. Arguing against the humus theory, Liebig was vocal in eliminating any suggestion of life from soils. Having been mysteriously alive to the vitalists some half-century before, it is no exaggeration to say that soils became dead in this period. Johnston's address to the RASE in York offers an insight into the effects of this conceptual change: as he worried over the dangers the 'infusorial animals' of the soil might pose to crops, he could not have known that what he called a 'wholly unthought of field of inquiry', (what would become soil biology), would be needed to understand the secrets of nitrogen fixation.[185] The mid-nineteenth-century shift from seeing soils as living to inorganic systems continues to have profound impacts today, as described by Graham Harvey: 'Extraordinary though it may seem, von Liebig's thinking dominates modern arable farming. Crop growing is still seen as chiefly a matter of chemistry. The idea that the biology of a soil might play some major part is barely considered by today's farmers, a mindset encouraged and reinforced by the pesticide and fertiliser manufacturers'.[186] The nineteenth-century chemical language of soils continues to define the materiality of soils today, and to devastating environmental effect.

But as in *Jane Eyre*, the material and conceptual changes that soils underwent in the mid-nineteenth century were not without their tensions. By suggesting complexity that might defy chemistry's reductionism, Johnston's attempts to develop classificatory structure from 'soils found in practice to possess very different agricultural capabilities' and Liebig's efforts to set his 'chemistry of agriculture' apart from the practical concerns of 'agricultural chemistry', raised tensions between practice and theory, particulars and universals. Such tensions recur in science as applied to soils throughout my thesis, for it was not only in the countryside that soils were of increasing scientific interest during the 1840s. To the sanitarians struggling to create healthy populations in the rapidly expanding industrial city,

[185] Johnston, 'The Present State of Agriculture', p. 234.
[186] Graham Harvey, *Grass-Fed Nation: Getting Back the Food we Deserve* (London: Icon Books, 2016), p. 67.

chemistry offered ways to think anew about soils in terms of disease and contagion. Such concerns are on the margins in *Jane Eyre*, where Jane's father is long dead from 'typhus fever' contracted 'visiting among the poor of a large manufacturing town' (26). As my second chapter on Gaskell's industrial fiction shows, Liebig's *Organic Chemistry* was once more at the forefront of efforts to understand the soils of the city.

Chapter 2. Sympathy for the Soiled: Mud, Metaphor, and Metabolic Rift in Gaskell's Industrial Fiction

> The most prolific source of disease in towns is certainly defective drainage and sewerage. Where large numbers of human beings are collected together, it is apparent that there must result a vast amount of refuse matter of every description, to which must be added the solid and fluid excretions of the body; [...] In Manchester, according to Dr Playfair, as much of the excretae of the town as amounts to 1500 tons weekly is carted away by the Cheshire farmers. And here I would point out what cannot be too much insisted upon as facilitating the introduction of sanitary improvements, that the very matter, which, if left to itself, becomes, as we have seen, the focus of the most fatal diseases, is in itself most valuable as manure.
>
> 'Lecture on the Insalubrity of Towns', *Manchester Guardian*, 28 May 1845.[1]

Sewage was subject to competing and seemingly contradictory understandings in the mid-nineteenth century, seen here in the *Manchester Guardian*.[2] 'Night soil', as human excrement was often euphemistically referred to in the *Guardian*'s pages, was simultaneously the pestilential site of disease and a potential resource for agricultural improvement.[3] As the epigraph above suggests, Lyon Playfair, Officer for Health for Lancashire and consulting chemist to the Royal Agricultural Society of England (RASE), was well positioned to explain this at once pathological and productive potential of sewage matter. As translator of Liebig's *Organic Chemistry in its Application to Agriculture and Physiology*, he helped to disseminate

[1] Anon., 'Lecture on the Insalubrity of Towns', *Manchester Guardian*, 28 May 1845, pp. 6-7 (6).
[2] My focus in this thesis is on these competing understandings of sewage, rather than the practical implementation of schemes that used sewage as manure. Given the scale of the operation Playfair describes, it is curious William Palin makes no direct mention of sewage being used as manure in his 1845 prize-winning report on 'The Farming of Cheshire' for the RASE. However, William Garnett, in his 1849 report, 'Farming of Lancashire', describes sewage being transported along the Bridgwater Canal 'to the amount of 20,000 tons in a year', around 400 tons a week. In *Agriculture in Lancashire* (1849), George Beesley highlights the extensive use of night soil on land between Manchester and Liverpool, applied from the Mersey and Irwell Canal at approximately 40 tons per acre. Garnett cites the Liverpool and Manchester Railway as the means by which 'any quantity of manure' could be brought from Manchester, with night soil 'preferable to anything else'. Garnett quotes a farmer stating that he only uses 'night-soil from the factories'. This practice is also recorded in William Rothwell's 1850 *Report of the Agriculture of the County of Lancaster*, with night soil described as being 'brought in barrels from the cotton mills'. George Beesley, *A Report on the State of Agriculture in Lancashire* (Preston: Dobson and Son, 1849); William James Garnett, 'Farming of Lancashire', *Journal of the Royal Agricultural Society of England*, 10 (1849), pp. 1-51; William Palin, 'The Farming of Cheshire', *Journal of the Royal Agricultural Society of England*, 5 (1845), pp. 57-111; William Rothwell, *Report of the Agriculture of the County of Lancaster* (London: Groombridge and Sons, 1850). For more on the history of sewage manuring in the nineteenth century see: Nicholas Goddard, '"A Mine of wealth"? The Victorians and the agricultural value of sewage', *Journal of Historical Geography*, 22.3 (1996), pp. 274-90; John Sheail, "Town wastes, agricultural sustainability and Victorian sewage", *Urban History*, 23, pt. 2 (August 1996), pp. 189-210.
[3] Anon., 'Removal of Night Soil', *Manchester Guardian*, 3 March 1847, p. 7; 'The Night-Soil Nuisance', *Manchester Guardian*, 8 April 1854, p. 8; 'Nuisance', *Manchester Guardian*, 4 October 1854, p. 7.

both a chemical programme for improved farming and a chemical pathology for epidemic disease. This chapter focuses on Manchester, examining Elizabeth Gaskell's *Mary Barton* (1848) and *North and South* (1854-55) and scientific writing by Liebig, Playfair, and Robert Angus Smith, a chemist who, having studied in Giessen in the early 1840s, made Manchester his home until his death in 1884. Gaskell's fiction here stands alongside sanitary and agricultural chemistry as part of a shared investigation into, what the *Guardian* labelled, the city's 'economy of sewage'.[4]

Gaskell was certainly familiar with the improving 'science of agriculture' examined in chapter 1; as I come to below, she referenced Liebig's *Organic Chemistry* in her 1851 short story, *Mr Harrison's Confessions*.[5] Her father, William Stevenson, was briefly a 'scientific farmer' and Gaskell owned a copy of his *General View of the Agriculture of Surrey* (1809), commissioned by the Board of Agriculture and Improvement.[6] Such detail situates her industrial novels within a wider interest, seen across her fiction, in 'agricultural science', the 'nature' of 'soils', and 'experiments in agriculture'.[7] In *Wives and Daughters* (1864-66), for example, the Hamleys attend agricultural meetings in order to develop 'a practical knowledge of agriculture', introducing improvements, principally by draining land, that impact both farming and sanitation.[8] Yet literature and science readings of her work remain largely confined to the biological sciences.[9] Uncovering Gaskell's knowledge of Liebigian chemistry

[4] Anon., 'The Economy of Sewage', *Manchester Guardian*, 10 October 1846, p. 4.
[5] Elizabeth Gaskell, *Mr Harrison's Confessions* (1851; London: Hesperus Press, 2014), p. 55.
[6] Jenny Uglow, *Elizabeth Gaskell: A Habit of Stories* (London: Faber & Faber, 1993), pp. 10-11; William Stevenson, *General View of the Agriculture of the country of Surrey. Drawn Up for the Board of Agriculture and Internal Improvement* (London: Phillips, 1809).
[7] Gaskell's short story 'My French Master' (1853) describes the unnamed father's obsession with 'agricultural science' and the 'nature' of soils. 'Experiments in agriculture' are also discussed in the 1853 short story, 'Morton Hall'. In *Sylvia's Lovers* (1863), meanwhile, agricultural discussion focuses on manures: 'for twenty miles inland there was no forgetting the sea', with 'refuse shell-fish, sea-weed, [and] the offal from melting-houses […] the principal manure of the district [of Monkshaven]'. Elizabeth Gaskell, 'My French Master', in *The Works of Elizabeth Gaskell, Volume 3*, ed. by Charlotte Mitchell, 10 vols (1853; London: Pickering and Chatto, 2005), pp. 53-72 (63); 'Morton Hall', in *The Works of Elizabeth Gaskell, Volume 3*, ed. by Charlotte Mitchell, 10 vols (1853; London: Pickering and Chatto, 2005), pp. 21-52 (36); *Sylvia's Lovers*, in *The Works of Elizabeth Gaskell, Volume 9*, ed. by Marion Shaw, 10 vols (1863; London: Pickering and Chatto, 2005), p. 14.
[8] Elizabeth Gaskell, *Wives and Daughters*, in *The Works of Mrs Gaskell, Volume 10*, ed. by Josie Billington, 10 vols (1864-6; London: Pickering and Chatto, 2005), pp. 189. *Wives and Daughters* is often seen as an important influence on *Middlemarch*, and I discuss Gaskell's novel briefly in chapter 4 when examining the importance of land drainage in Caleb Garth's improving cultivation of Loamshire.
[9] Carol Martin (1983) suggests that Gaskell was influenced by her cousin Charles Darwin and that her depictions of class conflict in *North and South* may in turn have had an influence on Darwin's depictions of inter-species competition in the *Origin*. Louise Henson (2002) and Leon Litvack (2004) have since continued this discussion on the relationship between evolutionary theory and Gaskell's work, with Amy King (2003), Danielle Coriale (2008), and Anne Secord (2013) extending the critical focus further into the biological sciences with readings of herbalist medicine, natural history, and botany in *Mary Barton*. Carol A. Martin, 'Gaskell, Darwin and *North and South*', *Studies in the Novel*, 15.2 (1983), pp. 91-107; Louise Henson, 'The "Condition-of-England" debate and the "Natural History of Man": an important scientific context for the social-problem fiction of Elizabeth Gaskell', *Gaskell Society Journal*, 16 (2002), pp. 30-47; Leon Litvack, 'Outpost of Empire:

and the science of agriculture thus addresses a critical neglect in the field, for though 'motivated by the Victorian impulse to engage with the social and environmental ills of society', the general feeling seems to persist that Gaskell was, in John Parham's words, '[not] especially interested in science'.[10]

As my examination of sanitary and agricultural chemistry in her fiction shows, not only is this false, but such is the depth of her engagement with these sciences that her industrial novels in turn trouble, what Ralph O'Connor calls, the 'defining dyad' of Literature and Science.[11] Gaskell's writing, as Martin Hewitt has explained, demands to be read 'as a medium of knowledge'.[12] With mid-century 'Manchester […] central to thinking about the links between approaches to social problems and physiology', as Andrew Mangham has recently shown, and with Robert Kargon illuminating Liebig's central position in the city's scientific culture, I approach Gaskell's writing as part of a thriving ecology of literature and science.[13] My chapter argues that metaphor and analogy were defining features of the city's fiction and science – viewed here as, what Allen MacDuffie would call, 'complementary forms of knowledge production'.[14] Seen in this light, Gaskell, Playfair, and Smith, in developing Liebig's science, can be understood as building complementary knowledges of sewage and soil in and around Manchester from 1845 to 1855.

In these years, Manchester stood at the epicentre of growing unease over the design of industrial civilisation. Recent work in the environmental humanities has largely read this concern in terms of atmospheric pollution.[15] But alongside urban expansion came rural

---

Scientific Discovery and Colonial Displacement in Gaskell's *Wives and Daughters*', *The Review of English Studies*, 55.2 (2004), pp. 727-58; Amy Mae King, 'Taxonomical Cures: The Politics of Natural History and Herbalist Medicine in Elizabeth Gaskell's *Mary Barton*', in *Romantic Science: The Literary Forms of Natural History*, ed. by Noah Heringman (Albany: State University of New York Press, 2003), pp. 255-70; Danielle Coriale, 'Gaskell's Naturalist', *Nineteenth-Century Literature*, 63.3 (2008), pp. 346-75; Anne Secord, 'Elizabeth Gaskell's Social Vision: The Natural Histories of *Mary Barton*', in *Uncommon Contexts: Encounters Between Literature and Science, 1800-1914*, ed. by Ben Marsden, Hazel Hutchinson and Ralph O'Connor (London: Routledge, 2013), pp. 125-44.

[10] John Parham, '"For you, pollution". The Victorian Novel and Human Ecology: Benjamin Disraeli's *Sybil* and Elizabeth Gaskell's *Mary Barton*', *Green Letters*, 14.1 (2011), pp. 23-38 (33). This is countered by Litvack, who examines Gaskell's 'sophisticated' scientific knowledge in *Wives and Daughters*. 'Outposts of Empire', p. 738.

[11] Ralph O'Connor, 'The Meanings of "Literature" and the Place of Modern Scientific Nonfiction in Literature and Science', *Journal of Literature and Science*, 10.2 (2017), pp. 37-45 (38).

[12] Martin Hewitt, *Making Social Knowledge in the Victorian City* (London: Routledge, 2019), p. 52.

[13] Andrew Mangham, *The Science of Starving in Victorian Literature, Medicine, and Political Economy* (Oxford: Oxford University Press, 2020), p. 120; Robert H. Kargon, *Science in Victorian Manchester: Enterprise and Expertise* (Manchester: Manchester University Press, 1997), p. 107.

[14] Allen MacDuffie, *Victorian Literature, Energy, and The Ecological Imagination* (Cambridge: Cambridge University Press, 2014), p. 17.

[15] See Jesse Oak Taylor, *The Sky of Our Manufacture: The London Fog in British Fiction from Dickens to Woolf* (Charlottesville: University of Virginia Press, 2016).

depopulation, interrupting time-honoured nutrient cycles between human and environment. While less obvious than the 'lead-coloured cloud' that envelops Milton in *North and South*, this interplay of demographics and soils is no less important for understanding Gaskell's realism as an examination of life in the industrial city.[16] Famine and disease in her novels are the visible effects of soil nutrients being lost to the urban worker, fertile matter instead collecting as sewage in the city and impacting human health by contributing to both epidemic disease and poor nutrition. Conceptualised in the 1860s by Karl Marx, this process has since been christened metabolic rift, a theory to capture the shocking conditions Friedrich Engels described in Manchester in *The Condition of the Working Class in England in 1844*.[17] Neither Marx nor Engels are the subject of this chapter, however; I use metabolic rift to frame a process also documented by Gaskell, Playfair, and Smith. I am interested in their work, then, not only for its bearing on sanitary issues, but because it speaks to a larger concern over the emergence of the industrial city as a model of human development. 'The stakes were high', MacDuffie explains, 'for a restoration of ecological balance was necessary if the modern city would appear as a necessary part of, not outcast from, a superintending Providential narrative'.[18] My chapter's primary argument is that, as *Mary Barton* details the terrible effects of metabolic rift on the industrial poor, *North and South* seeks to reconcile its effects by restoring a functioning relationship between industrial and land-based economies, offering a new angle on those 'tropes of reconciliation' that Catherine Gallagher finds across industrial fiction.[19]

In making this argument, I approach Gaskell, Liebig, Playfair, and Smith as together conducting examinations into the actor-network of the industrial city. As this Latourian reference suggests, my reading is aided by new materialism. My chapter applies Stacey Alaimo's concept of 'trans-corporeality', Karen Barad's understanding of 'intra-activity', and Bruno Latour's 'Actor-Network Theory' to both Gaskell's fiction and chemical science.[20]

---

[16] Elizabeth Gaskell, *North and South*, ed. by Angus Easson, intro. by Sally Shuttleworth (1854-55; Oxford: Oxford University Press, 1998), p. 59. (All further references to *North and South* are to this edition and are given parenthetically in the body of the chapter.)

[17] For more on Engels and metabolic rift see John Parham, 'Biggish data: Fredrich Engels, material ecology, and Victorian data', *European Journal of Culture and Political Sociology*, 6.3 (2019), pp. 344-64 (346). For Marx see Kohei Saito, *Karl Marx's Ecosocialism: Capital, Nature, and the Unfinished Critique of Political Economy* (New York: New York University Press, 2017).

[18] MacDuffie, *Energy*, p. 59; see also Christopher Hamlin, 'Providence and Putrefaction: Victorian Sanitarians and the Natural Theology of Health and Disease', *Victorian Studies*, 28.3 (Spring 1985), pp. 381-411 (380-81).

[19] Catherine Gallagher, *The Industrial Reformation of English Fiction: Social Discourse and Narrative Form, 1832-1867* (Chicago: University of Chicago Press, 1985), p. 127.

[20] Stacy Alaimo, 'Trans-Corporeal Feminisms and the Ethical Space of Nature', in *Material Feminisms*, ed. by Stacy Alaimo and Susan Hekman (Bloomington, Indianapolis: Indiana University Press, 2008), pp. 237-64; Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*

These new-materialist thinkers all understand agency as existing beyond the human, and I am indebted here to John Parham, who has shown the possibilities of applying their work to nineteenth-century writing.[21] Taken together, Alaimo, Barad and Latour capture agencies that act both internally and external to the body, agencies that constitute material and discourse as co-shaping, and agencies that associate to form a network of human and non-human actors. Their conceptions of agency support my reading of fiction and science as related knowledges of metabolic rift in the industrial city. And while this aims to address structural division in the field of Literature and Science, it also suggests a new conception of Gaskell's realism. Her industrial fiction is agential, I show, an argument I make primarily in reading *Mary Barton*; Gaskell engages with the foundational position of representationalism in literary realism so as to generate sympathy for the poor. While my methods and arguments differ from earlier readings of Gaskell's realism, then, I nevertheless consider both *Mary Barton* and *North and South* within an established critical tradition, viewing her fiction as an effort to generate readerly sympathy.[22]

My first section, 'Liebig's Chemical Pathology', examines part II of Liebig's *Organic Chemistry* via Gaskell's *Mr Harrison's Confessions*. I explain the role of fermentation, putrefaction and decay as chemical processes in Liebig's aetiology of disease, and establish Gaskell, Liebig, Playfair, and Smith within Manchester's ecology of literature and science. Section two, 'Tracing Agency in Manchester', reads *Mary Barton* alongside Playfair's sanitary 'Report on the State of Large Towns in Lancashire' (1845). Both texts use metaphor to examine the actor-network of the industrial city, yet Gaskell's writing generates sympathy by showing how the poor are constituted as putrefying matter, by figures such as Playfair, through material-discursive intra-actions. 'Purity in Soil' then turns to *North and South* to show how Gaskell reconciles metabolic rift in Margaret Hale's and John Thornton's marriage, embodying the agricultural fertility of the south fixed in marriage to the industrial

(Durham, NC: Duke University Press, 2007); Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network-Theory* (Oxford: Oxford University Press, 2005).

[21] See Parham, 'Biggish data'; see also John Parham, 'Bleak Intra-actions: Dickens, turbulence, material ecology', in *Victorian Writers and the Environment: Ecocritical Perspectives*, ed. by Laurence W. Mazzeno and Ronald D. Morrison (London: Routledge, 2017), pp. 114-29.

[22] For critical readings of Gaskell and sympathy see: Mary Poovey, *Making a Social Body: British Cultural Formation, 1830-1864* (Chicago: University of Chicago Press, 1994), p. 143; Elizabeth Starr, '"A Great Engine for Good": The Industry of Fiction in Elizabeth Gaskell's *Mary Barton* and *North and South*', *Studies in the Novel*, 34.4 (Winter 2002), pp. 385-402; Jill Matus, '*Mary Barton* and *North and South*', in *The Cambridge Companion to Elizabeth Gaskell*, ed. by Jill Matus (Cambridge: Cambridge University Press, 2007), pp. 27-45; Elaine Freedgood, 'The Novelist and Her Poor', *Novel: A Forum on Fiction*, 47.2 (2014), pp. 210-23; Jennifer Maclure, 'Diagnosing Capitalism: Vital Economics and the Structure of Sympathy in Gaskell's Industrial Novels', *Nineteenth-Century Contexts*, 38.5 (2016), pp. 343-52.

north. With Margaret's narrative trajectory long seen as 'questioning the literary conventions of female purity', I show how the novel draws on Smith's investigations into soil fertility and water purification to develop a chemical poetics rendering Margaret pure yet fertile in contact with the dirt of Milton.[23] My final section, 'Sympathy by Extraction', then troubles this reading by showing how Thornton's dinner scheme, (which in feeding the poor expresses Gaskell's solution to cross-class sympathy), is ultimately financed by the extraction of soil fertility and indentured labour in North America. Gaskell can only eliminate domestic suffering by exporting extraction elsewhere. Considering *North and South* and *Mary Barton* together in conclusion, I read these industrial fictions as open systems that mirror the industrial economy they chronicle, narrative solutions that offer the illusion of closure while eliding extractive and exploitative relationships that extend elsewhere.

Liebig's Chemical Pathology

Before examining Liebig's pathology through *Mr Harrison's Confessions*, a word on the plot of this little-read short story is required. Often seen as a precursor to *Cranford*, Gaskell's novella sees medical doctor Harrison arrive in the provincial town of Dunstable to take up a position as junior partner in an established practice. Harrison falls in love with the vicar's daughter, Sophy, but somehow soon finds himself presumed engaged to three other women. This is after his stock has already fallen as his latest treatments fail to live up to the town's expectations. As Erika Wright notes, '"Mr Harrison's Confessions" deals precisely with the problems a young general practitioner faces when attempting to enact a reforming agenda in a world suspicious of new methods'.[24] A modernising doctor struggling to negotiate the professional and marital politics of provincial England in the second quarter of the nineteenth century, Harrison is an antecedent of Eliot's Lydgate, another whose science, as I come to in chapter 4, is influenced by Liebig's chemistry.

Liebig and 'agricultural chemistry' (55, 60) are mentioned on several occasions in *Mr Harrison's Confessions*. This science is introduced as Harrison journeys with prominent members of Dunstable to a nearby hall for a picnic, where he overhears lawyer and 'hobby' (33) farmer Mr Bullock denouncing unpruned hedgerows crowding the path as 'shocking

[23] Uglow, *Elizabeth Gaskell*, p. 380.
[24] Erika Wright, *Reading for Health: Medical Narratives and the Nineteenth-Century Novel* (Athens, OH: Ohio University Press, 2016), p. 141. See also Marie Fitzwilliam, '*Mr Harrison's Confessions*: a study of the general practitioner's social and professional dis-ease', *Gaskell Society Journal*, 12 (1998), pp. 28-36.

farming' (30).[25] Bullock soon enters into a discussion with the local farmer, overheard once more by Harrison:

> Mr Bullock was holding a conversation at the garden-door on the nature of different manures, in which it struck me that, if Mr Bullock had the fine names and the theories on his side, the farmer had all the practical knowledge and the experience, and I know which I should have trusted. I think Mr Bullock rather liked to talk about Liebig in my hearing; it sounded well, and was knowing. (35-36)

The passage indicates a depth of awareness of contemporary science rarely attributed to Gaskell's writing, and a direct examination of agricultural chemistry unsurpassed in her fiction. Bullock undoubtedly favours Liebig's inorganic mineral theory which, as outlined in chapter 1, went against established practice; the farmer maintains, correctly, that adding organic matter to soils benefits his crops.[26] By introducing Liebig's name in Harrison's hearing, Bullock seeks to convey a sense of his status and education to the doctor. But the passage also suggests the particular medical applications of Liebig's chemistry which, as a doctor trained in the 1840s, Harrison would be expected to know. A discussion on 'the nature of manures' is well placed to introduce such concerns. Where *Organic Chemistry* sought to explain how manures acted in soils via chemical decay, Liebig argued that similar processes caused disease in the human body.

Liebig's chemical pathology followed a reductionist programme familiar from his chemistry of agriculture. While the contagious action of diseases 'correspond remarkably to our common conceptions of life', he explained, 'they are really chemical processes dependent upon the common chemical forces'.[27] Liebig divided these processes into putrefaction, fermentation, and decay; putrefaction and fermentation were understood to be anaerobic processes, whereas decay depended on oxidisation.[28] Despite these differences, all were 'chemical transformations' dependent on the chemical forces of 'combination and decomposition', by which 'a body […] enables another body, with which it is in contact, to

[25] One of the modernising improvements high farming sought to implement was to cut back hedgerows. This will be seen again in *Middlemarch* in chapter 4.
[26] The passage thus dramatises a discussion taking place across British agriculture in the mid-nineteenth century. As is now known, part of the reason that animal manures are so beneficial for crops is the microbial communities they introduce to the soil. Even if inorganic factory-produced fertilisers offer the correct nutrient balance, these bacterial populations are inevitably absent, making it more difficult, if not impossible, for plants to access certain nutrients.
[27] Justus von Liebig, *Organic Chemistry in its Application to Agriculture and Physiology*, trans. by Lyon Playfair (London: Taylor and Walton, 1840), p. 354.
[28] Liebig, *Organic Chemistry*, p. 45. As I explain in chapter 3, Liebig christened decay 'eremacausis', compounded of the Greek for 'slow' and 'combustion', to denote what he understood to be 'a slow process of combustion'. *Organic Chemistry*, p. 45; see also pp. 229-30.

enter into the same state'.[29] Organic molecules, being larger and thus supposedly more unstable than inorganic molecules, were especially liable to suffer from putrefaction, fermentation, and decay.[30] Liebig explained how putrefying muscle or pus, for example, 'communicate their own state of putrefaction to the sound blood from which they were produced'.[31] Miasmas were shown to operate in the same way when introduced to the blood via the lungs – 'communicating the state of decomposition, of which they themselves are the subject, to certain parts of the organism'.[32] As Margaret Pelling describes, Liebig's pathology 'establish[ed] a common and flexible notion of process for all epidemic, endemic, and contagious diseases'.[33]

This understanding became known as the zymotic analogy: 'The diseases incident to the period of the growth of man, contagion and contagious matters, have their analogues in many chemical processes', *Organic Chemistry* explained.[34] The analogical reasoning was undoubtedly Liebig's, but the term was in fact coined by William Farr. Working at the Registrar General's Office in London, Farr came up with the classification 'zymotic diseases', (after *zymosis*, Greek for fermentation), to cover the 'epidemic, endemic, and contagious diseases' described by Pelling. As William Brock explains, 'Farr had clearly accepted that this group of diseases, which included cholera, typhoid, typhus, and scarlet fever, were all blood diseases that arose from specific chemical poisons derived either from without or generated within the victim's body'.[35] Liebig's chemical pathology was thus seen to explain how putrefaction and decay in the external environment generated identical processes within the body; as Christopher Hamlin evocatively puts it, 'the essence of the concept of zymotic disease was that disease was a spreading internal rot, that it came from an external rot, and that it could be transferred to others'.[36]

This message was of foundational importance to the British sanitation movement in the mid-nineteenth century. Kargon notes that Liebig's chemical pathology supported the work of sanitarians such as Edwin Chadwick, emphasising the importance of removing the

[29] Liebig, *Organic Chemistry*, pp. 220, 225.
[30] Liebig, *Organic Chemistry*, p. 346.
[31] Liebig, *Organic Chemistry*, p. 350.
[32] Liebig, *Organic Chemistry*, pp. 365-66.
[33] Margaret Pelling, *Cholera, Fever and English Medicine: 1825-1865* (Oxford: Oxford University Press, 1978), p. 145.
[34] Liebig, *Organic Chemistry*, p. viii.
[35] William H. Brock, *Justus von Liebig: The Chemical Gatekeeper* (Cambridge: Cambridge University Press, 1997), p. 208.
[36] Hamlin, 'Providence and Putrefaction', p. 386.

cause of miasmas – 'the filth which polluted the town' – from urban centres.[37] As Brock and Pelling both explain, by offering an explanation for how miasmas acted on the body, the zymotic analogy formed an important step in the development towards bacterial theories of disease in the later nineteenth century.[38]

Yet Playfair and Gaskell were also typical of many, for whom engaging in theoretical debates was of less concern than addressing the root causes of disease. Whether one subscribed to a contagionist or miasmatist conception of disease transmission, this was to be achieved by removing putrefying filth from urban centres. The aim was to improve the living conditions of the poor through improved access to education and sanitation, an urban iteration of the improvement ethos sweeping 1840s agriculture. *Organic Chemistry* offered another valuable message, then, in that putrefying waste in one location might decay as fertile matter in another. Seen in this light, addressing metabolic rift meant substituting chemical putrefaction in the city for oxidising decay in the countryside. Liebig's science thus formed the cornerstone of Edwin Chadwick's hopes for sewage recycling.[39]

Liebig's chemical pathology also served to rationalise established beliefs in a relationship between soils and disease. James Kay-Shuttleworth, writing on the state of Manchester's working-class districts in 1832, linked 'unsewered' streets – 'the common receptacles of mud, refuse, and disgusting ordure' – to the spread of cholera, first diagnosed in Britain only months earlier.[40] '[S]hould Cholera visit this neighbourhood', he wrote of Little Ireland, 'a more suitable soil and situation for its malignant development cannot be found'.[41] In such passages, common across 1830s writing on cholera, soil served as both literal site of contagion and metonym for a location or nation likely to suffer repeated outbreaks of the disease. For example, the *Quarterly Review* reported in 1832 that 'cholera, like the small-pox or plague, takes root in the soil in which it has once possessed'.[42] Medical journal the *Lancet* wrote similarly in 1831, explaining how, 'in every soil over which it travels, [cholera] deposits that source of successive generations of calamity […] in whatever

[37] Kargon, *Science in Victorian Manchester*, p. 119.
[38] Brock, *Liebig*, p. 209; Pelling, *Cholera*, pp. 105-27.
[39] Liebig and Chadwick exchanged letters discussing the diverse potential applications of organic chemistry to sanitary concerns, with Playfair the intermediary: see Kargon, *Science in Victorian Manchester*, p. 118.
[40] James Kay, *The Moral and Physical Condition of the Working Classes Employed in the Cotton Manufacture in Manchester* (London: James Ridgeway, 1832), pp. 25, 13. James Kay-Shuttleworth and his wife Lady Janet Kay-Shuttleworth would become good friends of the Gaskells. They attended the Unitarian Cross Street Chapel, where William was reverend.
[41] Kay, *Moral and Physical Condition*, p. 23. Kay was one of the main sources Engels used for his discussion of Manchester in *Condition of the Working Class*.
[42] Quoted in Alan Bewell, *Romanticism and Colonial Disease* (Baltimore: Johns Hopkins University Press, 1999), p. 243.

part of India it broke forth, there it seems to have deposited the seeds of new irruptions of the distemper'.[43] By refuting the idea that disease 'reproduces itself as seeds reproduce seeds', Liebig's 1840 pathology had the effect of clarifying some of this terminology surrounding soils and disease in the 1830s.[44] The zymotic analogy suggested the *Lancet*'s metaphor of cholera seeds lying dormant in soils be replaced with an understanding of analogous chemical processes acting within and without the human body in the disease's developmental stages.[45]

As with his chemistry of agriculture, Liebig's English and Scottish students became important advocates for his chemical pathology upon returning to British cities. Few were more important in this regard than Playfair. Having completed his doctoral study under Liebig and translated *Organic Chemistry* into English, Playfair accepted a position as consulting chemist at Lancashire's Clitheroe dyeing works in 1841. He was appointed honorary professor of chemistry at the Royal Manchester Institution early in 1843, asking Robert Angus Smith, who he had studied with in Giessen, to be his assistant. When Playfair was offered a position later that year as a commissioner on Robert Peel's Health of Towns Commission, he asked Smith to be his assistant once more.[46] The two men came to be authorities in sanitary and agricultural chemistry.[47] Playfair was the first consulting chemist to the RASE and set up a laboratory in Manchester to carry out the work.[48] As I examine below, Smith's science came to focus on sewage recycling and the relationship between oxidising decay, soil fertility, and water purity into the 1850s.

Playfair arrived in Manchester on the threshold of scientific celebrity. He had already made a name for himself at the 1840 meeting of the British Association for the Advancement

---

[43] Quoted in Bewell, *Romanticisim and Colonial Disease*, p. 245. The fear was that cholera would become endemic on, and indeed in, British soil. These fears were bound up with questions of race and nation and worries over perceived forms of pollution from the colonies.

[44] Liebig, *Organic Chemistry*, p. 345. Liebig is discussing yeast here, the fermenting action of which he believed was a chemical process rather than a biological process. In this belief he was wrong, although not alone in the mid-nineteenth century: see Brock, *Liebig*, p. 204.

[45] *The Lancet* would become an important source of dissemination for the applications of Liebig's science to medicine through the 1840s. The journal included numerous reviews of his works, translations of his chemical lectures, and, across 1842 and 1843, 'a series of articles […] that made Liebig's views on animal chemistry more assimilable'. Brock, *Liebig*, p. 207. Rationalising existing practice with its simplicity and breadth of application, Liebig's chemical pathology chimed with *Lancet* editor Thomas Wakley's aim to establish 'a new era in medicine'. As Pelling describes, the journal even went so far as to christen Liebig 'a man of the century'. *Cholera*, pp. 129-30.

[46] Kargon, *Science in Victorian Manchester*, pp. 91, 88.

[47] Both men gave evidence to the *Second Report of the Metropolitan Sanitary Commission* in 1848, for example. *Metropolitan Sanitary Commission: Second Report of the Commissioners Appointed to Inquire whether any and what special means may be requisite for the improvement of the Health of the Metropolis, with Minutes of Evidence* (London: William Clowes & Sons, 1848).

[48] See Paul Brassley, 'Agricultural Science and Education', in *The Agrarian History of England and Wales, vol. 7, 1850-1914*, ed. by E. J. T. Collins (Cambridge: Cambridge University Press, 2000), pp. 594-649 (609-10); E. John Russell, *A History of Agricultural Science in Great Britain* (London: George Allen & Unwin, 1966) p. 114

of Science (BAAS) in Glasgow, where he read 'On Poisons, Contagions, and Miasms' from *Organic Chemistry*.[49] The 1842 BAAS meeting, held in Manchester, cemented his reputation.[50] Playfair read a report on Liebig's research into physiology and pathology, taken from the recently published *Animal Chemistry*, and this time his name was included among the prestigious 'Reports of Researches in Science' in the published account of the meeting.[51] Liebig was disappointed not to attend himself, but one person who was present, having helped organise the event, was William Gaskell.[52] Whether he heard Playfair's report is unclear, but the issues to which Playfair spoke were certainly of interest. As reverend at the Unitarian Cross Street Chapel, Gaskell 'serviced the educational and scientific side of Manchester life', writes Eileen Yeo.[53] His charitable work focused on alleviating the suffering of the poor by improving the educational opportunities and living conditions of the working classes. From its inception in 1852, he served on the board of the Manchester and Salford Sanitary Association with, among others, Angus Smith.[54] In a striking example of the interrelations between literary and scientific domains in the period, Gaskell and Smith also served on the board of the Manchester Literary and Philosophical Society, where Liebig was an honorary member.[55]

Playfair's stay in Manchester was ultimately brief, and he left for London in 1845. But in that short time, he had a marked impact on the city, as indicated by frequent mentions of his work in the *Manchester Guardian*. The paper's reporting on the 1842 BAAS meeting included a detailed account of 'Playfair['s] […] abstract of Professor Liebig's report on organic chemistry'.[56] Playfair's professorship at the Royal Manchester Institution was

[49] Justus von Liebig, 'On Poisons, Contagions, and Miasms', read by Lyon Playfair, in *Notices and Abstracts of Communications to the British Association for the Advancement of Science at the Glasgow Meeting, August 1840* (London: John Murray, 1840), pp. 72-73.
[50] Kargon, *Science in Victorian Manchester*, pp. 88, 90.
[51] Lyon Playfair, 'Abstract of Professor Liebig's Report on "Organic Chemistry applied to Physiology and Pathology"', in *Report of the Twelfth Meeting of the British Association for the Advancement for Science, held at Manchester in June 1842* (London: John Murray, 1843), pp. 42-54.
[52] William Gaskell 'exhibited specimens of the horns of the Wapiti Deer'. *Notices and Abstracts of Communications to the British Association for the Advancement of Science at the Manchester Meeting, June 1842* (John Murray, 1843), p. 70. On Liebig's disappointment on not being able to attend see Brock, *Liebig*, p. 155.
[53] Eileen Janes Yeo, *The Contest for Social Science* (London: Rivers Oram Press, 1996), p. 66.
[54] Both men delivered public lectures on the Association's behalf in 1854.
[55] Pelling, *Cholera*, p. 128. Smith was elected a member of the Manchester Literary and Philosophical Society in 1845, made secretary in 1852, and served as either president or vice-president from 1859 onwards: see Kargon, *Science in Victorian Manchester*, p. 127. William Gaskell was a member from 1840.
[56] Anon., 'The British Association for the Advancement of Science', *Manchester Guardian*, 25 June 1842, p. 5. Articles covering the meeting also noted other sessions where Liebig's and Playfair's science was debated, even quoting from *Organic Chemistry* and 'the excellent translation of Dr. Playfair': see 'The British Association for the Advancement of Science', *Manchester Guardian*, 29 June 1842, p. 5. For Playfair defending Liebig's views on catalysis see 'Friday', *Manchester Guardian*, 25 June 1842, p. 3.

reported in Spring 1843, as was his appointment as 'analysing chemist' to the RASE.[57] The paper also kept readers updated on the progress of Playfair's inspections on the health of Lancashire's towns, publishing the introduction to his finished report when it appeared in Spring 1845.[58] But it was Playfair's many public lectures that were chronicled in the greatest detail. These included courses of four lectures on general chemistry (Spring 1843) and 'the progress of chemistry' (Summer 1844), as well as six lectures on 'the chemistry of vegetation' (January – March 1845).[59] All were delivered 'to a numerous auditory, including the usual large proportion of ladies', as one *Guardian* reporter observed in July 1844.[60] Across all these articles, covering a wide variety of topics, the 'views […] of Liebig and Dr. Playfair' were often referred to as one.[61] Through Playfair, then, Liebig's chemistry was also being outlined and debated in the *Guardian*'s pages.[62]

Gaskell read the *Manchester Guardian* throughout the 1840s. She also lived with a husband immersed in Manchester's scientific circles.[63] Kargon explains the city's mid-century scientific culture as 'civic science'.[64] Science in Manchester during these years combined the culture of *Wissenschaft*, an ideal of scientific research imported from Liebig's laboratory in Germany, with public duty, professionalisation and a drive to foster institutions for the advancement and practical application of science. In the 1840s, Playfair and Smith were joined in the city by chemists James Allan, Edward Schunk and Joseph Henry Gilbert, all of whom earned their PhDs in Giessen (Gilbert's chemistry will feature again in chapter

[57] Anon., 'Local and Provincial Intelligence', *Manchester Guardian*, 15 March 1843, p. 4. The paper detailed how the Institution furnished him with 'a laboratory' to carry out the work for the RASE: see 'Local and Provincial Intelligence', *Manchester Guardian*, 12 April 1843, p. 4. Playfair's name also featured heavily in the *Guardian*'s report on the Manchester Agricultural Society meeting and dinner in September that year: see 'Manchester Agricultural Society', *Manchester Guardian*, 27 September 1843, p. 4.
[58] Anon., 'Report on the Sanatory Condition of The Large Towns of Lancashire, by Dr, Lyon Playfair', *Manchester Guardian*, 2 April 1845, p. 4. Playfair's sanitation work in Lancashire was reported first in August 1843: 'Local and Provincial Intelligence', *Manchester Guardian*, 2 August 1843, p. 4. See also: 'Wigan', *Manchester Guardian*, 10 May 1845, p. 6; 'Lecture on the Insalubrity of Towns', p. 6; 'Why are Towns Unhealthy?' *Manchester Guardian*, 24 January 1846, p. 6. Playfair used 'sanatory' instead of 'sanitary' in his writings, a spelling picked up in the popular press.
[59] These were generally delivered to audiences at the Manchester Institution and again at the Manchester Athenaeum.
[60] Anon., 'Dr Lyon Playfair's Lectures on the Progress of Chemistry', *Manchester Guardian*, 10 July 1844, p. 6.
[61] Anon., 'Conversazione at the Royal Institution', *Manchester Guardian*, 5 April 1843, p. 6. Playfair's appointment at the Royal Manchester Institution was welcomed in part due to 'his high reputation as the translator of Liebig's work on agricultural chemistry, and the expounder of Liebig's principles and views in this country': 'Local and Provincial', 15 March 1843, p. 4.
[62] As might be expected, Playfair drew heavily on Liebig's chemistry in his public lectures. See, for example, his 'Chemistry of Vegetation' series, and in particular the reports of these lectures that ran in the *Manchester Guardian* through February 1845: Anon., 'Dr Playfair's Lectures on the Chemistry of Vegetation', *Manchester Guardian*, 5 February 1845, p. 6; 12 February 1845, p. 2; 19 February 1845, p. 8; 26 February 1845, p. 6.
[63] It seems plausible, though I am yet to find evidence to prove this, that Elizabeth and William attended Playfair's lectures in person.
[64] Kargon, *Science in Victorian Manchester*, p. 107.

4); Allan and Schunk were close friends of the Gaskells, as Jenny Uglow describes.[65] Critics thus understand Gaskell's awareness of contemporary science stemming from a variety of sources, including personal intercourse with scientists, public lectures, and her wide reading of newspapers, periodicals and books held in the Portico library, where William was chairman from 1849.[66] Here she would have found copies of Liebig's *Organic Chemistry* (1840), *Animal Chemistry* (1842), *Familiar Letters on Chemistry* (1843), and *Researches on the Chemistry of Food* (1847).[67] Gaskell likely came into contact with Liebigian chemistry from a wide variety of sources, then.

As *Mr Harrison's Confessions* indicates, Gaskell seems to have been familiar with Liebig's writing first-hand. The second mention of Liebig in Gaskell's story sees his name stand in for *Organic Chemistry*. Harrison describes how, following dinner at Mr. Bullock's house, the lawyer 'brought out Liebig, and called me to him' (55):

> 'I can understand a good deal of this agricultural chemistry,' said he, 'and have put it in practice – without much success, hitherto, I confess. But these unconnected letters puzzle me a little. I suppose they have some meaning, or else I should say it was mere book-making to put them in.' (55)

The 'unconnected letters' are chemical symbols. 'I can only remember that C means carbon and O oxygen', Bullock complains, 'and I see one must know the meaning of all these confounded letters before one can do much good with Liebig' (55). Yet the agricultural portion of *Organic Chemistry* only contained chemical symbols on one page, for it was Liebig's aim to write for a wider audience who, like Bullock, could not be expected to know their chemical alphabet.[68] Where the book's second half addressed physiological chemistry, however, Liebig could expect a more scientifically literate medical readership, and he accordingly used chemical symbols on fourteen pages.[69] As his pathology depended on organic compounds undergoing combinations and decompositions, the chemical alphabet and

[65] Elizabeth Gaskell's extensive reading forms an important part of the evidence for this chapter, but it is important to remember that she and William also had many scientific friends and thus the opportunity to discuss contemporary science with those conducting it. 'Elizabeth had known many scientists, from the aristocratic amateur Lord Francis Egerton, patron of Manchester science, to her close friend Benjamin Brodie, professor of chemistry at Oxford', writes Uglow. 'In Manchester she met practical inventors like Fairbairn and Naysmith, theoretical and experimental physicists like James Joule, analytical chemists like James Allan and Edward Schunk and dynamic teachers such as Henry Roscoe, who breathed new life into the school of chemistry at Owen's College'. Uglow, *Elizabeth Gaskell*, pp. 559-60.
[66] Shirley Foster, '"We sit and read and dream our time away": Elizabeth Gaskell and the Portico Library', *Gaskell Society Journal*, 14 (2000), pp. 14-23; Barbara Brill and Alan Shelston, 'Manchester: "A Behindhand Place for Books": The Gaskells and The Portico Library', *Gaskell Society Journal*, 5 (1991), pp. 27-36.
[67] I have been unable to check this myself, but Litvack suggests there is no record of any scientific books being borrowed during the 1850s in William Gaskell's name: 'Outposts of Empire', pp. 738-39.
[68] See Liebig, *Organic Chemistry*, p. 183.
[69] See Liebig, *Organic Chemistry*, pp. 234, 238, 240, 264, 302, 311, 313, 319-22, 327-28, 365.

an understanding of chemical equivalency was indispensable for showing how processes of putrefaction, fermentation, and decay acted on the elemental constitution of organic substances. Where Harrison 'explain[s] the meaning of the symbols, and the doctrine of chemical equivalents' to Bullock, then, his knowledge reflects that which the doctor trained in the 1840s would be expected to know. More to the point, the contents of *Organic Chemistry* as presented in *Mr Harrison's Confessions* reflect the portion of Liebig's text which explained his chemical pathology.

Liebig's and Playfair's sanitary and agricultural chemistry, as I come to in my next sections, spoke to the problems of nutrition and sanitation that Gaskell would investigate in *Mary Barton* and *North and South*. Yet Gaskell and Playfair can be linked, not only via Liebig's chemistry directly, but through a broader discourse of 'low fever' in which the social and environmental problems of towns and cities were bracketed together. Describing districts 'low in the scale of health' in his report on Lancashire's towns, Playfair explained how 'continued exposure to morbific causes produces a low state of the system', a particular problem on poorly draining 'low grounds' and in 'low lodging houses', such as cellars.[70] In *Mr Harrison's Confessions*, meanwhile, the new doctor's arrival in Dunstable is especially welcome due to 'a low kind of typhoid, in the oldest part of the town' (6). Similar 'low' fevers afflict the poor in *Mary Barton*, the children who attend Lowood School in *Jane Eyre*, and disadvantaged populations in Dickens's *Bleak House*, for example.[71] For mid-nineteenth-century writers of both fiction and science, low discourse linked low income and low geography to the lowered health of the lower classes. In this way, while Liebig's chemical pathology refined how the action of diseases such as cholera, typhoid, and typhus were understood, his zymotic analogy was at the same time incorporated into a pre-existing discourse. This discourse of low fever should be situated alongside the ethos of improvement, for where low income and low geography combined to spread moral and physical disease, so what Playfair called 'the combined action of physical improvements, and […] extension of education', could together raise or 'improve' poorer populations to better health and higher social standing.[72]

---

[70] Lyon Playfair, 'Report on the State of Large Towns in Lancashire', in *Second Report of the Commissioners for inquiring into the State of Large Towns and Populous Districts* (London: William Clowes and Sons, 1845), pp. 345-486 (440, 429, 414, 389).
[71] Elizabeth Gaskell, *Mary Barton*, ed. and intro. by Shirley Foster (1848; Oxford: Oxford University Press, 2006), p. 59. (All further references to *Mary Barton* are to this edition and are given parenthetically in the body of the chapter.) Charles Dickens, *Bleak House*, ed. and intro. by Nicola Bradbury, preface by Terry Eagleton (1852-53; London: Penguin, 1996), p. 338.
[72] Playfair, 'Large Towns in Lancashire', p. 474.

Gaskell shared in the discourse of low fever.[73] She also had access to Liebig's chemical pathology through her scientific friends, Liebig's original writings, and reports of his work in the *Manchester Guardian*. Here she could also have read of Playfair's chemical lectures, sanitary writing, and agricultural chemistry. Accounting for these many potential influences on her work presents a methodological problem, however. As Catriona Livingstone observes, 'What is lacking in the field of literature and science is a model that takes account both of the existence of mutual two-way influences *and* of the specificities of conceptual transmission'.[74] To meet this challenge, I read mid-nineteenth-century Manchester as an ecology of literature and science, an ecology of knowledge production that accounts for both general and specific links between fiction and science. Reading in this way allows for both divergence and agreement in conceptual engagement. As Gillian Beer observes, 'scientists work with the metaphors and the thought-sets historically active in their communities'; and as Livingstone adds, '[l]iterary writers, in helping to determine those "metaphors" and "thought-sets," inform both the selection of phenomena deemed worthy of scientific investigation, and the way in which scientific findings are constituted through language'.[75] In this way, where Gaskell's fiction engages with organic chemistry, she re-inflects the discourse in which Playfair's sanitary reporting is also situated. Their work is best captured as part of a mutual endeavour. Instead of viewing a writer of fiction on the one hand and practitioners of science on the other, the remainder of this chapter understands their writings as related knowledges of the industrial city. Turning now to Gaskell's industrial fiction with *Mary Barton*, these knowledges meet in Manchester's pathological soils.

Tracing Agency in Manchester

Gaskell's personal letters attest to a keen dislike of Manchester's soil. In an undated letter to Mary Howitt, she bemoaned how, 'living in Manchester, all round being a clayey soil, one sees little or nothing of spring flowers';[76] on moving from Dover Street to Plymouth Grove in 1850, she wrote to Eliza Fox that 'the garden will be a great delight in our new house. Clay soil it *will* be, and there is no help for it, but it will be gay and bright with common

[73] I draw this idea of a shared discourse from Rachel Crossland, 'Sharing the Moment's Discourse: Virginia Woolf, D. H. Lawrence and Albert Einstein in the Early Twentieth Century' (unpublished doctoral thesis, University of Oxford, 2010).
[74] Catriona Livingstone, 'Experimental Identities: Quantum Physics in Popular Science Writing and Virginia Woolf's *The Waves*', *Journal of Literature and Science*, 11.1 (2018), pp. 66-81 (75; emphasis in original).
[75] Quoted in Livingstone, 'Experimental Identities', p. 75.
[76] Elizabeth Gaskell, 'Letter to Mary Howitt, [undated]', in *The Letters of Mrs Gaskell*, ed. by J.A.V. Chappell and Arthur Pollard (Manchester: Manchester University Press, 1997), p. 798.

flowers'.[77] Lancashire's heavy soils had more nefarious impacts on the region's population than inhibiting their enjoyment of springtime blooms, however. As Playfair's sanitation report explained, 'Wigan is in a very low state as to its sanatory arrangements, particularly an undrained part of the town situated on impermeable clay'.[78] Gaskell's letters also speak to a belief in the pathological potential of clay soil, as she wrote to Janet Kay-Shuttleworth (wife of James) from Warwick in 1850: 'The weather here is so different to Manchester, owing I suppose to the soil being limestone instead of clay, that we have sunshine here, and leaves on the trees while last week at Manchester the trees were bare, and there was thick fog'.[79] Her words speak to the same belief in how, unlike free-draining limestone, impermeable clays contributed to the generation of miasmatic emanations detrimental to health. Soils thus featured prominently in the discourse of low fever and were acknowledged as one of the agents acting in the spread of disease.

Playfair's translation of *Organic Chemistry* needed to capture a similar sense of distributed agency if British audiences were to understand the explanatory power of Liebig's pathology. Living in close proximity to clay was not the root cause of disease; nor was it simply the case that miasmas generated disease where water stagnated on impermeable soils. For Liebig, it was the 'chemical action' of putrefying matter in such circumstances that, when introduced to the body, served as the agent of disease transmission.[80] His chemical pathology thus captured what Stacey Alaimo has more recently called 'human corporeality as trans-corporeality', evident here in Playfair's translation:[81]

> The slightest action of a chemical agent on the blood exercises an injurious influence; even the momentary contact with air in the lungs, although effected though the medium of cells and membranes, alters the colour and other qualities of the blood. Every chemical action propagates itself through the mass of blood.[82]

Chemical agency underpinned Liebig's pathology. Introduced to the blood via the lungs, putrefying matter suspended in miasma communicated its 'active chemical character' from the external environment to the body.[83] Liebig thus understood the human, to borrow Alaimo's words once more, as 'always intermeshed with the more-than-human world' via chemical processes of putrefaction, fermentation, and decay.[84] As Playfair and Gaskell

[77] Gaskell, 'Letter to Eliza Fox, 26 April 1850', *Letters of Mrs Gaskell*, pp. 110-13 (111; emphasis in original).
[78] 'Wigan.' *Manchester Guardian*, p. 6.
[79] Gaskell, 'Letter to Lady Kay-Shuttleworth, October 1850', *Letters of Mrs Gaskell*, pp. 133-36 (134-35).
[80] Liebig, *Organic Chemistry*, p. 361
[81] Alaimo, 'Trans-Corporeal Feminisms', p. 238.
[82] Liebig, *Organic Chemistry*, p. 360.
[83] Liebig, *Organic Chemistry*, p. 357.
[84] Alaimo, 'Trans-Corporeal Feminisms', p. 238.

explore in their writing, this trans-corporeal discourse of 'chemical agency' could be harnessed to inscribe the aetiology of urban disease.[85]

Playfair's 'Report on the Large Towns of Lancashire' described the many agencies acting in the spread of 'zymotic disease'.[86] Explaining how sewage and 'such refuse […] acts in a most destructive manner, either as an exciting, or as a predisposing cause of disease', he followed Liebig in attributing trans-corporeal agency beyond the human. Referring to how 'the physical causes of disease act powerfully', he drew attention to 'noxious agencies at present existing in all our large towns' – agencies that were both environmental and social.[87] Factors such as 'drainage, cleansing, supplies of water, [and] building regulations', along with 'local acts and usages', all impacted 'public health and morals'.[88] Playfair thus described a 'low sanatory state […] generally synonymous with a low moral state' marked by prostitution and the abuse of alcohol and opium.[89] The 'close contact' resulting from the 'indiscriminate intermixture of sexes' in lodging houses, for example, contributed to 'immense moral evils' while making these sites the 'foci of malignant diseases'.[90] In this way, social and environmental factors combined in the creation of 'depressing agencies' acting on the human;[91] individuals who survived low fever might still suffer from 'low morals', 'the diminution of the physical and mental energies', even 'idiocy and insanity'.[92] The agencies contributing to ill-health in the industrial environment were multifaceted, Playfair explained, and understood to impact disadvantaged population in a number of ways.

Gaskell seems to have been influenced by Playfair's report when writing *Mary Barton*. Playfair's findings were reported by the *Guardian* in April and May 1845, with Gaskell beginning her novel in Autumn that year. This places her composition of the first volume, where the most penetrating accounts of the poorest districts of Manchester are to be found, in the months after Playfair's report was being discussed in the local press.[93] An article from May, for example, quoted Playfair's account of Wigan, adding italics to emphasise the town's shocking sanitary condition – 'situated on impermeable clay, and

[85] Liebig, *Organic Chemistry*, p. 354.
[86] Playfair, 'Large Towns in Lancashire', p. 430.
[87] Playfair, 'Large Towns in Lancashire', p. 428.
[88] Playfair, 'Large Towns in Lancashire', p. 345.
[89] Playfair, 'Large Towns in Lancashire', p. 472.
[90] Playfair, 'Large Towns in Lancashire', pp. 387, 390.
[91] Playfair, 'Large Towns in Lancashire', p. 435.
[92] Playfair, 'Large Towns in Lancashire', pp. 444, 451, 463.
[93] This was following the death of her son. As she wrote in an 1849 letter: 'the tale was formed, and the greater part of the first volume was written […] when I took refuge in the invention to exclude the memory of painful scenes'. Quoted in Shirley Foster, 'Introduction', *Mary Barton*, pp. vii-xxvi (vii).

abounding in filth of every description'.[94] *Mary Barton* uses an identical formulation to describe sewage in Berry Street, in Manchester's Ancoats district:

> It was unpaved: and down the middle a gutter forced its way, every now and then forming pools in the holes with which the street abounded. […] As they passed, women from their doors tossed household slops of *every* description into the gutter; they ran into the next pool, which overflowed and stagnated. (58; emphasis in original)

The formulation may be a common euphemism for excrement, or a turn of phrase borrowed from Playfair, but what is clear is that Gaskell's writing also distributes agency beyond the human.[95] As 'household slops of *every* description' are 'tossed' into the street, sewage 'runs' and 'overflows' and 'stagnates', agential verbs testifying to putrefying organic matter acting in the heart of city. Karen Barad coins the term 'intra-action' to denote 'the mutual constitution of entangled agencies'.[96] Gaskell's and Playfair's writings capture something similar – agencies that resist demarcation into social and natural spheres of action, but that emerge together as one in the urban environment. Thus, in the passage above, insufficient sewerage, poorly draining soil and chemical putrefaction intra-act as sewage 'stagnates'. This sewage 'forces its way' in the 'unpaved' street, 'forming' a pathological environment as clay soil and night soil come into contact.

Mary Barton inscribes these intra-acting agencies with devastating clarity. John Barton and George Wilson have travelled to Ancoats to help Ben Davenport and his family. With Davenport out of work due to the 'depression of trade' (23), the family have 'sunk lower and lower' until they are forced to live in 'a cellar' (58), where Davenport has inevitably come 'down wi' the fever' (57). Low discourse here draws associations across natural and social spheres of action, Gaskell showing how economic and environmental agencies combine to situate human bodies within a pathological environment. Barton and Wilson pass into the family home, finding 'three or four little children rolling on the damp, nay wet brick floor, through which the stagnant, filthy moisture of the street oozed up' (58). These conditions generate 'a low, putrid, typhoid kind [of fever]; brought on by miserable living, filthy neighbourhood, and great depression of mind and body' (59). The fever is diagnosed as 'typhus' (62), but the 'putrid' action of zymotic disease is not the root cause of Davenport's condition. 'The fever' is the expression of intra-acting agencies that simultaneously constitute Davenport as a 'worn skeleton of a body', generating the 'naked

[94] 'Wigan', *Manchester Guardian*, p. 6; emphasis in original.
[95] Playfair, 'Large Towns in Lancashire', p. 349.
[96] Barad, *Meeting the Universe Halfway*, p. 33.

madness' (61) and 'wild mad agony of the fevered man' (63). In this way, human and typhus emerge together as the expression of intra-acting agencies in the Berry Street cellar.

Gaskell's novel continues to examine these agencies as Davenport approaches death. Emphasising the 'putrid' quality of his illness alongside stagnating pools of sewage, her account traces something akin to Liebig's description of analogous chemical processes acting in the body and the environment; where scholars have long understood miasmas as central to how industrial fiction imagines social relations, Gaskell develops this tradition by tracing associations via trans-corporeal 'chemical agency'.[97] At the back of the cellar lies a door, leading 'into a back cellar, with a grating instead of a window, down which dropped the moisture from pigsties, and worse abominations. It was not paved', the reader learns, 'the floor was one mass of bad smelling mud' (62). This singular 'mass of […] mud' is composed of the soils underlying the city and the soils generated by humans and animals, forming putrefying organic matter that, as the 'foetid' (58) smell indicates, circulates in miasma to re-enter the lungs. These lungs are already weakened, for as this '"back apartment" made a difference in the rent', costing the Davenports 'threepence more for having two rooms' (62), less money is available for food, leaving the family 'well-nigh clemmed' (60). These intra-acting agencies form what Mangham calls 'famine fever', emblematic of what Jennifer Maclure describes as 'a pathological system of capitalism', writ large on Davenport's body at the moment of his death:[98] 'The flesh was sunk, the features prominent, bony, and rigid. The fearful clay-colour of death was over all' (69). The soil in which the cellar lies is transposed onto Davenport's dying body, the adjectival use of clay describing his impending death in a formulation which makes plain the wider associations generating fever, malnourished bodies, and the excremental stratum of the city. In so doing, Gaskell traces Liebig's analogy between chemical processes acting in the external environment and within the body in the opposite direction, the metaphor active in the 'clay-colour of death' situating the moment of death itself in close proximity to the agencies at work in the development of disease.

The Berry Street cellar is a capitalist assemblage. The spread of fever, as Tina Young Choi explains, becomes 'an involuntary and inevitable condition of urban life' in such conditions.[99] Agencies at once natural and social, chemical and economic, human and non-human, intra-act to constitute pathological bodies and environments as one; to borrow

[97] See, for example, Tina Young Choi, 'Writing the Victorian City: Discourses of Risk, Connection, and Inevitability', *Victorian Studies*, 43.4 (2001), pp. 562-89 (564).
[98] Mangham, *Science of Starving*, p. 128; Maclure, 'Diagnosing Capitalism', p. 349.
[99] Choi, 'Writing the Victorian City', p. 562.

Barad's words, these 'agencies do not precede, but rather emerge through, their intra-action'.[100] In this way, *Mary Barton* describes the effects of metabolic rift. As with Friedrich Engels, also writing on Manchester's poor in the 1840s, Gaskell and Playfair each render metabolic rift as lived experience. Where Alaimo's trans-corporeality explains the mutual entanglement of bodies and environments, and Barad's intra-activity captures their mutual constitution, Bruno Latour's Actor-Network Theory offers a way to frame the related knowledges Gaskell and Playfair each construct. They approach Manchester as a 'local and connected site' symptomatic of the networked agencies acting in the creation of a pathological capitalism.[101] In this way, their accounts of the urban environment offer, in Latour's words, 'sturdy but extremely narrow views of the connected whole', namely industrial capitalism's developmental programme expressed as the industrial city.[102]

There is a defining feature of Manchester's ecology of literature and science that here comes to the fore. The structure of analogy is of central importance to Liebig, Playfair, and Gaskell, suggesting a link between their respective writings that speaks to 'the relationships between scientific knowledge and literary form' that O'Connor highlights in his programme for the field of Literature and Science.[103] Analogies and metaphors hold competing ideas in tension without these ideas falling apart. Liebig thus used analogical reasoning to show the human body and wider environment joined in a continuum of chemical action, in so doing bridging oppositional concepts such as human and non-human, internal and external, life and death. The discourse of low fever was valuable in similar ways for Playfair. The metaphoric potential of lowness allowed him to highlight the environmental and social agencies acting in the formation of epidemics. Yet for both, scientific inquiry remained bounded by a strict conception of analogical reasoning. As seen in chapter 1, Liebig presented scientific knowledge-making structured upon literary form as unreliable and outdated; *Organic Chemistry* dismissed the humus theory as founded on nothing more than 'analogy, that fertile source of error', which is perhaps why, despite analogy's clear importance to the theory, Liebig and Playfair resisted referring directly to their chemical pathology in such terms.[104] But Gaskell's writing, as I now explore further, is limited by no such compunction. Inscribing matter in metaphor, most obviously in rendering Davenport's death in clay, Gaskell's realism reroutes agency, as metaphors do meaning, towards the material.

[100] Barad, *Meeting the Universe Halfway*, p. 33.
[101] Latour, *Reassembling the Social*, p. 179.
[102] Latour, *Reassembling the Social*, p. 181.
[103] O'Connor, 'Meanings of "Literature"', p. 43.
[104] Liebig, *Organic Chemistry*, p. 26.

The principal difference between Gaskell's and Playfair's accounts of metabolic rift is how their writing functions to create sympathy for the poor. Playfair's understanding of low fever's aetiology is inseparable from his representation of 'the lowest mendicants, thieves, and prostitutes'.[105] His conception of 'close contact' with 'abandoned women' as liable to spread immoral behaviour, for example, is supported by the same logic that underpins Liebig's pathology.[106] As Hamlin explains, mid-nineteenth-century sanitarians often 'envision[ed] a process of moral contagion, the exact complement of the process Liebig had described'.[107] But in Playfair's report, physical and moral health do not simply complement each other, they constitute body and character together as one: 'The low state of the system produced by continued exposure to the physical causes of disease creates an appetite for stimulants,' he explained, 'which gradually lowers the moral as well as the physical condition'.[108] Material and discourse here become co-shaping as Playfair details 'bad sanatory [*sic*] condition – a term generally synonymous with a low moral state'.[109] In this way, Playfair's account is caught within a discourse that renders disadvantaged populations as putrefying matter, the same putrefying matter, of course, from which he hoped to remove them.

Gaskell's writing is shaped by the same discourse, but *Mary Barton* works to resist this damaging representation so as to create sympathy for the poor. Scholars have long read Gaskell's realism as an effort to generate sympathy. Mary Poovey argues that Gaskell addresses 'the crisis of the "hungry forties" […] by using the genre's conventional focus on individual characters to engage readers imaginatively with the problems of the poor'.[110] Thus *Mary Barton*, for Elizabeth Starr, offers 'a sympathetic tour of working-class life' embodied in a 'sympathetic representation of fallen woman Esther'.[111] 'In the world of the novel', adds Jill Matus, 'sympathy is the highest order of feeling', yet this has also led to criticism of *Mary Barton*.[112] Elaine Freedgood, for example, questions 'sentimental […] ideas about the suffering of the laboring class', and with it a fiction that 'is a melodrama and not a realist

[105] Playfair, 'Large Towns in Lancashire', p. 387.
[106] As Natalka Freeland shows, Playfair was by no means alone in making 'homologies between dirty streets and streetwalkers'. Natalka Freeland, 'The Politics of Dirt in *Mary Barton* and *Ruth*', *Studies in English Literature 1500-1900*, 42.4 (2002), pp. 799-818 (809).
[107] Hamlin, 'Providence and Putrefaction', p. 389.
[108] Playfair, 'Large Towns in Lancashire', p. 469.
[109] Playfair, 'Large Towns in Lancashire', p. 472.
[110] Poovey, *Social Body*, p. 143.
[111] Starr, 'Industry of Fiction', p. 387.
[112] Matus, '*Mary Barton* and *North and South*', p. 30.

novel'.[113] Yet it is here, I would propose, where the construction of realism in fact meets Gaskell's sympathy-inducing aims. *Mary Barton* seeks to bring a bourgeois readership into contact with disadvantaged populations, generating a form of sympathy, identified by Maclure, that is 'visceral and non-cognitive, occurring in response to close contact between vulnerable bodies'.[114] The most obvious example of this, as I come to below, is Esther's narrative. Yet achieving such contact requires addressing the dominant representation of prostitution in low discourse, countering a conception of moral contagion that, following Liebigian logic, maintains separation along lines of income and class. Creating sympathy thus means engaging with material and discourse as co-shaping in the industrial city, revealing how individuals come to be constituted in ways that inhibit sympathetic contact.

Mary Barton portrays Esther sympathetically as a 'poor thing' (121), 'poor aunt Esther' (376), 'the poor crushed Butterfly' (378). Readerly sympathy is generated as Gaskell details the combined agencies that have directed Esther into prostitution. Led astray by 'love' and an unfulfilled 'promise' of marriage, she and her young daughter are abandoned by the child's father – an 'officer' supposedly 'ordered to Ireland' (156). As 'cold bleak winter' leaves her daughter perilously ill, Esther is unable to work, her little money consumed by the 'food and medicine' (157) which alone can preserve her daughter's life. The economics of industrial capitalism demand rent be paid in full and on time, however, meaning mother and child face homelessness (157). Just as the dirt of the street marks 'her faded finery […] now dirty white' (121), and 'cold' exposure constitutes a body ravaged by tuberculosis and 'spitting of blood' (158), Esther's character as a 'street-walker' is constituted by the environmental, economic, and imperial agencies of industrial modernity.[115] These intra-acting agencies force her to choose between the death of her child or life as an 'abandoned and polluted outcast' (228). Gaskell cannot condone Esther's decision, as I explain below, but *Mary Barton* nevertheless traces the factors leading disadvantaged women to the point of prostitution. This may be thought of in Baradian terms as Esther's 'becoming' into prostitution.[116] 'Just as the Davenport's cannot prevent the filth of the street from seeping into their home', writes Natalka Freeland, 'none of the novel's working class characters can escape the social problems this dirt metonymically represents'.[117]

[113] Freedgood, 'Novelist and Her Poor', pp. 214, 218.
[114] Maclure, 'Diagnosing Capitalism', p. 346.
[115] As Freeland shows, Gaskell shows similar agencies acting in *Ruth*, leading the titular character to prostitution. Freeland, 'Politics of Dirt', pp. 809-10.
[116] Barad, *Meeting the Universe Halfway*, p. 150.
[117] Freeland, 'Politics of Dirt', p. 802.

As Freeland shows, *Mary Barton* does not accept any straightforward equation of filth with vice. For example, Mary's belief that she 'must never soil her hands' (26), which leads her to reject 'soiled' and 'dirty' (76) Jem for a promised life of ease with wealthy Harry Carson, becomes evidence of a dangerous 'likeness' to Esther (124). In such moments, it is as much the desire to be clean, as it is proximity to dirt, that leads to potentially immoral behaviour.[118] This complicates a narrative that Hamlin identifies as common to mid-Victorian pathology – 'an image of how the pure was corrupted by impurity and in the process transformed into a replica of the impurity that would perpetrate future corruption'.[119] As Mary comes to believe 'her beauty should make her a lady […] the rank to which she firmly believed her lost aunt Esther had arrived' (26), so a dangerous belief, 'infused years ago by her aunt Esther, *fermented* in her bosom' (79; my emphasis). There is an obvious figurative sense in which fermentation, as in 'to excite' or 'stir up', is being employed here.[120] But read for its specific connotations in terms of Liebig's pathology, introduced via the Davenport cellar in the novel's previous chapter, a chemical process acting on the body here engenders a dangerous putrefaction; tracing the aetiology of the process, however, sees corruption generated by a misguided desire to be clean, rather than through proximity to putrefying matter. To advance Freeland's argument, then, Gaskell uses the free association of metaphor to challenge the logic of Liebig's pathology. So as Mary resists her aunt's fate, Gaskell counters Playfair's conception of the poor as a homogenous 'mass' akin to the putrefying mud of the Davenport cellar and all equally prone to corruption.

This is not to say that such associations are merely the product of Esther's 'diseased mind' (228). Gaskell portrays the damaging effects of Playfair's logic on the lives of the poor, showing Esther internalising the polluting connotations of low discourse. As *Mary Barton*'s narrator explains, 'Hers is the leper sin, and all stand aloof, dreading to be counted unclean' (154). Esther is painfully aware of how her presence 'repulsed' (123) and 'revolted' (232) those she loves; John Barton meets her touch with a 'fierce repulsing action' (154) and Mary feels 'a kind of repugnance' (230) in her presence. As Jem Wilson is wrongly arrested for Carson's murder, Esther blames herself for asking him to protect Mary 'from falling'

[118] It could be said that contact with clay even develops potentially positive connotations. When Jem Wilson knocks Carson down amidst the 'deep clay ruts' of Turner Street (171), it is clear who acts justly and who fails to heed a valuable lesson. Jem marries Mary before the novel's end while Carson, shot by John Barton in the climactic action of a wage dispute, is found dead in 'the dust' (226) of the same 'muddy road' (174), contact with soil that has the indirect effect, in ending Carson's life, of preserving Mary's innocence.
[119] Hamlin, 'Providence and Putrefaction', p. 389.
[120] 'Ferment, *v.*', in *The Oxford English Dictionary* [online], <https://www.oed.com/view/Entry/69362> [accessed 11 May 2021].

(160). Her 'poor, diseased mind', 'rendered morbid by […] consciousness of her own degradation', believes 'the black curse of Heaven rested on all her doings, were they for good or for evil' (228). The reader thus sees Esther constituting herself through a discourse that remakes disadvantaged individuals as putrefying and corrupting matter. Where Gaskell 'highlights the broken links between reality, representation, and feeling' in the context of hunger, as Mangham has suggested, so she details how representation and reality intra-act in the making of disadvantaged populations.[121]

Gaskell is not 'recast[ing] the relation between dirt and vice as a choice between opposites', as Freeland argues, but showing how dirt and vice come to be falsely constituted as one in the industrial city.[122] As Esther is constituted as putrefying matter, this construction is always mediated via the perspective of individuals rather than the narrator. The novel is entirely consistent, I would propose, in having Esther exclaim in 'frantic' desperation that she and Mary 'must never kiss' (235), yet allowing Mary to fall into her aunt's arms and remain uncorrupted by physical contact with prostitution (225). Indeed, this is precisely Gaskell's point. Low discourse acts on the lives of the poor, and is an impediment to the improvements sanitarians hope to effect, because it inhibits sympathetic contact and expressions of love and care; Esther repeatedly refuses help, and ultimately dies, because she truly believes herself to be corrupting matter. She is constituted as such by a low discourse internalised by Manchester's population, material and discourse intra-acting in the moments of 'repulsion' and 'repugnance' her touch engenders. This referentiality is not merely circular, but emergent across the discourse and matter of the urban environment. Esther's 'becoming' as a prostitute is thus the expression of intra-actions between mental and physical health, the environment in which she lives, and the discourse in which she articulates her sense of self.[123] Where Barad is right to highlight the agency of the material world, then, it is important to keep in mind that representations act on the world as surely as matter acts in the making of representation.[124]

Esther's narrative attests to human life 'as neither pure cause nor pure effect but part of the world in its open-ended becoming'.[125] Like Jane Eyre, Esther's character is constituted in terms of soil, but where Jane's self emerges alongside the improved soils of the country

[121] Mangham, *Science of Starving*, p. 130.
[122] Freeland, 'Politics of Dirt', p. 805.
[123] In this way, even where Playfair tries to move against low discourse – such as where he highlights that 'It is too common a mistake to transpose the effect for the cause, and to ascribe the disease to the indulgence of those propensities which in the first place were created by the low sanatory state of the district' – his understanding of cause and effect presupposes agencies emerging across distinct spheres of action, environmental then social. Playfair, 'Large Towns in Lancashire', p. 472.
[124] For more on this see Parham, 'Bleak intra-actions', pp. 116-18.
[125] Barad, *Meeting the Universe Halfway*, p. 150.

estate and colonial plantation, Esther constitutes herself as the putrefying sewage matter of the city. In this way, *Mary Barton* shows how low discourse acts on those it describes while simultaneously emerging from the environments and activities engendered by a pathological capitalism. Gaskell's writing is thus distinct from Playfair's account of moral and physical contagion; her narratives of Esther and the Davenport cellar create situated knowledge of Manchester's disadvantaged populations by engaging with 'the generation […] of bodies and other objects of value in scientific knowledge projects', as Donna Haraway puts it.[126]

The aims of literary realism and the construction of literary realism here meet in Gaskell's writing. To create sympathy is to engage with the tenets of representationalism, the ontological foundation of the mid-nineteenth-century realist novel. Gaskell's account of material-discursive intra-activity is built on the free association of metaphor. Where Jesse Oak Taylor identifies metonym as the means by which *Bleak House* captures 'an entangled collection of human and nonhuman actors displaying emergent properties that cannot be reduced to the sum of its parts', *Mary Barton*'s metaphors shows these agencies to be emergent across matter and discourse in relation.[127] Once more, the novel as representation offers an agential world where material and discourse are co-shaping in the Baradian sense, in turn countering Baradian theory's dismissal of representationalist realism.[128]

Yet Gaskell is also bounded by a moral code built on her Unitarian beliefs.[129] Ultimately, she cannot condone Esther's actions. Having described the agencies that have led her into prostitution, Esther asks Jem, 'Do you think God will punish me for that?' (157) – for sacrificing her moral purity to save her daughter's life. *Mary Barton*'s answer to this question is yes. Not only do Esther's actions fail to save her daughter from 'death' (157), they of course lead to her own death at the close of the novel (378). 'She'll go to America with us; and we'll help her to get rid of her sins' (376), Mary pleads in desperation, but just as Mary never loses her purity, Esther cannot regain a pure state once she has lost it. In this way, 'the once innocent Esther' (378) remains shut out from 'that happy class to which she could never, never more belong' (230). While putrefaction is evidently a process akin to Liebig's pathology, purity thus remains an inviolable state in *Mary Barton.* As my next

[126] Donna J. Haraway, 'Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective', *Feminist Studies,* 14.3 (1988), pp. 575-99 (595).
[127] Taylor, *Sky of Our Manufacture,* p. 27.
[128] *Mary Barton*, like *Jane Eyre*, thus challenges Barad's conceptualisation of 'representationalism's construal of matter as a passive and blank slate awaiting the active inscription of culture whereby the relationship between materiality and discourse is figured as one of absolute exteriority'. Barad, *Meeting the Universe Halfway*, p. 150.
[129] For a detailed account of Gaskell's Unitarianism see Uglow, *Elizabeth Gaskell*, pp. 5-7.

section explains, this marks a major distinction between *Mary Barton* and *North and South*, a distinction that relates to how Gaskell 'no longer had to split her heroine into "good" and "bad" – Mary and Esther', as Uglow puts it, in the latter novel.[130] For where purity is a state in the former, in the latter purity becomes a process, providentially ordained, but dependent on contact with a world prone to putrefaction. It is here, as I now show, where Gaskell's sees hope for a reconciliation of metabolic rift, *North and South* uniting the soils of the city with the soils of the country in the marital union of John Thornton and Margaret Hale.

Purity in Soil

North and South has long been read as an examination of the relations between city and country. Scholars have here seen Margaret and Thornton as symbolising, and indeed troubling, a host of broader positions. Writing in the mid-1970s, Nancy Mann noted that their 'personal struggle […] represents […] a variety of class, economic, religious, intellectual and ethical conflicts' – including 'agriculture against industry'.[131] More recently, Nathan K. Hensley and Philip Steer have seen this as a clash of 'Victorian energy regimes […] a form of confrontation between (1) the traditional organic economy […] and (2) a new, coal-fired economy'.[132] Such a division, captured by Divya Athmanathan as the 'English regional binary of Industrial north and the agrarian South', is foregrounded in the novel's title.[133] Many scholars have thus highlighted Margaret's position as a mediator charged with overcoming, what Anna Burton calls, the 'inherent and inherited dichotomies of North and South'.[134] For as Terence Wright examines, Gaskell's novel is principally interested in the relations between northern and southern England, Margaret and Thornton transcending easy binaries in a narrative that, to quote Rosemarie Bodenheimer, is 'not really organised as a

[130] Uglow, *Elizabeth Gaskell*, p. 372.
[131] Nancy D. Mann, 'Intelligence and Self-Awareness in *North and South*: A Matter of Sex and Class', *Rocky Mountain Review of Language and Literature*, 29.1 (Spring 1975), pp. 24-38 (34).
[132] Nathan K. Hensley and Philip Steer, 'Signatures of the Carboniferous: The Literary Forms of Coal', in *Ecological Form: System and Aesthetics in the Age of Empire*, ed. by Nathan K. Hensley and Philip Steer (New York: Fordham University Press, 2019), pp. 63-82 (68).
[133] Divya Athmanathan, '"You might pioneer a little at home": Hybrid Spaces, Identities, and Homes in Elizabeth Gaskell's *North and South*', in *Place and Progress in the Works of Elizabeth Gaskell*, ed. by Lesa Scholl and Emily Morris (London: Routledge, 2015), pp. 37-52 (37). This title was implemented, of course, by Charles Dickens. For Gaskell's troubled relationship with Dickens while writing *North and South* see Uglow, *Elizabeth Gaskell*, pp. 355-68.
[134] Anna Burton, 'Remarks on Forest Scenery: *North and South* and the Picturesque', *Gaskell Society Journal*, 32 (2018), pp. 37-54 (43). On Margaret's mediating position see: Lesa Scholl, 'Moving Between *North and South*: Cultural Signs and the Progress of Modernity in Elizabeth Gaskell's Novel', in *Place and Progress in the Works of Elizabeth Gaskell*, ed. by Lesa Scholl and Emily Morris (London: Routledge, 2015), pp. 95-105 (96-97); Wendy Parkins, 'Women, mobility and modernity in Elizabeth Gaskell's *North and South*', *Women's Studies International Forum*, 27 (2004), pp. 507-19 (508).

system of contrasts'.[135] For many scholars, then, Thornton and Margaret's marriage symbolises the reconciliation of class, regional, and economic positions.[136] Viewing their union as addressing metabolic rift takes this criticism in a new direction while focusing on the relations between industrial and land-based economies long noted as implicit in their courtship.

One distinction that can immediately be drawn between *Mary Barton* and *North and South* is in how the two novels represent the countryside. Scholars have long noted that, in the earlier novel, Gaskell's realist portrayal of industrial life gives way to an 'old-world' (5) agricultural idyll conjuring what Uglow calls 'a vanished literary Pastoral'; as the Barton and Wilson families are seen walking near Manchester in Green Heys Fields, the countryside is introduced in terms of a rustic purity that 'speaks of other times', a vision to contrast sharply with a city marked by stagnation and putrefaction.[137] Rural and urban are not so easily set against each other in *North and South*. Helstone is as likely to be seen as a site of disease as of health by Mrs Hale, who complains of the village's 'unhealthiness' (18). As 'a deep, clear pond' (5) in Green Heys Fields is defined by the purity of its waters in *Mary Barton*, Helstone's 'stagnant ponds' are the putrefying cause of 'bad air' (42). Mrs Hale's tone changes, however, when confronted with the prospect of life in Milton: 'You can't think the smoky air of a manufacturing town, all chimneys and dirt like Milton-Northern, would be better than this air, which is pure and sweet, if it is too soft and relaxing' (45). But the novel once more moves against any straightforward contrast between the healthful purity of the country and corrupting dirt of the city. Milton's '"unparliamentary" smoke' (59) is evidently 'most unpropitious to health' (68), but the soil underlying the suburb of Crampton, where the Hale's rent a home, is quite unlike Manchester's clay. It is more akin to the freely draining limestone Gaskell praised from Warwick in 1850, for as Thornton explains, 'Crampton is on gravelly soil, and by far the most healthy suburb in the neighbourhood of Milton' (64).

Thornton's words reflect the latest understanding of soils as sites of purification. Working from Manchester during the late 1840s and early 1850s, Angus Smith researched this topic for the BAAS.[138] His initial report on water purification was reprinted by the

[135] Terence Wright's argument as explained by Parkins, 'Women, mobility, and modernity', p. 508; Rosemarie Bodenheimer, '*North and South*: A Permanent State of Change', *Nineteenth-Century Fiction,* 34.3 (1979), pp. 281-301 (281).
[136] Parkins, 'Women, mobility, and modernity', p. 513; Mann, 'Intelligence and Self-Awareness', p. 34; Bodenheimer, 'A Permanent State of Change', p. 292.
[137] Uglow, *Elizabeth Gaskell,* p. 194. Read more favourably, however, this rift in representation might be said to speak to the metabolic rift between industrial and land-based economies examined in the novel.
[138] Although yet to be examined by scholars of literature and science, historians of science have considered Smith's work in three articles from the 1970s and 1980s. A. Gibson and W. V. Farrar (1974) are scathing of

Manchester Guardian in August 1849.[139] Smith explained how 'water may purify itself' by movement through 'a filter'. 'However true it be that all soil filters water', he noted, 'any admixture of clay is detrimental', with the 'purest waters' found to 'pass through great depths of sand or gravel'.[140] This was because, in passing through soil, water underwent a chemical process of purification. Smith understood 'porous soils' not only as mechanical filters, but as 'oxidising agent[s]' – sites where organic matter suspended in water underwent oxidisation, leaving humic acids and nitrates in the soil and releasing carbon dioxide to the air. As Liebig had explained, oxidisation was a process of decay; Smith's science thus distinguished between essentially good and bad forms of decomposition, pathological putrefaction being distinct from healthy decay:

> No doubt this is a very important provision of nature for the prevention of the evil consequences of putrefaction; it is the complete destruction of all dangerous gases and the perfect purification of the most impure substances; […] We see […] the two great agents of sanitary improvement at work for us, the air and water acting through the soil; whatever goes through such an ordeal is made pure.[141]

Smith's science offered a discourse of purity as providential process. For Smith, purification was evidence of God's hand in a system that 'works for us' by removing 'the evil consequences of putrefaction' through a quasi-sacramental 'ordeal'. 'The drainage of a country is therefore that which removes the evil effects of decomposition, as well as the excess of moisture', he wrote.[142] In simple terms, where movement in soil allowed for purifying decay, stagnation led to putrefaction and zymotic disease. Seen in this way, there

---

Smith's contribution to sanitary science, though Eville Gorham (1982) argues Smith should at least be considered important as the first to isolate acid rain and call for a 'chemical climatology' – a precursor to the atmospheric studies of today. A. Gibson and W. V. Farrar, 'Robert Angus Smith, F.R.S., and "Sanitary Science"', *Notes and Records of the Royal Society of London*, 28.2 (April 1974), pp. 241-62; Eville Gorham, 'Robert Angus Smith, F.R.S., and "Chemical Climatology"', *Notes and Records of the Royal Society of London*, 36.2 (April 1982), pp. 267-72. John Eyler (1980) also suggests that Smith's work remains highly significant and ought to be studied, primarily because it offers one of the first attempts to apply scientific method to environmental problems. John M. Eyler, 'The Conversion of Angus Smith: The Changing Role of Chemistry and Biology in Sanitary Science, 1850-1880', *Bulletin of the History of Medicine*, 54.2 (Summer 1980), pp. 216-34. Both Hamlin and Kargon reference Smith's work, Kargon labelling him the creator of the field of sanitary chemistry: Kargon, *Science in Victorian Manchester*, p. 123. Hamlin notes Smith's 'respected, if unique, station in the scientific community', as a scientist that actively stayed away from London, parliamentary committees, and law courts, favouring instead chemical research into the complex environmental problems of his time, such as air quality, sewage disposal, and water purity. Christopher Hamlin, *A Science of Impurity: Water Analysis in Nineteenth Century Britain* (Bristol: Adam Hilger, 1990), p. 247.

[139] Robert Angus Smith, 'On the Air and Water of Towns', in *Report of the Eighteenth Meeting of the British Association for the Advancement for Science, held at Swansea in August 1848* (London: John Murray, 1849), pp. 16-31 (30). For this text in the *Manchester Guardian* see: Robert Angus Smith, 'The Air of Towns', *Manchester Guardian*, 8 August 1849, p. 2; 'The Water of Towns', *Manchester Guardian*, 11 August 1849, p. 9.

[140] Smith, 'Air and Water of Towns', pp. 28, 24.

[141] Smith, 'Air and Water of Towns', p. 24.

[142] Smith, 'Air and Water of Towns', p. 24.

were healthy and pathological expressions of decomposition, a view that Gaskell came to examine, and ultimately share with Smith, in *North and South*.

A similar poetics of flow and stagnation can be discerned in Gaskell's novel. Helstone's 'stagnant ponds' (42) are associated with the 'stagnant habits of mind' (301) of those who live in the country. Thus Mr Hale believes that movement prevents mental stagnation; 'I must make myself busy', he says, 'to keep off morbid thoughts' (38). But as Hale succumbs 'to morbid regret' (268) following his wife's death, an 'uneventless and monotonous' (170) life in Helstone is shown to generate that 'morbid state of conscience' from which 'country clergymen', with their 'isolated lives' (380), are liable to suffer. In this respect, Hale and John Thornton are of 'distinctly opposite natures' (80). Thornton's remarks on Crampton's soil suggest 'he is a clear-headed fellow' (64), certainly prone to none of the 'mental and bodily languor' (47) that afflict the clergyman. Where stagnation defines both countryside and country people, the free flow of water through Crampton's 'gravelly soil' frames the movements of the industrial population: 'The side of the town on which Crampton lay was especially a thoroughfare for the factory people. In the back streets around them there were many mills, out of which poured streams of men and women two or three times a day' (71). Where fluid movement denotes healthy activity in Gaskell's novel, then, forms of stagnation become pathological.

Following a 'serene life' in Helstone (28) and a 'drifting' (50) and 'dreaming' (59) existence in London, Margaret Hale is soon swept up in the flows of Milton life. Living in Crampton, she finds herself 'constantly falling in with' the 'streams' (71) of factory labourers flowing through the neighbourhood. She is at first prejudiced against them, perceiving 'a slovenly looseness which struck [her] as different from the shabby, threadbare smartness of a similar class in London' (59). But within Milton's 'streams' of people she meets chronically 'unhealthy' Bessy Higgins and her 'careworn' (72) father, Nicholas. In this way, she gains 'a human interest' (74) in the industrial city: 'As she went along the crowded narrow streets, she felt how much of interest they had gained by the simple fact of her having learnt to care for a dweller in them' (99). Following Gaskell's programme in *Mary Barton*, as Margaret becomes part of Milton life, she acquires sympathy for the industrial poor via close contact with individuals of that class. But more than this, as she becomes part of Crampton's 'streams' of people, subject to fluid movement 'along the crowded narrow streets', her prejudices are filtered out via contact with Milton's populace. In contact with 'the poor' whom her Aunt Shaw will later be shocked to find are 'dirty' (363), Margaret is exposed to the metaphorical

'dirt' (98) of the industrial city, and thus subject to a process of purification ongoing in Crampton's gravelly soil.

If Milton is viewed as an actor-network, Margaret's small acts of kindness can also be seen to transform action around her. Giving Bessy flowers from 'the fields that lay around the town' (72) on their first meeting, for example, she establishes an initial connection between country and city. 'North and South has both met and made kind o' friends in this big smoky place' (73), Nicholas Higgins says approvingly, words that hint at Margaret's role in the wider narrative. As she gifts flowers to Bessy, Margaret brings 'the sweet profusion of the South' (72) to the impoverished factory workers of Milton. 'I might take her a little preserve, made of our dear Helstone fruit' (157), she later says, another moment of exchange that gestures towards *North and South*'s solution to metabolic rift, Margaret mediating fertile flows within a network stretching, but also stagnating, across country and city.

For as the industrial strike soon shows, even Milton's fluid movement is prone to stagnation. The usually busy factory workers here become 'unusual loiterers in the streets […] sauntering along' (131). They form an 'irregular stream of human beings, that flowed through Milton's streets', creating 'an unusual heaving among the mass of people in the crowded road' (171). Fluid movement has become pathological, generating an 'irregular' flow that begins to stagnate; '[the labourers] did not appear to be moving on, so much as talking, and listening, and buzzing with excitement, without much stirring from the spot where they might be' (171-72). As is the case in *Mary Barton*, the lived experience of this stagnation is 'clemming' (133);[143] 'In *North and South*', writes Mangham, 'the most intense periods of hunger are the result of strike action'.[144] Gaskell's poetics of flow thus trouble the novel's 'environmental dichotomies' that, as Burton rightly argues, 'fold into one another, change across the trajectory of the text, or break down completely'.[145] Where urban and rural environments are at once sites of both health and disease, so each suffers from 'poverty' and the ill-effects of stagnating systems.[146]

As in Helstone's ponds, the stagnation of Milton's populace leads to corruption – corruption that Margaret is in turn capable of relieving. The striking factory workers' lack of movement creates 'a thunderous atmosphere, morally as well as physically' (172), expressed once more in terms of pathological flow as the mob storms Thornton's mill: '[Margaret]

[143] For clemming in *North and South* see pp. 133-34, 154-56, 201, 220, 292-93, 305-07, 320, 324.
[144] Mangham, *Science of Starving*, p. 131.
[145] Burton, 'Forest Scenery', p. 44.
[146] Gallagher, *Industrial Reformation*, p. 178.

looked round and […] saw the slow-surging wave of the dark crowd come, with its threatening crest, tumble over, and retreat' (172). Her efforts to protect Thornton from violence see her hit on the head by a stone, flung by a member of the mob, the flow of blood from the resulting gash on her head serving to release the stagnation of the strike. The following passage gestures towards those relations between bodily fluids and the social body that Jules Law finds across mid-nineteenth-century fiction:[147]

> They were watching, open-eyed and open-mouthed, the thread of dark-red blood which wakened them up from the trance of passion. Those nearest the gate stole out ashamed; there was a movement through all the crowd – a retreating movement. (179)[148]

Following the flow of Margaret's 'tears' and 'the drip of blood from her wound' (180), movement is restored to the wider environment as the mob leaves Thornton's mill. When first serialised in *Household Words*, *North and South*'s mob scene followed a report on London's sewerage; 'The object of drainage is to carry off the refuse of a town', the article reported, 'Good drains are those which do carry it off, and which leave none of it to stagnate and putrefy'.[149] Where Gaskell 'refus[es] to keep [Margaret] "pure" and separate from the activities generally associated with […] the system', as Bodenheimer argues, so to read *North and South*'s industrial strike within its original print ecology is to understand a new relation between Margaret and the wider network in terms of drainage.[150] As the flow of her bodily fluids relieves a dangerous blockage in the social body, Margaret acts like a 'good drain', relieving corruption by helping to 'carr[y] off all the sewage matter at a steady pace, without leaving an atom […] to stagnate and rot'.[151]

Margaret thus occupies a mediating position between stagnation and movement in the wider environment. Gaskell's poetics of flow also chart Margaret's internal struggles, her 'muddled transition' from childhood to womanhood.[152] Recovering from her swoon

[147] Jules Law, *The Social Life of Fluids: Blood, Milk & Water in The Victorian Novel* (Ithaca, NY: Cornell University Press, 2010).
[148] This 'thread of dark-red blood', drawing connections between the individual and the social, foreshadows imagery that will be of central importance in chapter 4, where I examine George Eliot's imaginary of community connectedness via webs and threads in *Middlemarch*.
[149] Anon., 'Commission and Omission', *Household Words*, 18 November 1854, pp. 319-24 (320).
[150] Quoted in Parkins, 'Women, mobility, and modernity', p. 517. Bodenheimer also discusses Margaret's impurity in terms of contact with 'the male' and 'the public'. This speaks to the relations between public and private spheres in the novel that, though not the focus of my reading, have long occupied scholarly attention. For a detailed examination of this critical history see Ben Moore, 'Invisible Architecture and Social Space in *North and South*', *Gaskell Society Journal*, 32 (2018), pp. 17-36 (17-18). See also: Gallagher, *Industrial Reformation*, p. 149; Athmanathan, 'Hybrid Spaces', pp. 42-46.
[151] 'Commission and Omission', p. 324.
[152] Bodenheimer, 'A Permanent State of Change', p. 297.

following the mob scene, Margaret remembers 'insolent words spoken about herself' (185) by Thornton's sister while she was barely conscious – that she was 'bold and forward' (183) in putting her arms around Thornton before the mob. This gossip 'confronts her with forbidden knowledge', Matus writes, a consciousness of her own sexuality.[153] At the thought of 'disgracing [herself] in that way' (190), Margaret's 'cheeks suddenly became one flame of fire' and she cries 'scalding tears' (190) born of 'a deep sense of shame' (191). Where being rendered impure causes Margaret's bodily fluids to flow, then, a parallel may be drawn with Smith writing on purification in the *Guardian*: 'all the water which falls on the soil is filtered by passing through', he explained, 'that is to say, it first becomes exceedingly impure, being filled with matter from the surface, and gives a part of this out again in passing through the soil'.[154] In the same way, as Margaret is exposed to life in a 'dirty town' (82), and with it what Gallagher calls 'a morally complex world', her 'maiden pride' (191) is brought into question.[155] Having been rendered 'exceedingly impure', she is forced to confront the potentially corrupting influence of her repressed sexuality. While Margaret knows that she remains 'pure before god' (191), from here forward the narrative subjects her to an 'ordeal' akin to Smith's understanding of chemical purification.

As Smith explained in a follow-up BAAS paper, purification in soil served another purpose. While decomposing 'organic matter on the surface of the ground [is] bad for health', he wrote, it is also 'bad also for the soil, which loses its food for plants'.[156] This was because fertile nitrogen was lost to the atmosphere in the formation of ammonia. By creating the conditions for oxidising decay, 'motion through soil' purified water while fixing nitrogen so as to leave soluble nitrates in the soil on which plants could feed.[157] Without chemical decay, not only would water remain impure, but soils could not be fertile.

This understanding of purity and fertility as different expressions of a single process is essential to understanding how Gaskell negotiates Margaret's burgeoning sexuality, her growing love for Thornton, and ultimately the novel's reconciliation of metabolic rift. While images of bodily flow, such as blushing or crying, are familiar features of Victorian courtship plots, *North and South* uses one particular term that introduces resonances of purification as a form of decay. As Margaret rejects Thornton's proposal, she causes him an acute sense of

[153] Matus, '*Mary Barton* and *North and South*', p. 42.
[154] Smith, 'Air and Water of Towns', pp. 27-28.
[155] Gallagher, *Industrial Reformation*, p. 172.
[156] Robert Angus Smith, 'On the Air and Water of Towns. Action of Porous Strata, Water and Organic Matter', in *Report of the Twenty-First Meeting of the British Association for the Advancement for Science, held at Ipswich in July 1851* (London: John Murray, 1852), pp. 66-77 (68).
[157] Smith, 'Action of Porous Strata', p. 73.

'mortification', shown outwardly by 'washed tears in his eyes' (196). Mortification was a multivalent term in the mid-nineteenth century. The principal meaning referred to the religious act of 'mortifying the body', a 'bringing under control of one's appetites and passions'.[158] This sense of ritual purification relates to the more general sense of 'humiliation' caused by an 'awkward or embarrassing situation'.[159] And while archaic today, 'mortification' in the mid-nineteenth century also referred to the 'death of part of the body' from the onset of decay, a 'localized necrosis of tissue'.[160] Capturing ideas of purification together with decay, and in terms that relate directly to Margaret's shame at the bodily experience of growing sexual passion, the embedded metaphors of mortification are ideally suited to *North and South*'s conception, via Smith, of purification as process.

Thornton's proposal is of course not the first Margaret receives. Early in the novel, she rejects Henry Lennox, causing him a similar feeling of 'mortification' (32). Margaret in turn feels 'guilty and ashamed' (32) that her hitherto 'high maidenly dignity' (28) and 'pure serenity' (29) have been compromised by 'having grown so much into a woman as to be thought of in marriage' (32-33). With a dim sense that her purity has been brought into question, she soon experiences 'bitter mortification' (68) herself. Lennox's proposal marks the beginning of Margaret's sexual awakening, a process intensified by her actions before the mob. Where, as Matus explains, 'Margaret's knowledge and awareness of herself as sexually attractive is repeatedly denied [by Margaret herself]', so her consequent experience of mortification accompanies, what Athmanathan calls, the 'thematic of sexual taint that also attaches to Margaret when she attempts to save Thornton'.[161] Viewed in this light, Margaret's actions bring her into contact with 'dirt' (45, 98) that 'stain[s] her whiteness' (280). This is true in a literal sense, of course, as she becomes part of the flows of Milton life, but

[158] 'Mortification', in *The Oxford English Dictionary* [online], < https://www.oed.com/view/Entry/122481> [Accessed 11 May 2021].
[159] 'Mortification', *OED* [online].
[160] 'Mortification', *OED* [online]. Gaskell employed these multiple meanings to great effect in *Mr Harrison's Confessions*. Harrison's surgical ability is questioned following his decision not to amputate the arm of a patient, John Brouckner, because he believes the limb might be saved. Popular opinion believes his refusal stems instead from cowardice: 'Was there not such a thing as mortification coming on after a clumsy operation?' (64), a Dunstable resident asks. This leaves Harrison feeling 'mortified' (66). As the patient's arm is threatened by the onset of decay, repeated questioning of the doctor's ability leaves Harrison experiencing the metaphorical gnaw and bite of professional humiliation. These associations of mortification circulate together as Brouckner's wife implores the doctor to take off her husband's arm and 'spare him to me' (69): 'It was mortifying enough', Harrison relates, 'but I thought of the power which was in my hands, as I firmly believed, of saving the limb, and I was inflexible' (69). It is unclear whether Harrison refers to the 'mortifying' experience of having his expertise questioned, or that the arm has begun 'mortifying' enough to justify its removal. The ambiguity provides striking evidence of the dual connotations of mortification during the period, unstable meaning that Gaskell exploits in her writing.
[161] Matus, '*Mary Barton* and *North and South*', p. 42; Athmanathan, 'Hybrid Spaces', p. 46.

mortification registers this at the level of metaphor. The term captures the 'sexual taint' that Margaret is forced to confront as the novel progresses, an ordeal by which she finally reconciles her purity with a burgeoning, and of course fertile, sexuality.

Unlike in *Mary Barton*, where Mary and Esther correspond to 'good' and 'bad' versions of femininity, so as Uglow explains, Margaret 'combine[s] passionate sensuality and pure idealism'.[162] Mortification thus serves, I would propose, as a form of chemical purification that parallels the oxidisation of organic matter in soils, decay that allows for purity and fertility to exist together as one. This is surely the process Thornton refers to when, following Margaret's rejection, he tells her 'You look as though it tainted you to be loved by me. You cannot avoid it. Nay, I, if I would, cannot cleanse you from it' (196). As Margaret's sexual awakening is made 'the object of universal regard' before the mob, she experiences 'a sense of shame so acute that […] she would fain have burrowed her head into the earth' (192), a common turn of phrase that nevertheless gestures to the chemical poetics of her purification. Thornton's refusal to 'cleanse' speaks to a belief in the purifying potential of contact with dirt – knowledge that Thornton himself, following his remarks on soil, clearly adheres to. Where scholars have highlighted the 'centrality of Margaret's relationship with her environs' in other contexts, so it should not escape notice here that her desire to escape 'shame' in 'the earth' is articulated on a 'gravel' soil that, as Smith noted, gave the 'purest waters'.[163] As the filtering 'streams' flowing through Crampton purify Margaret of her prejudices against factory workers, so the oxidising analogue of mortification serves as an ordeal by which she confronts her deeper prejudice against the perceived 'taint' of her own sexuality.

This can be seen following the lie Margaret tells to protect her brother from the threat of court martial. Frederick Hale faces trial for his involvement in a mutiny aboard a Royal Navy vessel but returns to England to see his mother before she dies. As he sets off on the return journey to Cadiz, where he lives in exile, Margaret accompanies him to Outwood station – and is seen by Thornton with, what he takes to be, a love rival. Frederick is then recognised by Mr. Leonards, an old and disreputable acquaintance, who attempts to apprehend him. Frederick's train arrives just in time, but Leonards falls from the platform in the ensuing scuffle and later dies; questioned by the police, Margaret denies all knowledge in an effort to protect her brother. This lie intensifies Margaret's purification by ordeal, bringing

[162] Uglow, *Elizabeth Gaskell*, p. 372.
[163] Burton, 'Forest Scenery', p. 42.

her 'pure and exquisite maidenliness' (270) into question once more. Thornton, serving as magistrate on the inquest, realises her falsehood and stops the investigation to protect her from further 'shame' (280). Realising this, Margaret is confronted with 'the lurid fact that, in Mr. Thornton's eyes, she was degraded' (283). Yet, while Margaret believes she is 'degraded and abased in Mr. Thornton's sight' because of her 'faithless' (285, 397) falsehood, Thornton of course thinks she has lied to protect her lover. This lends her actions the deeper 'shame' (279) of sexual depravity: 'How could one so pure have stooped from her decorous and noble manner of bearing!' (270), Thornton exclaims. Margaret is made aware of how her actions have been construed in terms of sexual 'impropriety' and 'degrad[ation]' (316) by Thornton's mother. Only now, forced with renewed urgency to confront her sexuality, does she feel the sting of 'mortification' (324). She thus experiences the biting 'shame' (397) and 'morbid' (399) awareness of her sexual awakening seen for a second time, however unjustly, through the eyes of others. With her falsehood long acknowledged as 'formally parallel' to her actions before the mob, as she is once more rendered impure, the feeling of mortification again accompanies her sexual awakening.[164]

Relating Margaret's emotional state back to her environs exposes this relationship in terms of an oxidising decay. Before Margaret accepts Thornton's love, she returns to Helstone, where she comes to understand the agrarian south, not in the idealised terms of 'Tennyson's poems' (12) or 'German Idyls' (380) as before, but as subject to perpetual change:[165]

> There was change everywhere; slight, yet pervading all. Households were changed by absence, or death, or marriage, or the natural mutations brought by days and months and years, which carry us on imperceptibly from childhood to youth, and thence through manhood to age, where we drop like fruit, fully ripe, into the quiet mother earth. (394)

To be 'ripe' for death and to pass into the 'earth' is to serve as 'fruit' for future generations via a chemical process of decay explained by Smith. As Margaret sees that a fondly remembered 'decaying cottage' (388) has disappeared, she comes to understand the 'golden stillness of the land' (385) as an illusion. Stagnation, even in the countryside, is not the natural order of things; 'If the world stood still, it would […] become corrupt' (400), she realises. Margaret thus not only 'learns to accept the inevitability of change', as Uglow explains, but to distinguish between healthy decay and pathological putrefaction,

[164] Bodenheimer, 'A Permanent State of Change', p. 293.
[165] As Bodenheimer notes, this involves Margaret 'recognis[ing] the destitution and solitude of agricultural labour'. 'A Permanent State of Change', p. 284.

understanding the former as a necessary process 'pervading all' (395).[166] In the same way, as Mr. Bell tells her, 'the tainting blood of falsehood runs through us all' (395), 'taint' that only now does Margaret come to accept: 'And I too change perpetually – now this, now that – now disappointed and peevish because all is not exactly as I had pictured it, and now suddenly discovering that the reality is far more beautiful than I have ever imagined it' (401). She thus rejects any possibility that she might 'deaden [her] heart […] by becoming a nun', accepting instead an existence negotiating a world 'of earthly passion' (400). Only once Margaret accepts decay as part of the 'beautiful' 'reality' of the agricultural environment, then, can she acknowledge her hitherto mortifying sexuality as a fertile part of her womanhood.

Accordingly, it is finally 'beautiful shame' (436) that she feels on accepting Thornton's love at the end of the novel. Margaret's Aunt Shaw is, in this sense, correct that 'Milton has quite corrupted her' (330). While corrupting putrefaction is distinct from purifying decay, Margaret's purity is earned in contact with the world; she has 'pick[ed] up' and 'show[s] the dirt' (417), as her cousin Edith suggests towards the novel's end.

Thornton's love assails Margaret as 'some great power, repugnant to whole her previous life' (197), because it forces her to renounce purity as an inviolable state and engage with an understanding of purity by degrees. Margaret comes to understand that she is 'not pure *enough* to be indifferent to the lowered opinion of a fellow creature' (286; my emphasis). Where Margaret's purity is soiled by falsehood and public displays of affection, so being rendered as impure creates the conditions to negotiate the potentially corrupting influence of her own sexuality. She thus comes to accept her sexuality as a necessary part of her being, and therefore becomes pure and fertile, rather than pure in the more sterile sense of the word. This sterility is in fact embodied in 'the peculiar cleanliness' of the 'white and pure' Thornton household, devoid of 'dirt' (112) but also of feeling. As scholars have noted, it is sympathy as well as capital that Margaret brings to her marriage, a point I will address in my next section. Margaret should not be seen as a passive intermediary to purify and pollute, but an active mediator in the Latourian sense, transforming action through the wider network.

Viewed in chemical terms, Margaret is oxidised. In one of his Manchester 'Lectures on Chemistry', Playfair described nitrogen as 'the bachelor of organic elements, from its repugnance to a union with others', a memorable phrase quoted by the *Guardian*. As I explain in chapters 3 and 4, chemical combinations were often described as marital unions in

[166] Uglow, *Elizabeth Gaskell*, p. 385.

nineteenth-century chemistry; important here is that nitrogen (N) remains unobtainable to plants before being converted to nitrates (NO_3). Oxidisation makes nitrogen soluble in water and thus part of a fertile and fecund nature. In the same way, as Margaret overcomes her initial 'repugnance to the idea of a manufacturing town' (59), along with her later 'repugnan[ce]' (197) towards Thornton and her own sexual passion, marital union converts the unobtainable nitrogen of her repressed sexuality into the fertile nitrates formed by oxidising decay.

Margaret's fertility is thus fixed in marriage. For Lesa Scholl, writing outside of this chemical context, their union offers a 'procreative marriage of the North to the South'; as Burton notes, Margaret and her environs are 'intermeshed' in the trans-corporeal sense.[167] Read in terms of soil, then, *North and South* examines the position of the individual within larger nutrient cycles. The movement of Margaret's bodily fluids captures, what Law calls, speaking of nineteenth-century fiction more generally, 'the dissolution of the individual body in the social body'.[168] At the same time, at the level of metaphor, Margaret's oxidisation by mortification embodies the soil fertility of the agrarian south made accessible to the 'clemming' industrial north. Margaret's relationship to her environs is both direct and analogical, then. Through her, *North and South* imagines a reciprocal flow across agricultural and urban environments, reuniting the soils of the countryside with the soils produced by the inhabitants of the industrial city.

As I come to below, these poetics find their more prosaic expression in Thornton's factory dinner scheme. Beforehand, I would note that a similar imaginary of fertile flow can be seen in Angus Smith's proposed solution to metabolic rift. While *North and South* was being serialised in *Household Words*, Smith was arguing that water could transport sewage from cities to surrounding agricultural land. When applied to farmland, sewage water 'will then filter through the ground and naturally will take the course of the drainage water', he wrote in 'On Sewage and Sewage Rivers', thus 'adding to the amount of pure water in the river'.[169] The productivity of agricultural land, Smith suggested, might increase 'tenfold' under this system: 'such fertility of soil would certainly allow us to build upon farm works of

[167] Scholl, 'Moving Between *North and South*', p. 104; Burton, 'Forest Scenery', p. 50. Margaret is thus 'intermeshed' with her environment and part of, what Alaimo terms, 'the often unpredictable and unwanted actions of human bodies, non-human creatures, ecological systems, chemical agents, and other actors'. Alaimo, 'Trans-Corporeal Feminisms', p. 238.
[168] Law, *Social Life of Fluids*, p. 19.
[169] Robert Angus Smith, 'On Sewage and Sewage Rivers', *Memoirs of the Literary and Philosophical Society of Manchester*, ser. 2, 12 (1855), pp. 155-75 (171).

such a kind that health and appearance might also be consulted as well as profit'.[170] Smith envisaged fertile networks flowing between city and country to satisfy economic, agricultural, sanitary, even aesthetic needs. I have found no evidence to suggest that he drew inspiration directly from *North and South* while working on this scheme, though the suggestion is plausible. Yet efforts to trace direct influence are perhaps beside the point here. As with the understanding of low fever, the chemical poetics of flow served as a shared discourse by which Gaskell and Smith built related solutions to metabolic rift within Manchester's ecology of literature and science.

Once again there is both agreement and divergence in conceptual engagement here. For where Smith's proposal heals metabolic rift by re-establishing regional networks of nutrient exchange, Gaskell's solution implies more far-reaching networks of food production and soil fertility, as I now explain.

Sympathy by Extraction

As regards Manchester's ecology of literature and science, Smith was central in transforming purity from a fixed state to a providential process. As an 'ordeal' to be endured, however, this creates a quasi-sacramental idea of purity, seen in Margaret and Thornton's courtship; both suffer hugely as pure and impure, stagnant and in motion, as prone to pathological putrefaction yet also healthy decay. As Margaret gives up purity in order to be purified in contact with the dirt of the city, then, there is a parallel to be drawn with the reader connecting with figures in Gaskell's fiction that they would normally be kept apart from. The logic of Liebig's pathology engendered those feelings of 'repugnance' towards the industrial poor that Margaret initially admits to at 'the idea of a manufacturing town' (59). *North and South* counters this conception; as Margaret establishes flows of nutrient exchange between agrarian south and industrial north, her union with Thornton furthers a fertile model of cross-class sympathy by preserving his factory dinner scheme. Margaret thus moves class relations towards love and care, creating relationships that are embedded in environments and communities. Yet these relationships are at the same time embedded within an extractive and globalised agricultural economy. This section argues that Gaskell's sympathy at home determines and is determined by extraction abroad.

The chemical poetics of *North and South*'s courtship plot act on Thornton's transition from master to sympathetic 'steward' (361). As Margaret identifies following one of their

[170] Smith, 'Sewage Rivers', p. 162.

first conversations, 'the poor men around him [… are] out of the pale of his sympathies' (87-88). Her influence, however, slowly changes his 'unfeeling' (166) nature.[171] On their first meeting, as Thornton 'look[s] upon her with an admiration he could not repress', her 'indifference' leads to his 'mortified feeling' (63). This 'mortification' (196) intensifies and spreads as Margaret rejects his proposal. Thornton's mother also experiences 'mortification' (186) as a result of being forced to break from her 'usual mode of talk – about facts, not opinions, far less feelings' (211) – to show 'maternal feeling' (189) towards her heartbroken son. Where Margaret introduces strong feeling to the familial relations of the Thornton household, Thornton in time learns to give sympathy himself. As he expresses his condolences to Margaret's father following Mrs Hale's death, 'his face, his eyes, his look, told of more sympathy that could be put into words' (271). Sympathetic contact in the domestic sphere foretells the 'sympathy' (421) that later grows in the workplace, Thornton's 'dinner scheme' (363) allowing for 'intercourse' that 'enable[s] both master and man to look upon each other with far more charity and sympathy' (420).[172] As in *Mary Barton*, sympathy stems from bringing 'individuals of the different classes into actual personal contact' (432).

Gaskell's chemical imaginary here offers an unacknowledged aspect of Thornton's lunch 'experiment' (363), long recognised by scholars as *North and South*'s programme for cross-class sympathy.[173] As Thornton, like Margaret, experiences romantic love for the first time, his passions are charted via imagery of movement and stagnation: 'He swept off his business right and left that day. It seemed as if his deep mortification of yesterday, and the stunned purposeless course of the hours afterwards, had cleared away all the mists from his intellect' (212). Purposeful activity soon turns again to mental stagnation, however – 'he gave way all at once; he was so languid that he could not control his thoughts; they would wander to her' (213). In these passages, Thornton undergoes the same kind of chemical transition as Margaret; movement and stagnation signify the action of mortification as distinct from a mental mist or miasma, a form of putrefaction clouding the intellect. Thornton must learn to

[171] An argument might be made here, akin to the removal of Margaret's prejudices against the industrial poor, that close contact with Thornton purifies her of her prejudices against 'shoppy people' – those who have 'made their fortunes in trade' (19). As Gallagher argues, 'Margaret must unlearn the prefabricated association between trade and vulgarity before she can properly perceive Thornton for what he is'. *Industrial Reformation*, p. 182.
[172] The giving and sharing of food charts Thornton negotiating private and public acts of sympathy. What he understands as a 'personal act' of love before the mob is, Margaret corrects him, an act of 'sympathy' (195) towards the men soon to be at the mercy of soldiers. With their courtship long seen to negotiate public and private concerns, this confusion perhaps speaks not only to Thornton's development of sympathy, but to how Thornton and Margaret's marriage serves at once as the union of two bodies and the healing of a rift in the social body.
[173] Starr, 'Industry of Fiction', p. 387.

negotiate his emotions in contact with Margaret, then, for like her he cannot shut himself off from the corrupting influences of 'earthly passion': 'He thought that he disliked seeing one who had mortified himself so keenly; but he was mistaken. It was a stinging pleasure to be in the room with her, and feel her presence' (239). Contact with Margaret thus allows Thornton to 'feel' the bitter sting of nevertheless purifying 'mortification', purifying because it gradually qualifies what Gallagher calls the 'extreme individualism' characteristic of his liberal economics.[174]

North and South's courtship plot generates fertile relationships by exposing Thornton to the purifying decay of mortification. In this way, Margaret directs him towards social involvement, expressed in the giving and sharing of food.[175] Mid-way through the novel, Thornton takes great care selecting 'grapes with the most delicate bloom' and 'the richest-coloured peaches' (214) as a gift for Mrs Hale, showing his growing feeling for others. Higgins later follows Margaret's advice and asks Thornton for work, leading Thornton to visit Higgins at home where he finds 'such a miserable black frizzle of a dinner' that he realises 'how, by buying things wholesale, and cooking a good quantity of provisions together, much money might be saved and much comfort gained' (361). This leads to the creation of the factory 'dining room' (361). To quote Maclure, 'the experience of close physical contact with the embodied sufferer arouses an immediate and instinctive sympathy that leads the sympathizer to provide care'.[176] Margaret's hand in 'the accident (or so it seemed) of his acquaintance with Higgins' (419) generates 'close contact' that allows the master 'to *feel* in his position as a manufacturer' (420; my emphasis). 'Significantly', writes Matus, 'only after the torment of love has opened Thornton up to his capacity to feel strongly is he capable of responding to Higgins'.[177] Situating Matus's and Maclure's readings within the novel's chemical imaginary, mortification exposes Thornton to a painful yet purifying ordeal by which the compass of his sympathies expands to the workers under his command. Akin to *Jane Eyre*'s qualification of empiricism in terms of felt experience, love and care qualify the hard 'science of trade' (226) to which Thornton adheres on first meeting Margaret. In his position as 'steward' (361) of the dinner scheme, Thornton becomes a model of social responsibility.

[174] Gallagher, *Industrial Reformation*, p. 177.
[175] Mann, 'Intelligence and Self-Awareness', p. 34.
[176] Maclure, 'Diagnosing Capitalism', p. 346; see also Bodenheimer, 'A Permanent State of Change', p. 292.
[177] Matus, '*Mary Barton* and *North and South*', p. 40.

The question remains, however, to what extent this scheme, as a solution to metabolic rift, serves as a model of environmental stewardship? As Wendy Parkins notes, 'movement in the novel is not unidirectional', and a reading could be advanced here that, by linking Thornton's movements to his environs, suggests the restoration of a regional nutrient cycle between city and country.[178] Following Margaret's rejection, Thornton takes an omnibus into the countryside surrounding Milton. Arriving at 'a small country town […] He went into the fields, walking briskly, because the sharp motion relieved his mind' (208). Rural fields here become sites of action and resolution rather than stagnation, 'sharp motion' helping Thornton gain the 'vivid conviction […] that [Margaret] should never hinder him from loving her' (208). Exposure to the agricultural environment sees Thornton commit to the purifying decay of mortification, movement from the city to the country thus serving a similar purpose as Margaret's return trip to Helstone. Read in terms of nutrient exchange, Thornton visits a rural 'market-place' (208) and is brought into contact with a local food network, the site where his 'family butcher' may later source the 'meat' for the 'hot-pot' (362) over which he sympathises with his workers. Viewed in this way, as mortification leads to sympathy, the dinner scheme returns local but inaccessible nutrients to the clemming industrial poor, reconciling metabolic rift.

But this reading ignores both the detail and wider context of Thornton's dinner scheme. Gaskell's industrial fiction is generally seen to resist programmatic economic solutions for the problems afflicting the poor.[179] I agree with Mangham that discussions of political economy in her novels are 'not intended to excuse ignorance, but to suggest that the subject which is immediately apparent – starving children and other physical signifiers of distress – is more important to the discussion than abstract principles'.[180] Hence Thornton's dislike of 'theory' and preference for viewing his 'dinner-scheme' as an 'experiment' (363). But what Bodenheimer calls 'an acceptance of the liberal principles of economy' at the same time continue to structure Thornton's dining room, which feeds the industrial poor by sourcing 'great stocks from Liverpool' (362).[181] As *Mary Barton* details, such goods are the spoils of an empire and laissez-faire capitalism embodied in the thriving 'Liverpool Exchange' (280) and 'glorious' Mersey river:

[178] Parkins, 'Women, mobility, and modernity', p. 508.
[179] As Hewitt notes, Gaskell is 'severe on the reduction of individuals to economic positions'. *Making Social Knowledge*, p. 58. Mangham highlights Gaskell's 'antipathy towards proselytizing on the basis of […] economic theory'. *Science of Starving*, p. 109.
[180] Mangham, *Science of Starving*, p. 110.
[181] Bodenheimer, 'A Permanent State of Change', p. 290.

> Mary […] saw down an opening made in the forest of masts belonging to the vessels in dock, the glorious river, along which white-sailed ships were gliding with the ensigns of all nations, not 'braving the battle', but telling of the distant lands, spicy or frozen, that sent to that mighty mart their comforts or their luxuries. (281)

As vessels sail to and from North America loaded with 'carcases not cut up, looking like corpses of sheep and pigs rather than like mutton and pork' (286), the implication is that Thornton's family butcher gets his meat, not from the local market, but from the other side of the world.

This is not to say that domestically grown food was suddenly overtaken by foreign imports in the mid-nineteenth century. *North and South* gestures to the domestic context as Thornton shows pleasure at 'a fine day, […] good for the harvest, I hope. If the wheat is well got in, we shall have a brisk trade next year' (213). A successful harvest meant lower grain prices, cheaper staple foods, and more money to purchase garments turned out in Thornton's mill. But if 'fresh eggs' and 'Cumberland ham' (15) point to local food systems and at the same time prohibitively expensive produce early in *Mary Barton*, moving from the late 1830s to the mid-1850s shows free trade opening the possibilities available to Thornton's dinner scheme. As Thornton gets his 'great stocks from Liverpool', *North and South* registers the repeal of the Corn Laws. (This is an important context for what Litvack understands as Gaskell's 'tacit complicity with the imperial project'.)[182] From 1846 Robert Peel began lifting protectionist measures maintaining a high price for grain. Answering Job Legh's call 'to set trade free' (86) in *Mary Barton*, this made staple foods available at cheaper prices, celebrated by the industrial poor, but much lamented by British farmers, who feared being driven out of business through the mass importation of American grains.

This was part of the context for James Finlay Weir Johnston's trip to North America, mentioned in chapter 1. Johnston was himself sanguine on the threat American farmers posed to British agriculture, claiming 'the expense of transport' from 'virgin soils' in the west to eastern ports like New York and Philadelphia gave American farmers little if any market advantage.[183] The *Blackwood's* reviewer of his *Notes on North America* was not convinced: 'so trifling is the original cost of production, that immense quantities of corn do annually reach the eastern sea-board […], a considerable portion of which is re-shipped to Liverpool,

[182] Litvack, 'Outposts of Empire', pp. 757-58.
[183] Anon., 'Johnston's *Notes on North America*', *Blackwood's Edinburgh Magazine*, December 1851, pp. 699-718 (700)

and sold there at prices greatly below its cost of production in this country'.[184] Production costs were perishingly low because North American farmers benefitted from a seemingly unending supply of fertile soil: 'having extracted from it all that its spontaneous fertility will yield, he sells his possession for what it may bring, and moves off westward to repeat the same exhaustive process on a fresh portion of the forest', Johnston reported.[185] As free trade opened cheaper food for the poor, then, laissez-faire economics simultaneously opened distant soils for production.

Reading *North and South* alongside *Mary Barton* shows this process in action. As Mr. Bell describes 'the very piles of warehouses that are built upon my father's orchards' (381), the 'ruddy American apples' (79) on display in the Hale household are now grown on another continent. Rather than showing a schism between land-based and industrial economies, as Darkshire orchards become Milton factories, *North and South* points to relations between country and city being rebuilt on a global scale. This complicates Parkins reading of the novel as a 'transition between traditional and modern forms of society represented by rural and urban', gesturing instead to a process captured by Raymond Williams: 'Much of the real history of city and country, within England itself, is from an early date a history of the extension of a dominant model of capitalist development to include other regions of the world'.[186] This is evident in *Mary Barton*, as Gaskell's narrator describes Jem and Mary's emigration to Canada:

> I see a long low wooden house, with room enough to spare. The old primeval trees are felled and gone for many a mile around; one alone remains to overshadow the gable-end of the cottage. There is a garden around the dwelling, and far beyond that stretches an orchard. (378)

Here are Darkshire's orchards, then, the site of food production moved to North America. Where 'primeval trees are felled and gone' to allow the industrial poor to emigrate to Canada at the end of *Mary Barton,* and as Thornton gets his staple food stuffs from Liverpool for his dinner scheme at the end of *North and South,* both novels rely on a transatlantic extraction of soil fertility for narrative closure. Gaskell's solution to metabolic rift is thus formed within an economic model that makes sympathy at home and extraction abroad interdependent. 'Thus

[184] 'Johnston's *Notes*', p. 702.
[185] 'Johnston's *Notes*', p. 700.
[186] Parkins, 'Women, mobility, and modernity', p. 516; Raymond Williams, *The Country and the City* (1973; London: Vintage, 2016), p. 402.

one of the last models of "city and country"', writes Williams, 'is the system we now know as imperialism'.[187]

The cotton for Manchester's mills came almost exclusively from the American South, meaning Gaskell's industrial fiction is in fact structured upon this model of imperial extraction.[188] Plantation slavery, the genocide of indigenous peoples, and North America's extraordinary soil fertility combine beyond the margins of her novels to impact everyday life in the industrial city. For Elaine Freedgood, *Mary Barton*'s calico curtains thus introduce to the novel 'significant historical threads of the uneven development which characterized (and characterizes) a global economy'.[189] This has been captured recently by Sukanya Banerjee, whose reading of 'ecologies of cotton' in the nineteenth century places the novel's mills alongside the cultivation of soil and cotton in India and North America.[190]

A similar focus occupies Julia Sun-Joo Lee's transatlantic reading of cotton in *North and South*. 'England is reimagined as part of a global community that links Lancashire to the American South', she explains.[191] Tensions between northern and southern England can thus only be reconciled, as her reading brilliantly draws out, if slavery continues in the United States and the American North and South remain divided.[192] National harmony can only be achieved, then, at the expense of conflict elsewhere.

Gaskell's conception of sympathy in Milton's cotton mills ultimately depends on the success of free markets. '[T]he Americans are getting their yarns so into the general market', Thornton explains, 'that our only chance is producing them at a lower rate' (144). Following a 'great rise in the price of cotton' (352) and the failure of 'a house in the American trade' (423), Thornton's factory dinner scheme is thus threatened by fluctuations in the cultivation and manufacture of cotton in America.[193] In this way, as liberalism shapes *North and South*'s food systems, free-market economics also structures the novel's cotton trade, generating the wealth Margaret will inherit from Mr. Bell. Standing at 'two thousand pounds, and the

[187] Williams, *The Country and the City*, p. 402.
[188] Sukanya Banerjee, 'Ecologies of cotton', *Nineteenth-Century Contexts*, 42.5 (2020), pp. 493-507 (495); see also Mangham, *Science of Starving*, pp. 139-40.
[189] Elaine Freedgood, *The Ideas in Things: Fugitive Meaning in the Victorian Novel* (Chicago: University of Chicago Press, 2006), p. 57.
[190] Banerjee, 'Ecologies of cotton', p. 494.
[191] Julia Sun-Joo Lee, *The American Slave Narrative and the Victorian Novel* (Oxford: Oxford University Press, 2010), p. 106.
[192] Sun-Joo Lee, *American Slave Narrative*, pp. 110-11.
[193] See especially pp. 418-23. For other passages of the novel making reference to the cotton trade see pp. 59, 82-83, 111, 117-24, 144-45, 163-64, 229-30, 302-03, 318, 352. As Liam Corley writes of *Mary Barton*, then, *North and South* also depends on 'foreign trade for both raw materials and markets'. Liam Corley, 'The Imperial Addiction of *Mary Barton*', *Gaskell Society Journal*, 17 (2003), pp. 1-11 (2).

remainder about forty thousand, at the present value of property in Milton' (413), this wealth stems from cotton, through which 'much additional value was yearly accruing to the lands and tenements which she owned in that prosperous and increasing town' (416). Scholars often view this wealth as representing 'the old landed order' – Uglow writing that Margaret 'us[es] the legacy of "old money" […] to save Marlborough Mill and ensure that Thornton's "experiments" will continue'.[194] This is incorrect. *North and South*'s conception of cross-class sympathy is in fact financed by the exploitation of indentured labour and the extraction of soil fertility on another continent.

While agreeing with much in Jennifer Maclure's reading of Gaskell's sympathy, then, I disagree that 'the transfer of money at the conclusion of the novel is a model of the kind of investment that would support an alternative, health-based version of capitalism'.[195] If this looks like 'capitalist investment as public health and community-building project', it is because Maclure, like Gaskell, focuses on 'restor[ing] the natural flow of sympathy through the social body' while forgetting the flow of nutrients and other raw materials to and from other continents.[196] The implication is clear – within a free-market economy, helping disadvantaged populations in the industrial city harms disadvantaged populations in more distant lands.

A pattern begins to appear here, seen before with St. John Rivers in *Jane Eyre* and to be seen again in *Bleak House*, *Our Mutual Friend* and *Middlemarch*. To 'pioneer a little at home', as Hale suggests Thornton might to improve his 'rough, heathenish […] Milton men' (123), is inevitably to pioneer abroad. Hale's remark is prompted by Thornton's boast that the 'wide commercial character' of Milton's manufacturers 'makes us into the great pioneers of civilisation' (123). As Thornton reasons on 'sound economical principles' (152) – or an 'inflexible Malthusianism', as Mangham puts it – disadvantaged populations on other continents share 'the fate […] of the workmen, who were passed by in the swift merciless improvement or alteration; who would fain lie down and quietly die out of the world that needed them not' (152).[197] As Patrick Brantlinger shows in *Dark Vanishings*, and as Bertha Mason's fall from the roof of Thornfield Hall charts in *Jane Eyre*, the counterpoint to improvement is extinction.[198]

[194] Uglow, *Elizabeth Gaskell*, pp. 170-01.
[195] Maclure, 'Diagnosing Capitalism', p. 150.
[196] Maclure, 'Diagnosing Capitalism', p. 351.
[197] Mangham, *Science of Starving*, p. 110.
[198] Patrick Brantlinger, *Dark Vanishings: Discourse on the Extinction of Primitive Races, 1800-1930* (Ithaca, NY: Cornell University Press, 2003).

North and South exposes the effects of extinction logic turned inward on the British poor. When Higgins identifies field labourers as 'welly clemmed to death' (133), and when Bessy dies, having been left 'in a waste' (73) by the cotton 'fluff' (102) in her lungs, and of course when Boucher commits suicide, 'his skin stained by the water in the brook, which had been used for dyeing purposes' (294), the novel registers the distributed effects of the improvement ethos at work across city and country. 'Farmer Dobson and the poor people on Bracy Common' (37) are as much on the wrong side of capitalism's uneven development as the industrial poor, eking an existence on marginal land deemed not worth enclosing for a domestic agrarian capitalism. But there is always the danger that this failure to improve is seen as a personal rather than systemic failing – 'those who have lived [in the country] all their lives are used to soaking in the stagnant waters' (306), Margaret explains.[199] This liberal focus on the individual also has the effect of hiding how British capitalism acts far beyond British shores: '[F]rom at least the mid nineteenth century', writes Williams, 'there was also this wider context within which every idea and every image was consciously and unconsciously affected'.[200] So as Bessy chokes on cotton cultivated on American soil, as Boucher drowns in a brook rendered poisonous by its manufacture, and as 'poor' British farmers struggle on the margins of a global food system, *North and South* renders just the visible effects of exploitation, expanding far beyond the novel's margins even as it rebounds inward on the British poor.

Exploitation in the colonies would be entirely hidden in *North and South*, but for the novel's Irish population. Thornton's 'imported hands from Ireland' (173) are the cause of much anger from Milton's industrial workers, anger which is expressed in mob 'violence' (165, 178). One of the ringleaders is Boucher, a man who has 'Irish blood' himself and whose large family conforms to the stereotype of 'Irish hordes' (173) seen arriving in England 'to steal work, food, and wages', as Susanne Cammack explains.[201] Thornton can of course only 'import' (175, 209, 318) Irish people like produce because of the terrible famine

[199] A similar argument might be made for Esther in *Mary Barton*, 'sunk so low' (160) having had aspirations 'above [her] far' in social standing (156). It is not contact with soil that leads Esther astray, in other words, but forgetting her place in the social scale. Liberalism may thus promote the dream of individual improvement, but here within a strictly moralistic and inhibiting economic structure.
[200] Williams, *The Country and the City*, p. 404.
[201] For a thorough examination of Boucher's ambivalent position, at once resident mob leader and imported cause of mob aggression, see Susanne S. Cammack, '"You Have Made Him What He Is": Irish Laborers and the Preston Strike in Elizabeth Gaskell's *North and South*', *New Hibernia Review*, 20.4 (Winter 2016), pp. 113-27 (115).

and death caused by the British.[202] Boucher's death thus gestures towards the treatment of all those indigenous peoples suffering at the hands of British imperialism beyond the novel's margins:

> Th' Union's the plough, making ready the land for harvest-time. Such as Boucher –'twould be settin' him up too much to liken him to a daisy' he's liker a weed lounging over the ground – mun just make up their mind to be put out o' the way. (293)

Boucher stands in the way of progress and is the necessary casualty of development, as a weed in the farmer's field is the necessary casualty of crop production. Like the indigenous peoples present by an obvious depopulated absence, 'felled and gone' with the aboriginal forest at the end of *Mary Barton*, the Irish 'mun just make up their mind to be put out o' the way'. That these words belong to Higgins and are expressed in relation to the industrial labourer's union only serves to expose the contradictions of improvement more starkly. While Higgins's position will later soften as he cares for Boucher's children, (an express reversal of the Malthusian logic that would see them perish with their father), his analogy nevertheless captures the counterpoint of the improvement ethos in its horrifying reality. Extinction awaits for those deemed beyond improving cultivation.

North and South's conception of cross-class sympathy is thus ambivalent. Like the marriage that concludes *Jane Eyre*, Margaret and Thornton's union imports wealth and exports improvement. In seeking to resist extinction at home by feeding the industrial poor, their work is caught within and shaped by the counterpoint of improvement abroad. This is perhaps unsurprising given both, like Jane Eyre, are themselves constituted through the improvement ethos. Margaret has educational opportunities to 'improve [her] mind' (12) and attains an enviable 'standard of cultivation' (18). As for Thornton, he is 'caught young, and acclimatised to the life of the mill', a practical education 'unsparingly cutting away all off-shoots in the direction of literature or high mental cultivation, in hopes of throwing the whole strength and vigour of the plant into commerce' (68). He is also an improved specimen, then, in a different register to Margaret perhaps, but not unlike the 'improvement of machinery […] seen […] in its highest perfection' (98) in his mill. While his dinner scheme aims at effecting some 'improvement of feeling' (420) between the classes, 'cultivating some intercourse with the hands beyond the mere "cash nexus"' (431), the exploitation of liberal economics remains implicit within *North and South*'s solution to metabolic rift. The twin

[202] Cammack, 'Irish Laborers', p. 116. See Brantlinger's chapter on 'The Irish Famine' for the British involvement in the famine. *Dark Vanishings*, pp. 94-116.

forces of British colonialism and capitalism, the improvement ethos and the 'cash nexus', finance sympathetic contact at home by extraction abroad.

Conclusion: Industrial Fiction as Open System

Gaskell's solution to industrial poverty does not eliminate metabolic rift, then, but exports it beyond British shores, inflicting it on those considered beyond improvement. As Mike Davis writes of the second half of the nineteenth century, it is no coincidence that 'in the very half-century when peacetime famine permanently disappeared from Western Europe, it increased so demonstrably throughout much of the colonial world'.[203] *Mary Barton* and *North and South* suggest the beginnings of this process. With 'no role to play in God's narrative of progress', indigenous peoples across the world were remade as, what Brantlinger calls, 'surplus or refuse population needing to be swept away to make room for a tidier, more English world'.[204] Thus, in Gaskell's industrial fiction, sympathy at home is facilitated by land clearance, soil cultivation, and the exploitation of indigenous, transported, and ultimately expendable labour abroad. Critics have long seen a discord between *Mary Barton*'s realist mode and 'pastoral' ending, but the improvement that structures the scene in Canada is in this way entirely consistent with Gaskell's aims to improve the industrial city.[205] With 'old primeval trees' replaced by 'an orchard', the indigenous ecology is swept away for a quintessentially English nature. Cultivation becomes the expression of British imperialism acting at home and abroad, both on and beyond the human, constituting diverse locations and peoples as so many natures to either improve or eradicate.

This slow eradication of social and ecological diversity can be seen taking other forms in Gaskell's fiction. Alice Wilson's knowledge of the countryside in *Mary Barton* is at odds with Job Legh's 'botanising' (47), for example. His 'moss-hunting' (44) classifies the 'mosses of different colours' (33) that Alice fondly remembers from her childhood along with the 'wild herbs' she collects 'for drinks and medicine' (16), by implication replacing what Amy King describes as 'an older tradition of the village herbalist or wisewoman' with a

[203] Mike Davis, *Late Victorian Holocausts: El Niño Famines and the Making of the Third World* (London: Verso, 2001), pp. 8-9.
[204] Brantlinger, *Dark Vanishings*, p. 114.
[205] Fariha Shaikh, 'Temporally out of Sync: Migration as Fiction and Philanthropy in Gaskell's Life and Work', in *Place and Progress in the Works of Elizabeth Gaskell*, ed. by Lesa Scholl and Emily Morris (London: Routledge, 2015), pp. 83-93 (84, 87). Shaikh suggests that this 'emigration scene is displaced from the realist field of narration' and offers a good critical history of this reading, arguing that 'Gaskell's use of the pastoral looks forward to a better future even as it refers to an idealized pre-industrialized past'. 'Migration as Fiction', p. 86.

globalising taxonomy.[206] Job's promised visit to Canada at the novel's conclusion, examined by Liam Corley, symbolises the introduction of 'taxonomic control' and 'the power of rational projection' to North America's 'primeval forest'.[207] Manchester's ecology of literature and science extends far beyond the industrial city, then, also offering universalising knowledge in the context of agriculture. Playfair was offered a position as Professor of Chemistry at the University of Toronto, Johnston was invited to New York to help 'found an Agricultural College', and *Mary Barton* ends with Jem Wilson taking up a position 'as instrument maker to the Agricultural College at Toronto' (362). Rather than 'suggest[ing] that Canada has the potential to move forward into an industrial age that will not mimic Manchester', as Fariha Shaikh suggests, the presence of improved agriculture in the colonies is the necessary counterpoint to the sanitary improvement of soils and people in the industrial city.[208]

Witnessed here is the world-building power of chemistry, opening soils for imperial exploitation, a process in which both Liebig's chemical pathology and agriculture remain central.[209] By reducing vital agencies such as fermentation and decay from biological to chemical processes, his chemistry remade soils as inorganic spaces receptive to improvement. Social, epistemic, and ecological diversity thus all make way for increased production. As I will draw out more fully in my chapter 3, Liebig's science offered universalising knowledge by which to incorporate the world's soil fertility into a burgeoning global economy.

Gaskell's industrial fiction thus acts alongside and facilitates the expansion of chemistry in its applications to soils. But like Brontë, she also reveals some of the violence inherent in this process. Though supporting colonial expansion through agricultural improvement, her industrial fiction also challenges the conception of life made expendable to the dictates of increased production. As Maclure argues in a domestic context, *Mary Barton* and *North and South* counter a laissez-faire capitalism underwritten by laissez mourir.[210] Eruptions of physical 'violence' in both novels might be approached as the visible expression

[206] King, 'Taxonomical Cures', p. 257. King complicates my reading here, understanding Alice's and Job's knowledges in terms of combination rather than replacement. 'Taxonomical Cures', p. 261.
[207] Corley, 'Imperial Addiction', p. 3.
[208] Shaikh, 'Migration as Fiction', p. 86.
[209] More work remains to be done on the applications of Liebig's organic chemistry to pathology and agriculture in colonial contexts. While not making reference to Liebig, Alan Bewell has shown how European medicine was critical of ecologies and environments that were seen, in various ways, to be non-European. Supporting agricultural clearance and improvement, Western ideas of sanitation were the primary weapons European colonisers used to create healthy settlements abroad: Alan Bewell, *Romanticisim and Colonial Disease*, p. 39. Mid-nineteenth-century pathology thus bound human bodies and soils together far beyond the industrial city, suggesting Liebig's theory of zymotic disease had an impact on colonial lands and peoples.
[210] Maclure, 'Diagnosing Capitalism', p. 344.

of slow violence continuing against those disadvantaged populations within England whose labour, removal, and destruction is the subject of Gaskell's fiction. This is the case as the mob attacks Thornton's mill and when John Barton, 'mad with seeing such as he was slighted' (373), murders Harry Carson. But this inter-class violence also exists within the extraordinary scales of soil fertility and indentured labour allowing for the American cultivation, and therefore Manchester manufacture, of cotton. The violence that ruptures Gaskell's fictions might also be approached as rendering visible systemic contradictions expanding beyond her domestically-conceived solutions to global problems.[211] Boucher, a mob leader whose 'Irish blood' simultaneously makes him the subject of colonial violence, is akin to Bertha Mason – 'driven mad' (177; see also 166, 293, 320) occupying a liminal position between colonising and colonised identities. Boucher's suicide captures a subject riven apart, and with it a novel unable to reconcile the contradictions of a liberal economy built on improvement for those within, but extinction for those beyond, British shores.

This is not meant as a condemnation of Gaskell's fiction.[212] As her novels seek to infuse love and care into relations that remain built on exploitation and extraction, I have shown an author struggling with the social and ecological limits of liberal economics. Both *Mary Barton* and *North and South* come up against the impossibility of transcending these limits to counteract systemic poverty beyond specific and artificially bounded contexts – the Canadian pastoral or the factory dining room. As Corley writes of *Mary Barton*, 'domestic social harmony […] is necessarily underwritten by the forcible extension and maintenance of empire', and as Hensley and Steer argue of *North and South*, 'this heavily freighted marriage plot […] can do nothing to address the destabilizing international economic shifts, always tending towards ruin'.[213] As in *Jane Eyre,* the burden falls on female restoration, here in the shape of Mary Barton and Margaret Hale, to reproduce and renew life in marriage. This 'retreat into the private, familial areas of the plot' thus offers 'false solutions', examined long ago by Gallagher in a social context, that can also be understood in ecological terms.[214] In a dynamically intra-connected global ecology, apparently local harmony begets distant disorder.

[211] For more on this see Corley, 'Imperial Addiction', pp. 5-7.
[212] Gaskell is undoubtedly committed to what Maclure calls 'ethical world making'; 'Diagnosing Capitalism', p. 347. I also agree with Cammack that Gaskell's largely favourable representation of the 'poor Irishmen' (176) in *North and South* 'critiques the laissez-faire policies of Britain', and with Corley's broader assertion that *Mary Barton* both 'interrogates and relies upon assumptions about British imperial power': Cammack, 'Irish Laborers', p. 114; Corley, 'Imperial Addiction', p. 2.
[213] Corley, 'Imperial Addiction', p. 3; Hensley and Steer, 'Literary forms of Coal', p. 71.
[214] Gallagher, *Industrial Reformation,* p. 148.

Gaskell's industrial fiction thus reveals a fracture that persists across mid-century realist form. Narrative closure is unable to reconcile – indeed unable to be conceived without – open networks of resource extraction. As Caroline Levine explains, (using Sun-Joo Lee's transatlantic reading of the American North and South in *North and South* as her example), 'social forms bring their logics with them into the novel, working both with and against literary forms and producing unexpected political conclusions out of their outcomes'.[215] Gaskell can only address the harm she vehemently opposes against disadvantaged populations by exporting that harm on other disadvantaged populations. At the level of form, as the bounded whole of narrative closure offers a sense of resolution, the economic and ecological networks of mid-nineteenth-century realism, as becomes increasingly clear now with Dickens, must remain open. Writing in the years where an economic model of boundless global growth took hold, these authors emerge as realist because they capture the pervasive experience of life in modern industrial society. The lives of realist fiction are lived in a closed system that turns out with deadly results to be open.

[215] Caroline Levine, *Forms: Whole, Rhythm, Hierarchy, Network* (Princeton: Princeton University Press, 2015), p. 42.

Chapter 3. World-ecology 'among the mud': Soil Exhaustion and the Chemical Economy in Dickens's London

> And have our agriculturists for a moment considered of what the home-made sewage manure consists? […] it must be remembered that we import as well as produce, fruits of the earth, and that our imports of food alone amount annually to 75,000,000*l.* – in other words, our own home-made guano contains the fertilising elements not only of our own soil, but that of all countries of the earth which pour out their cornucopias into our island […] and the whole of which is now allowed to run to waste.
>
> 'The Restoration of Our Soil, part II', *Once a Week*, 14 March 1863.[1]

Agricultural writers of the mid-nineteenth century, such as this anonymous contributor to *Once a Week*, frequently saw 'all countries of the earth' as fertile natures to sustain Britain's population. Describing a global yet wasteful circulation of nutrients, 'The Restoration of Our Soil' was one of several mid-century articles to express concerns over soil exhaustion.[2] Chemical analysis here isolates the same 'fertilising elements' in the 'fruits of the earth' and in 'home-made sewage'. But the article also figures sewage as 'guano', a term more commonly associated with bird excrement, imported to Britain from Peru throughout the mid-nineteenth century for use as manure.[3] Sewage – supposedly a local resource and source of 'home-made' soil fertility – becomes entangled within global networks of nutrient extraction; nutrients are here directed by the economics of laissez-faire, with fertile elements flowing into Britain from across and beyond the empire, then 'allowed to run to waste' rather than be re-used as manure. In Charles Dickens's *Bleak House* (1852-53) and *Our Mutual Friend* (1864-65) these issues shape an investigation of food production, consumption, and waste with global parameters. I read these novels alongside contemporary scientific investigations of soil and sewage by Justus von Liebig and British agriculturist, John Bennet Lawes. My chapter thus approaches Dickens's London – 'The World's Metropolis' – as an

[1] Anon., 'The Restoration of Our Soil, part II', *Once a Week*, 14 March 1863, pp. 316-18 (318).
[2] Anon., 'The Restoration of Our Soil, part I', *Once a Week*, 28 February 1863, pp. 258-60; 'Exhaustion of Soils', *London Review*, 2 November 1861, pp. 567-68; 'The Exhaustion of Our Soil', *London Review*, 23 July 1864, pp. 89-90.
[3] For more on the Victorian guano trade see Lesley Kingsley, 'Guano, science and Victorian high farming: An agro-ecological perspective', in *Victorian Sustainability in Literature and Culture*, ed. by Wendy Parkins (London: Routledge, 2018), pp. 126-45 (126-29).

investigation into the co-development of chemistry, capitalism, and globalised agricultures during the mid-nineteenth century.[4]

Scholars have long appreciated the ecological quality of Dickens's novels. J. Hillis Miller, in words meant for *Bleak House* but that apply too to *Our Mutual Friend*, describes the Dickensian 'web of interconnection from which no character is free'.[5] For Gillian Beer, Dickens's plotting is like Darwin's – 'superfecundity of instance serving an argument which can reveal itself only *through* instance and relations'.[6] As 'the great novelist of entanglement', confirms George Levine, 'Dickens has an ecological vision'.[7] More recently, this ecological focus has fallen on the capitalist economics of Dickens's fiction, calling attention to economies of coal and smoke in *Bleak House* and of waste and recycling in *Our Mutual Friend*.[8] And increasingly, scholars have also been highlighting, what Adam Grener calls, 'the imbrication of empire and ecology in Dickens's novelistic form'.[9] In this chapter, I show how mud, dirt, and dust link questions of ecological exhaustion and economic renewal across both of these novels, and that these issues extend not only beyond London but also beyond Britain's colonies.[10] For as Paul Young writes, 'the Victorian economy was marked

[4] Charles Dickens, *Our Mutual Friend*, ed. and intro. by Michael Cotsell (1864-65; Oxford: Oxford University Press, 2008), p. 132. (All further references to *Our Mutual Friend* are to this edition and are given parenthetically in the body of the chapter.)
[5] J. Hillis Miller, *Victorian Subjects* (Durham, NC: Duke University Press, 1990), p. 180.
[6] Gillian Beer, *Darwin's Plots: Evolutionary Narrative in Darwin, George Eliot and Nineteenth-Century Fiction* (Cambridge: Cambridge University Press, 2009), p. 6; emphasis in original.
[7] George Levine, *Darwin and the Novelists: Patterns of Science in Victorian Fiction* (Cambridge, MA: Harvard University Press, 1988), pp. 119, 131.
[8] For coal and smoke in *Bleak House* see: Allen MacDuffie, *Victorian Literature, Energy, and The Ecological Imagination* (Cambridge: Cambridge University Press, 2014), pp. 89-113; Jesse Oak Taylor, *The Sky of Our Manufacture: The London Fog in British Fiction from Dickens to Woolf* (Charlottesville: University of Virginia Press, 2016), pp. 21-43. Both these critics also read *Our Mutual Friend*, examining what MacDuffie calls 'renewable energies' and Taylor 'the economy of smog'. MacDuffie, *Energy*, pp. 114-36; Taylor, *London Fog*, pp. 44-67. There is of course a far longer critical history focusing on waste and recycling in *Our Mutual Friend*, largely centred on the novel's 'dust': Peter Sucksmith, 'The Dust-Heaps in *Our Mutual Friend*', *Essays in Criticism*, 23.2 (April 1973), pp. 206-12; Nancy Metz, 'The Artistic Reclamation of Waste in *Our Mutual Friend*', *Nineteenth-Century Contexts*, 34.1 (June 1979) pp. 59-72; Leona Toker, 'Decadence and Renewal in Dickens's *Our Mutual Friend*', *Connotations*, 16.1-3 (2006/2007), pp. 48-59.
[9] Adam Grener, 'Mapping the "Invisible Region, Far Away" in *Dombey and Son*', in *Ecological Form: System and Aesthetics in the Age of Empire*, ed. by Nathan K. Hensley and Philip Steer (New York: Fordham University Press, 2019), pp. 121-35 (122). See also: Paul Young, 'Dickens's World-System: Globalized Modernity as Combined and Uneven Development', in *The Oxford Handbook to Charles Dickens*, ed. by J.O. Jordan, R. Patten and C. Waters (Oxford: Oxford University Press, 2018), pp. 703-21; Ayşe Çellikol, 'The Compression of Space in Charles Dickens's *Little Dorrit*', in *Romances of Free Trade: British Literature, Laissez-Faire, and the Global Nineteenth Century* (Oxford: Oxford University Press, 2011) <doi:10.1093/acprof:oso/9780199769001.003.0007>.
[10] The most detailed existing investigation of soil, earth, and mud in *Bleak House* and *Our Mutual Friend*, moving beyond the dust mounds, is Sabine Schülting's *Dirt in Victorian Literature and Culture*. Though I reference Schülting's work throughout, her study focuses more on the aesthetics of dirt (broadly defined) in Dickens's fiction, rather than the ecological and economic resonances of soil in both novels. Sabine Schülting, *Dirt in Victorian Literature and Culture: Writing Materiality* (London: Routledge, 2016).

by a web of trading relationships and allied movements of capital and people that incorporated but went well beyond empire'.[11] To frame my investigation of soil in Dickens's global fiction, then, I borrow from Jason Moore's concept of world-ecology, identifying laissez-faire capitalism as 'a way of organizing nature' and an economic system simultaneously emerging through natures of the mid-nineteenth century.[12]

Dickens's engagement with Victorian science, as Adelene Buckland has shown, was far from the 'nugatory' relationship described by Francis O'Gorman.[13] Scholars have examined the impact of evolutionary theory, geology, chemistry, and thermodynamics on Dickens's fiction.[14] Dickens's friendship with Edwin Chadwick and his championing of the sanitary cause in *Household Words* have seen numerous readings of his novels in terms of miasma theory and Liebig's zymotic analogy.[15] But my focus in this chapter is not on Liebig's pathology, but his agricultural chemistry; Dickens's engagement with the science of agriculture, as advanced by both Liebig and Lawes, has almost entirely escaped critical

[11] Young, 'Dickens's World-System', p. 704.
[12] Jason W. Moore, *Capitalism and the Web of Life: Ecology and the Accumulation of Capital* (London: Verso, 2015), p. 2. Grener has shown the possibilities of Moore's world-ecology for examining nineteenth-century fiction in his reading of *Dombey and Son*: 'Moore's efforts to think beyond this binary [of society and nature] opens avenues for analyzing how capitalist accumulation organizes nature in historically specific configurations and is at the same time co-produced with that nature […] his methodology also facilitates a broader rethinking of the ecological dimensions of novelistic form'. Grener, 'Mapping', p. 128.
[13] Adelene Buckland, '"The Poetry of Science": Charles Dickens, Geology, and Visual and Material Culture in Victorian London', *Victorian Literature and Culture*, 35 (2007), pp. 679-94; Francis O'Gorman, *The Victorian Novel* (Oxford: Blackwell, 2002), p. 252.
[14] As George Levine has explained, Dickens was aware of Darwin's work, the principles of matter conservation, and the emerging science of thermodynamics: Levine, *Darwin and the Novelists*, pp. 125, 155-57. For more on Dickens at the intersections of chemistry and thermodynamics see: Ann Y. Wilkinson, '*Bleak House*: From Faraday to Judgement Day', *ELH*, 34 (1967), pp. 225-47. For Dickens and energy physics see: Barri J. Gold, *ThermoPoetics: Energy in Victorian Literature and Science* (Cambridge, MA: MIT Press, 2010), pp. 187-224; MacDuffie, *Energy*, pp. 89-136. For Dickens and chemistry see: Louise Henson, '"Phantoms Arising from the Scenes of Our Too-Long Neglect": Charles Dickens, Victorian Chemistry, and the Folklore of the Ghost', *Victorian Review*, 26.1 (2000), pp. 6-23; Tyson Stolte, '"Putrefaction Generally": *Bleak House*, Victorian Psychology and the Question of Bodily Matter', *Novel: A Forum on Fiction*, 44.3 (Fall 2011), pp. 402-23; Matthew Ingleby, 'Chemistry versus Biology: Dickens, Malthus, and the Familiarized Doppelgänger', *Victorian Review*, 39.2 (Fall 2013), pp. 97-113. For Dickens and geology see: Adelene Buckland, *Novel Science: Fiction and the Invention of Nineteenth-Century Geology* (Chicago: University of Chicago Press, 2013), pp. 247-73.
[15] For Dickens's relationship with Chadwick and the sanitary cause see: Catherine Gallagher, *The Body Economic: Life, Death, and Sensation in Political Economy and the Victorian Novel* (Princeton: Princeton University Press, 2006), pp. 102-04; John Parham, 'Bleak intra-actions: Dickens, turbulence, material ecology', in *Victorian Writers and the Environment: Ecocritical Perspectives*, ed. by Laurence W. Mazzeno and Ronald D. Morrison (London: Routledge, 2017), pp. 114-29 (119-20); Schülting, *Dirt*, p. 30. For readings of miasma theory in Dickens's fiction, focusing largely on *Bleak House*, see: Christopher Herbert, 'The Occult in *Bleak House*', *Novel: A Forum in Fiction*, 17.2 (Winter 1994), pp. 101-15 (105); Tina Young Choi, 'Writing the Victorian City: Discourses of Risk, Connection, and Inevitability', *Victorian Studies*, 43.4 (2001), pp. 562-89; Schülting, *Dirt*, pp. 92-94. For the suggestion of Liebig's zymotic analogy in Dickens's representation of Tom-all-Alone's in *Bleak House* see: Christopher Hamlin, 'Providence and Putrefaction: Victorian Sanitarians and the Natural Theology of Health and Disease', *Victorian Studies*, 28.3 (Spring 1985), 381-411 (390); Henson, 'Victorian Chemistry', pp. 19-20. Henson also notes that Dickens knew Lyon Playfair, with obvious implications for Dickens's knowledge of Liebig's pathology; 'Victorian Chemistry', p. 7.

attention.[16] Yet Dickens admired both men enormously. He described Lawes as 'one of the most famous practical chemists of his age' and visited his Rothamsted experimental farm in Hertfordshire to learn more about Lawes's social philanthropy.[17] He held a similar level of respect for Liebig; 'I wish I could be there to meet Baron Liebig', he wrote in 1851 to his friend, Sheridan Muspratt, who had gained his PhD in chemistry in Giessen – 'one of the greatest men in Europe, and in whom I am (as who is not?) most strongly interested'.[18] Liebig was visiting Liverpool, and Dickens's regard is unsurprising considering Liebig's science, as William Brock notes, focused on questions of 'food production, nutrition and public health'.[19] Dickens's own advocacy for similar causes is well known, and as editor of *Household Words* and *All the Year Round*, he published over twenty-five articles referring to Liebig's science, (especially as advanced in his popular *Chemical Letters*), between 1850 and 1865. This respect, indeed, was mutual; Dickens was delighted to hear that he 'ha[d] the honour to number him [Liebig] among my readers'.[20] It is this potential point of two-way influence that underpins the ecology of literature and science I reveal in this chapter, relations between novelist and scientist based upon a shared respect and the mutual reading of each other's work.

It is hard to overstate the reach of Liebig's organic chemistry in the mid-nineteenth century. References to his science in the early years of *Household Words*, the first issue of which appeared in March 1850, show the extraordinary range of applications Liebig's work found in these years. Explaining how the chemical manufacture of sulphuric acid had revolutionised soap production, for example, 'The Work of the World', published in September 1851, quoted at length from the third edition of Liebig's recently published *Chemical Letters*.[21] In December 1850, an article on 'The Martyrs of Chancery' highlighted the destitution of suitors by noting that 'Liebig tells us that no quantity of clothing will repel

[16] Matthew Ingleby's reading of chemistry and biology in Dickens's *The Haunted Man and the Ghost's Bargain* (1848) is the only exception to this I can find: 'Dickens saw chemists such as Lawes and Liebig as part of a liberal-progressive alliance in which he himself participated, recognizing that chemistry was engaged in resisting social theories that left no role for social (and by extension, technological) agency in the cause of human amelioration'. At the same time, Ingleby's reading overstates the extent to which Liebig sought to counter 'Malthusian logic' with his chemistry; 'Chemistry versus Biology', p. 109.
[17] Charles Dickens, 'The Poor Man and His Beer', *All the Year Round*, 30 April 1859, pp. 13-16 (13).
[18] Charles Dickens, 'Letter to Dr Sheridan Muspratt, 24 August 1851', in *The Letters of Charles Dickens, Vol. 6: 1850-1852*, ed. by Graham Storey, Kathleen Mary Tillotson and Nina Burgis, 12 vols (1988; Oxford: Oxford University Press, 2016), Oxford Scholarly Editions Online. <https://www.oxfordscholarlyeditions.com/view/ 10.1093/actrade/ 9780198126171.book.1/actrade-9780198126171-book-1>.
[19] William H. Brock, *Justus von Liebig: The Chemical Gatekeeper* (Cambridge: Cambridge University Press, 1997), p. ix.
[20] Dickens, 'Letter to Muspratt'.
[21] Anon., 'The Work of the World', *Household Words*, 13 September 1851, pp. 589-92.

cold without plenty of food'.[22] 'Illustrations of Cheapness' (June 1850) and 'The Great Coffee Question' (April 1851) referenced Liebig's physiological chemistry to explain the action of caffeine on the body.[23] Liebig's chemistry of agriculture was also referred to on numerous occasions. 'The Heart of Mid-London', co-authored by Dickens and W.H. Wills, described a farmer 'who had administered [his livestock's] food straight out of the scientific dietaries of Liebig', and 'The Golden Vale', published on 1st January 1853, explained the great soil fertility of Tipperary with reference to 'Liebig' and 'his disciples'.[24] All this before the final edition of *Bleak House* appeared in September 1853.

My primary argument is that Dickens engaged with the work of Liebig and Lawes in his fiction; *Bleak House* serves as an investigation of soil exhaustion and *Our Mutual Friend* as a narrative of soil restoration. Beginning with *Bleak House*, I frame Dickens's realism as an inductive enterprise that builds knowledge of soil degradation by examining depleted agricultures in relation. I argue too that this imaginary of exhaustion impacted Liebig's understanding of soil depletion, an emerging ecological concern that existed in tension with his extractive capitalist chemistry. As for *Our Mutual Friend*, the novel's marriage plots grapple with the same uneasy knowledge of degrading soils, arriving at a technoscientific solution to address soil exhaustion. At the same time, however, although both Dickens's novels expose nutrient extraction and inequality inherent to capitalist agricultures, their narrative conclusions preserve the unequal and productivist economics each critique. Considering Dickens and Liebig together, the knowledges of soil both men advanced in the 1850s and 1860s thus reveal a crisis that is, in Rob Nixon's terms, 'attritional', 'gradual' and 'out of sight'.[25] The concept of slow violence is again pertinent here, for it encapsulates not only the slow-moving crises and effects of soil degradation, diffused over large expanses of time and space, but equally how the knowledges Liebig's chemistry and Dickens's novels supply of this crisis ultimately elide the continuing exploitation of peoples and natures across the globe.

My first section, 'Combusting Soil in *Bleak House*', reads Mr Krook's spontaneous combustion for both its analogical and methodological significance. As an analogy with Chancery, Krook's shop serves as part of an examination into the economics of soil

[22] Anon., 'The Martyrs of Chancery', *Household Words*, 7 December 1850, pp. 250-52 (251).
[23] Anon., 'Illustrations of Cheapness', *Household Words*, 8 June 1850, pp. 253-56 (256); 'The Great Coffee Question', *Household Words*, 12 April 1851, pp. 49-53 (49).
[24] Charles Dickens and W. H. Wills, 'The Heart of Mid-London', *Household Words*, 4 May 1850, pp. 121-25 (121); Anon., 'The Golden Vale', *Household Words*, 1 January 1853, pp. 377-81 (377).
[25] Rob Nixon, *Slow Violence and the Environmentalism of the Poor* (Cambridge, MA: Harvard University Press, 2013), p. 2.

depletion; as a challenge to the normative facade of realism, Krook's death offers what the Warwick Research Collective (WReC) would call an 'irrealist aesthetic', here rendering visible the depletion of fertile natures under capitalism. Section two, 'Soil Exhaustion and the Chemical Economy', turns first to Liebig's chemistry of soil, showing how the logic of capital pervaded his science.[26] I then consider Lawes's and Liebig's investigations of soil exhaustion and renewal, revealing a debate that probed at the intersections of chemistry and the emerging science of energy physics, and suggesting that Liebig's thermodynamic awareness was influenced by his reading of *Bleak House*. In section three, 'Circulating Nutrients in *Our Mutual Friend*', I read the courtship plots of Lizzie Hexam and Eugene Wrayburn, Bella Wilfer and John Harmon, as respective examinations of domestic and global nutrient circulation. My final section, 'World-ecology in "The World's Metropolis"', troubles the ecological imaginaries of *Our Mutual Friend* and *Bleak House* by showing that both novels fail to eliminate the violence and exploitation they seek to resist. To conclude, I read these ecological tensions as a product of Dickens's inductive realist method, as a crisis of apprehension inscribed within the narrative structure of *Bleak House*. It is to this novel I now turn, beginning with the controversy surrounding Mr Krook's combustion, a debate in which Liebig's science was never far away.

Combusting Soil in *Bleak House*

Ever since George Henry Lewes criticised Dickens in December 1852 for his treatment of Mr Krook, scholars have approached *Bleak House* by way of spontaneous combustion.[27] Dickens had committed a 'fault in art', Lewes explained in the *Leader*, because spontaneous combustion was not 'scientific truth'[28] Mid-twentieth century scholarship often continued this focus on the relationship between Krook's death and scientific fact; Gordon S. Haight suggests the incident shows Dickens's 'intellectual limitations', whereas Trevor Blount considers the event 'proved' at the level of the novel, a narrative lent 'authenticity' by Dickens altering the January 1853 number to 'accommodate an answer' to Lewes.[29] More

[26] Warwick Research Collective (WReC), *Combined and Uneven Development: Towards a New Theory of World-Literature (Postcolonialism Across the Disciplines)* (Liverpool: Liverpool University Press, 2015), p. 70.
[27] For a detailed chronology of Lewes's and Dickens's debate, and for a copy of Dickens's letter responding to Lewes on 25 February 1853, see Gordon S. Haight, 'Dickens and Lewes on Spontaneous Combustion', *Nineteenth-Century Fiction*, 10.1 (June 1955), pp. 53-63. For the debate seen from Lewes's perspective see Rosemary Ashton, *G.H. Lewes: A Life* (Oxford: Clarendon Press, 1991), pp. 194-95. For a detailed critical history see Brooke D. Taylor, 'Spontaneous Combustion: When "Fact" Confirms Feeling in *Bleak House*', *Dickens Quarterly*, 27.3 (September 2010), pp. 171-84 (172).
[28] George Henry Lewes, 'Literature', *Leader*, 11 December 1852, p. 1189.
[29] Haight, 'Spontaneous Combustion', p. 63; Trevor Blount, 'Dickens and Mr. Krook's Spontaneous Combustion', *Dickens Studies Annual*, 1 (1970), pp. 183-211, 291-92 (189-90).

recently, literature and science scholars have focused on the analogical significance of Krook's death. Following George Levine's influential claim that Dickens 'used science as much for metaphor as for the latest news about the cosmos', Barri J. Gold understands Krook for his analogy with Chancery – 'a system driving so fast to entropy that nothing is to be done except to blow him up'.[30] For Jesse Oak Taylor, meanwhile, Krook offers 'a literalized metaphor for a reifying, steam-driven industrial modernity powered by the combustion of coal'.[31] Rarely noted, however, is that Liebig's chemistry featured heavily in the debate between Lewes and Dickens over Krook's demise; *Bleak House* in fact used the spontaneous combustion episode to engage Liebig on questions of science. This has important implications for the analogical significance of Krook's death, which I read in terms of soil exhaustion, but also for the methodological foundations of Dickens's realism, as I now explain.

The details of Krook's death are worth recounting. Krook is an inveterate hoarder whose inability to read the piles of papers he collects is symbolic of Chancery's futile processes. *Bleak House* makes this explicit: '[Krook] is called among the neighbours the Lord Chancellor', Miss Flite explains early in the novel, 'His shop is called the Court of Chancery'.[32] This shop, where 'everything seemed to be bought, and nothing to be sold' (67), leads MacDuffie to reason that 'Krook's spontaneous combustion results from his own manifestly unsustainable business practices'.[33] On the night of Krook's combustion, William Guppy visits his friend Tony Jobling, intent on the belief that in the shop below lie the 'bundle of letters' (511) that will reveal the truth of Esther Summerson's parentage. Guppy's scheming is soon interrupted by a 'stagnant sickening oil' (516) that coats his fingers. Jobling, sent to retrieve the papers from Krook, soon finds the cause: 'The Lord Chancellor of that Court […] has died the death of all Lord Chancellors in all Courts', the novel's omniscient narrator explains, 'inborn, inbred, engendered in the corrupted humours of the vicious body itself, and that only – Spontaneous Combustion' (519).

Writing in the *Leader* on 11th December 1852, Lewes famously objected to this as a scientific impossibility, 'which we doubt if [Dickens] can find one organic chemist of any authority to countenance now'.[34] If Dickens had at this point acknowledged Krook's death

[30] Gold, *Thermopoetics*, p. 196.
[31] Taylor, *London Smog*, p. 42.
[32] Charles Dickens, *Bleak House*, ed. and intro. by Nicola Bradbury, preface by Terry Eagleton (1852-53; London: Penguin, 1996), p. 69. (All further references to *Bleak House* are to this edition and are given parenthetically in the body of the chapter.)
[33] MacDuffie, *Energy*, p. 101.
[34] Lewes, 'Literature', 11 December 1852, p. 1189.

for its clear analogy with Chancery, the dispute would have ended there. Dickens of course did no such thing, instead defending Krook's death on the basis of scientific fact by working Lewes's criticism into the January 1853 number of *Bleak House* alongside supposed historical cases of spontaneous combustion. On January 15th, Lewes replied in the *Leader*; 'Liebig distinctly says that in modern times no physician of any repute acquainted with the natural sciences has accepted the theory of spontaneous combustion'. [35] In two long letters published in February 1853, Lewes then set about showing the impossibility of spontaneous combustion by extensive reference to the third edition of *Chemical Letters*, where Liebig had considered and dismissed such phenomena two years earlier. Yet Dickens still defended Krook's death on the basis of empirical fact, as he began in a private letter to Lewes on February 25th:

> My Dear Lewes,—
>
> Liebig is a great man, deserving all possible respect, and receiving no greater deference from any one than from me. But I cannot set his opinion – his mere opinion and argument – against full scientific evidence of a fact. That evidence appears to me to exist, on the subject which is called (rightly or wrongly) spontaneous combustion.[36]

Here perhaps lies evidence for Haight's dismissal of Dickens's 'intellectual limitations'.[37] More interestingly, I think, is that implicit in Dickens's rejection of Liebig's chemistry is the belief that the novelist has as much right 'to discriminate between truth and falsehood', as he put it to Lewes, as the scientist.[38]

This was contrary to the arguments made by Liebig in *Chemical Letters,* which sought to establish chemistry as a science and to explain 'the influence of this science on the useful arts'.[39] Spontaneous combustion offered Liebig 'an example to illustrate the method pursued by science […] for […] ascertaining the truth'.[40] The problem with historical reports was they came, not from 'highly cultivated physicians', but from those 'unpractised in observation'.[41] For Liebig, this showed the limits of a practice-based 'art' like medicine when unaided by the science of organic chemistry: 'The physician who has learned medicine, not as a science, but

[35] George Henry Lewes, 'Literature', *Leader*, 15 January 1853, p. 64.
[36] Charles Dickens, 'Letter to George Henry Lewes, 25 February 1853', in Haight, 'Spontaneous Combustion', pp. 58-60 (58).
[37] Haight, 'Spontaneous Combustion', p. 63.
[38] Dickens, 'Letter to Lewes', p. 58.
[39] Justus von Liebig, *Familiar Letters on Chemistry, in its relations to Physiology, Dietetics, Agriculture, Commerce and Political Economy*, trans. by William Gregory, 3rd edn (Taylor, Walton, and Maberly, 1851), p. 1.
[40] Liebig, *Chemical Letters,* p. 281.
[41] Liebig, *Chemical Letters,* p. 282.

as an empirical art, acknowledges no principles, but only *rules* derived from experience'.[42] Chemistry was instructive, then, because it showed how an art might rise to a science. 'There was a time when chemistry […] was nothing more than an art, founded on empirical practice', he wrote, but with the proper experimental method, the chemist was now qualified 'to investigate phenomena in order to draw conclusions as to their *causes* and the *laws* which regulate them'.[43] The chemist was thus able 'to read the book of nature, to understand its language'.[44] As Daniel Hack notes, 'Liebig embellishes the familiar image of the book of nature to the point where it is no longer clear whether the chemist's expertise lies in the field of books or of nature'.[45] Implicit in this well-worked rendering of nature as text, and Liebig's attempts in *Chemical Letters* to revolutionise art in terms of science, is the sense that scientific truth is superior to the truths of art.

This was Lewes's line of attack in the *Leader*. Liebig had first investigated spontaneous combustion to give evidence in a court of law, as Lewes explained on 5th February 1853; 'two years ago, on the occasion of the Görlitz murder, the subject was thoroughly investigated by Liebig and Bischoff, who proved, in court, that all alleged cases were no more credible than were the alleged cases of witchcraft'.[46] His *Leader* article then quoted at length from *Bleak House*, only to dismiss Dickens's references to 'the *Philosophical Transactions*' by remarking that 'the authority […] of 1750 can be brought into no chemical court of 1853'.[47] Introducing these legal resonances to his attack on the novel supported a broader point about what constituted evidence in science: 'Knowing how much fiction is habitually mixed up with the sincerest evidence, few thinking men are in the habit of attaching much importance to "reported cases"'.[48] Dickens could cite as many historical examples as he liked, in other words, none could overrule the 'laws of combustion' that made Krook's death a scientific impossibility.[49] With chemical analysis 'establish[ing] truth' pertinent to both natural and judicial law, the chemist's expertise is once more seen to

[42] Liebig, *Chemical Letters*, p. 12; emphasis in original.
[43] Liebig, *Chemical Letters*, pp. 10-11, 3; emphasis in original.
[44] Liebig, *Chemical Letters*, p. 10.
[45] Daniel Hack, '"Sublimation Strange": Allegory and Authority in *Bleak House*', *ELH*, 66.1 (Spring 1999), pp. 129-56 (147).
[46] George Henry Lewes, 'Spontaneous Combustion. Two Letters to Charles Dickens. No. I.', *Leader*, 5 February 1853, pp. 137-38 (137).
[47] Lewes, 'Spontaneous Combustion', 5 February 1853, p. 137. Lewes had made a similar argument on 15th January, ridiculing Dickens's historical examples of spontaneous combustion as 'hav[ing] no weight in courts of science now-a-days'. 'Literature', 15 January 1853, p. 64.
[48] Lewes, 'Spontaneous Combustion', 5 February 1853, p. 137.
[49] Lewes, 'Literature', 15 January 1853, p. 64.

extend far beyond the laboratory.[50] For Lewes, as for Liebig, the chemist was well positioned to arbitrate truth – even in the pages of a novel.

At stake in Krook's demise, therefore, was what constituted realism in literature.[51] Lewes was arguing, as Brooke Taylor explains, for 'scientific realism in fiction'.[52] Dickens's defence of Krook's combustion on factual terms should thus be understood as part of a broader argument on methodological grounds, offering important context for what Levine calls the 'complicating antiscientific strain in his writings'.[53] Having dismissed Liebig's 'mere opinion' in his letter to Lewes on 25th February, Dickens explained how his methodology differs from the chemist:

> Now the object of my note is simply to assure you that when I thought of the incident – which came into my mind, as having that analogy [with Chancery] in it which is suggested at the end of the chapter – I looked into a number of books with great care, expressly to learn what the truth was. I examined the subject as a Judge might have done. And without laying down any law upon the case, I placed the evidence impartially before myself as I will place it before you.[54]

Dickens staked his claim for the novelist's expertise in the precise terms Lewes used for establishing Liebig's; examining the 'evidence' as a 'Judge', but crucially 'without laying down any law upon the case', Dickens argued for an examination of nature preceding from lived experience rather than the experimental investigations of chemistry. I thus agree with Hack that 'Dickens uses the spontaneous-combustion incident to investigate and manipulate […] distinctions between […] scientific and literary authority'.[55] But more than this, by beginning with experience rather than 'law', Dickens charts an inductive rather than deductive route to 'truth' that is in fact implicit throughout *Bleak House*.[56] (George Eliot

[50] Lewes, 'Spontaneous Combustion', 5 February 1853, p. 137.
[51] Dickens was of course a great admirer of Liebig's science long before Lewes's criticism. If he took as much care researching spontaneous combustion as he claimed, it is inconceivable that he was not aware of Liebig's investigations in *Chemical Letters* before Lewes referenced the text himself: Dickens, 'Letter to Lewes', p. 58. As William Brock explains, Liebig's 'forensic arguments' rejecting spontaneous combustion received extensive coverage in *The Times* and the *London Medical Gazette* throughout 1850: *Liebig*, p. 286. It seems plausible, then, that in researching spontaneous combustion before Lewes's criticism, Dickens saw how he might use Krook's death to make a methodological point in *Bleak House* in response to Liebig's recent arguments over science and art. While this argument is speculative, what is more certain is that Lewes's heavy-handed criticism subsequently gave Dickens the perfect opportunity to respond to the methodological questions raised by Liebig.
[52] Taylor, 'Spontaneous Combustion', p. 184.
[53] Levine, *Darwin and the Novelists*, p. 124.
[54] Dickens, 'Letter to Lewes', p. 58.
[55] Hack, 'Allegory and Authority', p. 135.
[56] As in *Our Mutual Friend*, where Levine argues that Dickens is 'not self-consciously imagining the conditions of a scientific experiment', he is – to apply Levine's words to *Bleak House* – nevertheless 'mak[ing] the large moral and social issues of the book dependent on strategies of knowing'. George Levine, *Dying to Know: Scientific Epistemology and Narrative in Victorian England* (Chicago: University of Chicago Press, 2002), p. 154.

makes a similar argument more fully in her 1856 article 'The Natural History of German Life', as will be seen in the opening section of chapter 4.) Important here is that this inductive movement underpins the analogies *Bleak House* draws between Krook, Chancery, and other unsustainable economies that, as I now show, play out through soil.

At which point, it is worth noting that scholars have long viewed Krook's death as indicative of a novelist, to quote Levine, 'brilliantly outside the main stream of Victorian realism'.[57] From Eliot writing in 'Natural History' to Frederic Jameson in *The Antimonies of Realism*, critics have always recognised Dickens's portrayals of the London poor as somewhat sentimental, and he has often been criticised, as Levine notes, by those 'seeking more fluid, complex, unstable' selves.[58] But his novels simultaneously expose, what Raymond Williams calls, 'those social institutions and consequences […] not accessible to ordinary physical observation'.[59] 'The patterns of mutual informativeness coordinated in his novels by structural parallels and commanding metaphors all confirm the unitary nature of society', writes Elizabeth Ermarth.[60] The truths of *Bleak House* have been seen to lie less in the empirical reality of the novel's characters, then, than in how the narrative works as a whole to provide insight into broader structures of experience. It is this inductive movement – from observed reality to higher orders of meaning, from the everyday mud and dirt of the city to the extraordinary moment of Krook's combustion – by which *Bleak House* reveals economies in states of exhaustion under capitalism.

For in a limited sense, Dickens's portrayal of Krook was factually correct. With his body described as 'on fire within' (68) and 'with a spirituous heat smouldering in it' (328), *Bleak House* is consistent with the contemporary scientific understanding of combustion within the animal economy. An 1850 article Dickens published in *Household Words*, 'The Laboratory in the Chest', referred to 'Professor Liebig' in explaining life as 'a perpetual combustion'.[61] As Lewes explained when responding to Krook's death in the *Leader*, 'food furnishes fuel to the "devouring element" of fire'.[62] In time, 'the fire […] goes out (and that is

[57] Levine, *Darwin and the Novelists*, p. 130.
[58] George Eliot, 'The Natural History of German Life', *The Westminster Review* (July 1856), pp. 51-79 (55); Frederic Jameson, *The Antinomies of Realism* (London: Verso, 2013), p. 148; Levine, *Darwin and the Novelists*, p. 144.
[59] Raymond Williams, *The Country and the City* (1973; London: Vintage, 2016), p. 226.
[60] Elizabeth Deeds Ermarth, *Realism and Consensus in the English Novel* (Princeton: Princeton University Press, 1983), p. 182.
[61] Charles Knight, 'The Laboratory in the Chest', *Household Words*, 7 September 1850, pp. 565-69 (568, 566). As Ann Wilkinson discusses, 'The Laboratory in the Chest' formed part of Knight's 'Chemistry of a Candle' series, written up from Michael Faraday's lecture notes. Wilkinson, 'Faraday', pp. 235-37.
[62] George Henry Lewes, 'Spontaneous Combustion. Two Letters to Charles Dickens. No. II.', *Leader*, 12 February 1853, pp. 161-63 (161).

death;) and, after this, oxygen, still demanding fuel, attacks the combustible grate itself (and that is *decay*.)'[63] This understanding of oxidisation is familiar from Angus Smith's work, examined in chapter 2, but applied here to respiration in the human body rather than decay in soil. For Liebig, respiration and decay were thus closely related processes;[64] '*The process of decay is a process of combustion taking place at the common temperature*', *Chemical Letters* emphasised, 'in which the products of fermentation and putrefaction of plants and animal bodies combine gradually with the oxygen of the atmosphere'.[65] Liebig named this process of decay eremacausis, compounded of the Greek for 'slow' and 'combustion'.[66] Decay was thus the counterpoint to 'the functions, at once so simple and so wonderful, which oxygen performs in the animal economy'.[67] The essence of Liebig's understanding, then, was that slow combustion as respiration maintained the animal economy, but that slow combustion as eremacausis eventually caused organic bodies to die and decompose. As Lewes succinctly put it, 'Life is an incessant Decomposition and Recomposition; death is the cessation of the Recomposition'.[68]

This understanding of decay as slow combustion is strongly suggested in *Bleak House* through Richard Carstone. Introduced as a 'light-hearted' and 'handsome youth' (44), Richard comes to 'trust' (675) in Chancery, with predictable results. 'He has been induced to trust in the rotten reed', John Jarndyce explains, 'and it communicates some portion of its rottenness to everything around him' (560). This rot comes in the figure of Richard's lawyer, Mr Vholes, whose office at Symond's Inn is filled with 'dry rot and […] dirt and all things decaying and dismal' (620). Wilkinson is right that as Chancery consumes Richard, this rot extends from dwelling to body; as Louise Henson explains, Jarndyce and Jarndyce 'taints

[63] Lewes, 'Spontaneous Combustion', 12 February 1853, p. 162; emphasis in original. 'In one sense, Spontaneous Combustion is the incessant act of life itself; the tissues are called into activity through constant oxidation, and man is truly said to be ashes', Lewes wrote in his initial response to Krook's death. 'Literature', 11 December 1852, p. 1189.
[64] Liebig noted in *Organic Chemistry* that 'respiration must be regarded as a slow process of combustion or constant decomposition': *Organic Chemistry in its Application to Agriculture and Physiology*, trans. by Lyon Playfair (London: Taylor and Walton, 1840), p. 55. Liebig explained the process again in *Chemical Letters*, describing how oxygen in the blood 'causes the formation of products of oxidation or combustion […] and consequently gives rise to a disengagement of heat': *Chemical Letters*, pp. 335-36.
[65] Liebig, *Chemical Letters*, pp. 210-21; emphasis in original.
[66] As William Gregory explained in a footnote: 'In order to avoid ambiguity attached to the word *decay*, from its being in vernacular language applied to several processes which it is desirable to distinguish, the author proposed to substitute the term EREMACAUSIS, and this has been very generally adopted in scientific treatises, being a convenient mode of expressing the relation of decay to ordinary combustion': Liebig, *Chemical Letters*, pp. 210-11; emphasis in original. Playfair made a similar clarification in his translation of *Organic Chemistry* on p. 45.
[67] Liebig, *Chemical Letters*, p. 344.
[68] Lewes, 'Spontaneous Combustion', 12 February 1853, p. 162.

claimants because it is tainted by the rot of Chancery'.[69] But to be more specific, the 'dry rot' that consumes Richard is not quite the putrefaction of *Mary Barton*, and certainly not the purifying decay of *North and South*. What Esther Summerson describes as 'his gradual decay' (975) demands to be read as the slow combustion of eremacausis, as Tony Jobling, passing Richard in the street, makes clear to William Guppy: 'there's combustion going on there! It's not a case of Spontaneous, but it's smouldering combustion it is' (631).[70] As Levine writes, 'Dickens always saw himself as a realist committed to the truthful representation of commonly experienced particulars', and imagined through Liebig's science, spontaneous combustion becomes the extreme form of an observable process of decay taking place across the novel.[71] Differences between the novel's combusting bodies are quantitative rather than qualitative.

While drawing this analogy between Richard and Krook, *Bleak House* also links Richard's spendthrift ways to the economics of soil depletion. As Harold Skimpole makes clear, Richard is a soil from which to extract: '"I have the epicure-like feeling that I would prefer a novelty in help, that I would rather," and he looked at Richard and me, "develop generosity in a new soil, and in a new form of flower"' (95). As Esther here notes, if she is the flower, Richard is the soil, and coming to Skimpole's aid marks the beginning of his demise. Jarndyce returns the ten pounds Richard uses to pay Skimpole's debt, causing Richard to remark, 'I have got ten pounds more than I expected to have, and consequently I can afford to spend it without being particular' (139). Yet Richard's capital, like the fertility of a soil, is finite and must be renewed; Richard has soon 'exhausted his resources' (389). As MacDuffie explains of this faulty accounting, (in words that apply equally to extractive agriculture), 'a process that someone would reduplicate endlessly is put in direct contact with an exhaustible base of resources'.[72] Like a soil where fertility is extracted but never renewed, Richard's capital depletes within a system that turns out, with deadly results, to be open.

As Richard's capital is extracted by Vholes, *Bleak House* draws parallels between a depleting bodily economy and an extractive capitalist agriculture. In Vholes's room at

[69] Wilkinson, 'Faraday', p. 241; Henson, 'Victorian Chemistry', p. 17. Many critics have read the corruption of Chancery in this way. Blount and Taylor, for example, both read Chancery as a self-corrupting biological system: Blount, 'Dickens', p. 187; Taylor, 'Spontaneous Combustion', p. 176.
[70] Schülting has noted Liebig's theory of eremacausis in her discussion of *Bleak House*, but without making this link to Richard. She does link the process to Krook, although without the explicit focus on decay as slow combustion: 'Liebig stressed that a substance that was brought into close contact with putrefying matter would itself be affected by putrefaction. The pure would be infected, as it were, by the impure. In this context, Krook's proximity to the rotting things in his warehouse can be read as inducing his death'. Schülting, *Dirt*, p. 93.
[71] Levine, *Darwin and the Novelists*, p. 134.
[72] MacDuffie, *Energy*, pp. 100-01.

Symond's Inn, 'a smell as of unwholesome sheep, blending with the smell of must and dust, is referable to the […] consumption of mutton fat in candles' (621). As agricultural production sustains the work of the law, the lawyer 'mak[es] hay of the grass which is flesh' (621) by extracting Richard's 'resources' (389), with the result that Richard's health 'melt[s] away with the candles' (921) that consume his finances. Boundaries are thus blurred between bodily, monetary, and agricultural economies, linking Richard's depleting health and capital to the depletion of soil and sheep.

Vholes understands the extractive economics of this system perfectly – he is certainly a 'man of capital' (696), whatever he claims to the contrary. As the lawyer extracts Richard's wealth in 'support' of three daughters and 'an aged father in the Vale of Taunton' (607), Richard 'exhaust[s] his ardour in the Chancery suit', not as Ada hopes 'by being so very earnest in it' (695), but by expending his bodily and financial resources until none remain. To follow the agricultural parallel this exhaustion invites, if Jarndyce and Jarndyce falls as a 'blight' (594) on Richard, then Chancery falls as a blight on the soil. For as Richard's death indicates, such extraction cannot persist indefinitely – in agricultural terms, Vholes is 'making hay' but in the process 'exhaust[ing]' (695) the soil that sustains him. With the workings of Chancery equivalent to the capitalist economy, as many scholars have argued, *Bleak House* here suggests something of what Marx will understand as capitalism destroying the health of both the soil and the human.[73]

As Miss Flite notes, Richard is 'drawn to ruin' (567) just like Mr. Gridley, 'the man from Shropshire' (18, 19, 250, 252, 403).[74] By drawing this analogy between Richard as soil and Gridley as 'small Shropshire farmer' (395), the novel exposes the depletion of agricultures at increasing scales. Gridley is a 'ruined suitor' (16) whose 'farm and stock' (250) 'has gone in costs' (251). His 'whole estate' (251) has been consumed by Chancery, causing the farmer to rage at his impotency in the face of systemic extraction:

> The system! I am told, on all hands, it's the system. […] I mustn't go to Mr Tulkinghorn, the solicitor in Lincoln's Inn Fields, and say to him when he makes me furious, by being so cool and satisfied – as they all do; for I know they gain while I lose […] It's the system. (251-52)

[73] For Chancery read in terms of the capitalist economy see: MacDuffie, *Energy*, p. 105; Taylor, *London Fog*, p. 23.
[74] As 'a blight' (594) falls on Richard, Esther also sees 'a shade of' Gridley – 'that unfortunate man who died' (596). Richard is of course also 'dreadfully like' (592) Miss Flite herself, whose entire family is 'drawn' and ruined by 'the influence' (567) of Chancery.

This 'passion and heat' (250) is expressive of another case of slow combustion, Gridley's 'chafing […] manner' (244) signifying his 'rubbing', 'fretting', and 'friction' against the 'restraints' of Chancery.[75] What is more, as the farmer is 'worn out' (395, 404-05), his death charts an extractive relationship between the fields of Shropshire and 'these fields of Mr Tulkinghorn's inhabiting' (749), the fields of law. As with Richard, Gridley's death is the expression of Chancery's exploitative economics – 'where the sheep are all made into parchment, the goats into wigs, and the pasture into chaff' (661). With chaff denoting 'the husks of corn or other grain separated by threshing or winnowing', so as Richard like Gridley 'chafe[s]' (624) against Chancery, the near homonym between waste product (chaff) and futile work (chafe) draws links between their depleting resources and the systemic exhaustion of agriculture.[76] Thus, as both men are made into chaff, the fertility of the soil and the vitality of the human are both depleted by an economy defined by extraction. By drawing such parallels between human bodies and sites of agriculture, *Bleak House* offers an inductive investigation of resource exhaustion under capitalism.

Chancery denotes an economic system, as Moore's world-ecology would have it, exhausting both human and extra-human nature.[77] I agree with Gold that Dickens is 'upstream' of thermodynamics here, but what seems to be 'a profound sense of entropic decay' in the novel might also be thought of as the slow combustion of eremacausis.[78] Tulkinghorn has clearly learnt the economic rules of this energy system as they are currently understood. The trick is to keep the animal economy in balance, to keep 'cool and satisfied' by transferring the 'heat' of slow combustion elsewhere – which, as Gridley realises in the midst of his 'heat' (250) above, is exactly what Tulkinghorn achieves by consuming the farmer's material 'living' (251) along with his less tangible bodily 'energy' (405). *Bleak House* hovers here in the as yet uncertain transformations of matter and energy, eremacausis offering a sense of universal dissolution that will soon be known as entropy:

> In his lowering magazine of dust, the universal article into which his papers and himself, and all his clients, and all things of earth, animate and inanimate are resolving, Mr Tulkinghorn sits at one of the open windows, enjoying a bottle of old port. (352)

[75] 'Chafe, *v.*', in *The Oxford English Dictionary* [online], < https://www.oed.com/view/Entry/30151> [Accessed 11 May 2021].
[76] 'Chaff, *n.*[1]', in *The Oxford English Dictionary* [online], < https://www.oed.com/view/Entry/30161> [Accessed 11 May 2021].
[77] Moore, *Capitalism*, pp. 225-26.
[78] Gold, *Thermopoetics*, p. 188.

If the inductive direction of *Bleak House* is from the bodily economy to the capitalist economy, then here the novel expands to glimpse a 'universal' economy of nature that follows the rules of eremacausis.[79] With Chancery, as Ann Wilkinson notes, becoming 'dryer and dryer, more and more combustible', even soil is slowly combusting to dust.[80] In this way, 'a breeze from the country' is conspicuous for bringing 'plenty of dust in at Mr Tulkinghorn's windows' (352). As Gridley's example suggests, the world is slowly combusting as it decays, 'the oven made by the hot pavements and hot buildings' (661) in London suggesting an economy that is fatally heating up. This is why Tulkinghorn, whenever he 'has baked himself dryer than usual', turns to 'his mellowed port-wine half a century old' (661). The lawyer resists the action of universal decomposition by doing the work of bodily recomposition, keeping the 'dusty death' (118) of eremacausis at bay by consuming the produce of the soil.

Rather than saying the lawyer is 'embracing the decay that surrounds him', it is thus more accurate to say that he embraces the logic of eremacausis by exporting decay elsewhere.[81] This is in fact the foundational logic of Chancery's economics. As Tulkinghorn is careful to 'yield […] nothing beyond the service he sells' (192), Gridley's resources are laid open for extraction; just as Richard is clearly unable to 'sustain' (624) his expenditure, it is clear that nobody is doing the work of recomposition when it comes to the soil. Making these inductive comparisons – moving from 'microcosm to macrocosm', as MacDuffie puts it, 'from [Richard's] story to Chancery to the entire English economic order' – the novel reveals a failing agricultural system.[82] The systemic extraction of Chancery, with 'its decaying houses and its blighted lands in every shire' (15), thus captures the assimilation of the novel's soils into a particularly rapacious capitalist economics. By describing 'the entanglement of real estate in meshes of sheepskin, in the average ration of about a dozen of

[79] Even the 'mud' (13) that clogs Holborn Hill as the novel opens is coming to dust; fifteen of the novel's twenty-four usages of 'mud' come in the first third of *Bleak House*, in comparison to thirty-four out of forty-five mentions of dust that come in the remaining two thirds of the narrative – an incidental observation perhaps, were it not for this pervasive tendency towards degradation acting again and again through the narrative. The action of slow combustion is thus traced in matter transformation and inscribed across the narrative in this subtle change of language. For 'mud' and cognates see pp. 13, 14, 18, 23, 130, 163, 176, 256, 259, 260, 261, 358, 409, 711, 869, 882, 911. For 'dust' and cognates see pp. 17, 32, 43, 49, 64, 118, 159, 188, 235, 257, 302, 352, 406, 439, 441, 481, 588, 608, 620, 621, 626, 634, 635, 643, 661, 693, 710, 720, 738, 748, 752, 783, 784, 799, 804, 828, 895, 922, 948, 951, 953.
[80] Wilkinson, 'Faraday', p. 240.
[81] Gold, *Thermopoetics*, p. 219.
[82] MacDuffie, *Energy*, p. 105.

sheep to an acre of land' (504), *Bleak House* as world-ecology begins to delineate the 'entanglement' of 'capitalism-in-nature'.[83]

While there may be 'no healthier soil in the world' (642) than Chesney Wold, then, if this land has 'never known ploughshare' (255) it is because the cost of extraction is being paid elsewhere. Indeed, 'the plantations' (984) of the Dedlock estate gesture towards a history of subjection – stretching beyond the 'plantation fence' (296) – that I have shown to sustain the country estate in *Jane Eyre* and that I consider in more detail in this chapter's final section. Following the mid-century logic of nutrient flow, explained in chapter 2, the 'stagnant river' (20) of Chesney Wold denotes a clearly unsustainable nutrient economy. Stagnation in *Bleak House* – evident through the novel as Vholes's 'failing' 'digestion' (607, 621, 628, 697), Sir Leicester Dedlock's 'gout' (264, 817), and the 'stagnant channel of mud which is the main street of Tom-all-Alone's' (711) – offers the pathological expression of corrupted natural systems. But for the heat, this might be *Mary Barton* or *North and South*.

Yet the introduction of combustion into Dickens's novel is crucial. 'There is no punctual moment of disaster', writes Mark Fisher of crises under capitalism, in words particularly apt when it comes to soil exhaustion; 'the world doesn't end with a bang, it winks out, unravels, gradually falls apart'.[84] This is the case for Richard and Gridley, and would be true of *Bleak House* in general, of course, were it not for Krook. Spontaneous combustion has long been seen as 'a version […] of the corruption, decomposition, and dissemination Dickens describes' throughout the novel; to be more specific, however, Krook's combustion is a more rapid version of the eremacausis afflicting London itself. Krook, Richard, and Gridley are all consumed by combustion because they are unable to regulate their bodily and financial economies.[85] Like its analogue Chancery, Krook's shop consumes everything but gives back nothing of value; as with the 'mud' (13) that fills London's streets and gradually comes to dust through the narrative, the dirt and decay of Krook's shop is indicative of matter out of place, the systemic imbalance of an economy 'wasting away and going to rack and ruin' (70).[86] In this way, as Krook combusts on a 'tainting' (507) night, likely 'to turn […] the sewerage […] to account' (506) by spreading disease, the novel draws parallels between Krook's failing economy and the state of England's soils under capitalism. As Esther describes the 'strange lumber' (75) that litters Krook's shop, she draws attention, not only to

[83] Moore, *Capitalism*, p. 1.
[84] Mark Fisher, *Capitalist Realism: Is There No Alternative?* (Ropley, Hants: O Books, 2009), p. 2.
[85] For this argument made without my focus on soil and eremacausis see: Wilkinson, 'Faraday', pp. 240-43; MacDuffie, *Energy*, pp. 100-03.
[86] For more on the links between Chancery, Krook, and dirt see Blount, 'Dickens', pp. 193-200.

the materiality of is 'parchmentses and papers' (70), but specifically to the vegetal growth and soil fertility extracted in their creation.[87] Read for its analogy with Chancery as world-ecology, Krook's shop is characterised by a systemic imbalance between inputs and outputs that, as it recurs across variously sized systems throughout the novel, ultimately captures the exhaustion of soil in and through the capitalist economy.

'Only gradually and retrospectively does the force of the argument emerge from the profusion of example', writes Beer, in words meant for both Darwin's *Origin* and Dickens's *Bleak House*.[88] Her words capture Dickens's inductive movement from experienced particular to overarching meaning or truth about the state of the world under an extractive economy; as Grener finds of *Dombey and Son*, in *Bleak House* 'attention to a circumscribed milieu can nevertheless register the complex dynamics of capitalism'.[89] The correspondence between Dickens's narrators – of Esther's experience of the dirt in Krook's shop and the omniscient narrator's descriptions of mud in London – embeds this comparison of particulars into the structure of the novel, a point to which I return in conclusion. As Hack argues, Krook's spontaneous combustion is 'specific in nature and universal in reach', and thus, in *Bleak House*'s imaginary of exhaustion, becomes the visible expression of what happens to a system that extracts more from the soil than it returns.[90]

Critics have drawn out the Gothic aspects of the novel and Krook's death might here be read as a gothic eruption akin to the voice in *Jane Eyre*, in this case rupturing the normative surface of realism to register soil exhaustion that elides ordinary apprehension.[91] But then, as Ermarth shows, 'in Dickens it is the world entire that is intelligible'.[92] Krook's combustion is thus better read as an 'irrealist innovation' that, in WReC's terms, 'mediate[s] the lived experience of capitalism's bewildering creative destruction' in order to offer insight into the processes of 'the modern world system'.[93] This is what happens to that which is converted to capital with no regard for nature's laws of replenishment, the argument runs. To

[87] For more on the materiality of Krook's rags and papers see Patrick Chappell, 'Paper Routes: *Bleak House*, Rubbish Theory, and the Character Economy of Realism', *ELH*, 80.3 (Fall 2013), pp. 783-810, (789-90). Chappell's reading of the recycling of paper in the novel is more optimistic than my reading of exhaustion: 'Krook's picture, then, disrupts the impression that his shop epitomizes economic stagnation since it calls our attention to how a sheet of paper is only one phase of the material's longer lifecycle' (p. 794). As I show, however, any such recycling of materials ultimately exists within an extractive and exploitative economy.
[88] Beer, *Darwin's Plots*, p. 43.
[89] Grener, 'Mapping', p. 121.
[90] Hack, 'Allegory and Authority', p. 133.
[91] For more on the Gothic aspects of the novel, with a focus on the burial ground, see: Stolte, 'Putrefaction Generally', p. 420; Schülting, *Dirt*, pp. 92-5; Herbert, 'The Occult in Bleak House'.
[92] Ermarth, *Realism*, p. 182.
[93] WReC, *World-Literature*, pp. 77, 51, 50.

put this in ecological terms, by comparing systems that shift in scale, systems invariably found to be open and in a state of exhaustion, *Bleak House* arrives at the deeper structures of meaning hidden within observable reality. As the novel's inductive investigation concludes, then, England's soils are in a state of exhaustion under capitalism.

My next section examines soil and sewage as understood by Liebig and Lawes through the 1850s. The mid-century concerns over soil exhaustion, I show, examine the relations between the chemical circulation of matter and what will later be understood as entropy. Viewed in this light, one of the main subjects to which Liebig's organic chemistry spoke, and which is also one of the great concerns of *Bleak House*, is the nature of relations between matter and energy. These are the relations dramatised in the combustion of Krook's body and debated in the controversy that ensued; as Liebig's theory of eremacausis suggests, to think through questions that soon formed the field of energy physics was, in the early 1850s, partly to think with chemistry.

In the world of Dickens's novel, as soil becomes a site of slow combustion, a chemical understanding of circulating matter comes up against a nascent sense of energy transfer. This discordance is what differentiates Dickens's understandings of soil depletion from Gaskell's; as nutrients stagnate, energy becomes inaccessible to human use, accelerating a 'universal' process whereby 'all things of earth' are coming to dust. In this way, as Dickens's inductive realism in *Bleak House* stands in opposition to Liebig's deductive method, so his novel arrives at the truth of soil exhaustion years before Liebig would come to the same conclusion. As regards this chapter's ecology of literature and science, their mutual admiration not only points to how the form of *Bleak House* engaged with Liebig's scientific method, but how the novel's investigation of soil possibly impacted Liebig's scientific understanding. *Bleak House* now offers a way in to understanding Liebig's 'capitalization' of soils, and it was reading Dickens's novel that I suggest, in turn, helped to shape Liebig's understanding of soil exhaustion.[94]

Soil Exhaustion and the Chemical Economy

The opening of *Bleak House* has been read by several scholars as a vision of ecological exhaustion. Imagery surrounding 'the death of the sun', for Taylor, 'echoes the heat death promised by the second law of thermodynamics, which also fuelled anxieties about the exhaustion of the coal supply'; Dickens's famous 'Megalosaurus', according to MacDuffie,

[94] Moore, *Capitalism*, p. 111.

'is a vision of a dislocating ecological breakdown'.[95] Less obviously, though arguably more pervasively, similar concerns are evoked through mud; in a vast extension of *Mary Barton*'s Manchester cellar, the extraordinary quantities of soil accumulating in London suggest a corresponding agricultural depletion that, as I have shown, *Bleak House* will repeatedly confirm:

> As much mud in the streets, as if the waters had but newly retired from the face of the earth, and it would not be wonderful to meet a Megalosaurus, forty feet long or so, waddling like an elephantine lizard up Holborn Hill. Smoke lowering down from chimney-pots, making a soft black drizzle, with flakes of soot in it as big as full-grown snow-flakes – gone into mourning, one might imagine, for the death of the sun. Dogs, undistinguishable in mire. Horses, scarcely better; splashed to their very blinkers. Foot passengers, jostling one another's umbrellas, in a general infection of ill-temper, and losing their foot-hold at street-corners, where tens of thousands of other foot passengers have been slipping and sliding […] adding new deposits to the crust upon crust of mud, sticking at those points tenaciously to the pavement, and accumulating at compound interest. (13)

Dickens here captures the state of soil in a capitalist world ecology. Many scholars have examined this mud and mire as the accumulated excrements of humans and animals, and the ecological exhaustion of the novel's opening cannot be fully appreciated without understanding how nutrient circulation is disrupted by the growth of London as capitalist assemblage.[96] The movement and exhaustion of people and soil nutrients is constituted in and through the mutually supporting logic of financial and bodily economies. Describing 'deposits' of 'mud […] accumulating at compound interest' in the city, *Bleak House* thus offers something of Moore's movement of capitalism in nature, and nature in capitalism; the 'law and equity' of Chancery and 'the street mud', the novel makes clear, are 'kindred mysteries' (163). As human and animal excrement collects on Holborn hill, nutrients are remade in the language of capital, even as this fertility becomes unavailable for human use. There is an awful correspondence between liquidating soils as capital and liquefying nutrients as sewage.

A similar logic of capital circulation and accumulation pervaded Liebig's science. His inorganic mineral theory conceptualised soil as a bank account, a simple system of inputs and outputs. 'We could keep our fields in a constant state of fertility by replacing every year as much as we remove from them in the form of produce', he wrote in *Organic Chemistry*, 'but

[95] Taylor, *London Fog*, p. 34; MacDuffie, *Energy*, p. 93.
[96] Michael Steig, 'Dickens' Excremental Vision', *Victorian Studies*, 13.3 (March 1970), pp. 339-54; John Sutherland, 'What is Jo Sweeping?', in *Is Heathcliff a Murderer? Great Puzzles in Nineteenth-century Fiction* (Oxford: Oxford University Press, 1998), pp. 90-98; Taylor, *London Fog*, p. 35.

an increase of fertility, and consequent increase of crops, can only be obtained when we add more to them than we take away'.[97] This deduction implied that animal manures were of little value:

> The animals fed on these fields yield nothing to these soils which they did not formerly possess. The weeds upon which they live spring from the soil, and that which they return to it as excrement, must always be less than that which they extract. The field, therefore, can have gained nothing from the mere feeding of cattle upon them; on the contrary, the soil must have lost some of its constituents.[98]

Following this logic, and of course contrary to experience, livestock were seen to drain soils of their nutrients. Not only were animals understood as extractive rather than restorative, but if plants could only feed on soil nutrients in inorganic form, then the more complex organic compounds found in manure could be of no value unless broken down.[99] Counterintuitively, then, soils were inorganic spaces and needed to be kept as such if plants were to thrive.

Dickens advanced this view in *Household Words* in 1856: 'No modern discovery in chemical science promises to exercise a more immense influence over the welfare of nations than this observation of Liebig – that plants, although feeding upon air, take, each of them from the earth, mineral substances', explained 'Minerals That We Eat'; 'The impoverishment of fields by successive crops means only the exhaustion of the mineral components of the soil, and the whole business of the agriculturist is to restore continually to the fields, in a proper form, those minerals which his crops withdraw'.[100]

As one contemporary reviewer put it, Liebig's theory explained 'the connection which subsists between the living plant, and the dead earth in which it grows.'[101] The logic of capital thus acted through chemistry to reduce soils from a diversity of vital natures to potential production. If *Bleak House* captures something of this 'capitalization' of soil fertility, then *Chemical Letters* made this logic explicit:[102]

---

[97] Liebig, *Organic Chemistry*, p. 182
[98] Liebig, *Organic Chemistry*, p. 150.
[99] Liebig could not have known that plants form symbiotic associations with microbial life to access these nutrients. Indeed, much of this microbial life is sustained by manure, and introduced to soils from the intestinal tracts of animals. While these relationships remain imperfectly understood today, it is now clear that chemical fertilisers and pesticides destroy soil life and therefore, in the long term, reduce soil fertility.
[100] Anon., 'Minerals that we eat. In Two Chapters. Chapter the First', *Household Words*, 24 May 1856, pp. 437-42 (438).
[101] Anon., ['A Kentish Farmer'], 'Works on Agriculture', *Manchester Guardian*, 22 November 1843, p. 5. Not that soils were dead in 1843, when these words were written, but that viewing soils as inorganic chemical systems would remake them as dead and dying spaces in the generations since through the application of pesticides and fertilisers.
[102] Moore, *Capitalism*, p. 111.

> [T]he farmer will be able to keep an exact record, of the produce of his fields in harvest, like the account-book of a well regulated manufactory; and then by a simple calculation he can determine precisely the substances he must supply to each field, according to the crops he has reaped, and the quantity of these, in order to retore their original fertility. He will be able to express, in pounds weight, how much of this or that element he must give to the soil in order to augment its fertility for any given plant.[103]

As Liebig had explained in *Organic Chemistry,* inorganic fertilisers, such as 'the salts of phosphoric acid', could be supplied by 'chemical manufactories'.[104] Thus, from the mid-nineteenth century, as Moore explains, 'fertility could be increased through the application of fertilizers as circulating capital'.[105] Liebig's meaning above is that the farmer can 'express, in pounds weight', what nutrients are required for an optimum crop and purchase them in exact quantities from the factory. The field thus becomes an extension of the industrial economic system, Liebig's chemistry of agriculture acting seamlessly alongside capitalism to integrate soils into the modern factory economy.

With the purported ability to quantify the nutrient potential of any soil, Liebig's chemistry reduced all soils to capital. By providing data on 'cultivated plants which have grown on all types of soils', organic chemistry ultimately facilitated the extension of a globalising agriculture that, as in the epigraph to my first chapter, might 'subdue and people the whole earth'.[106] 'These researches and experiments are the great *desideratum* of the present time', Liebig explained in *Chemical Letters*:

> TO THE UNITED EFFORTS OF THE CHEMISTS OF ALL COUNTRIES WE MAY CONFIDENTLY LOOK FOR A SOLUTION OF THESE GREAT QUESTIONS, and by the aid of ENLIGHTENED AGRICULTURISTS we shall arrive at a RATIONAL system of HORTICULTURE, and AGRICULTURE, applicable to every country and all kinds of soil.[107]

The boundless extractive potential of Liebig's chemistry is here made explicit. As his emphasis captures, the rationalisation of soil fertility by chemistry had the power to open 'all

[103] Liebig, *Chemical Letters*, pp. 519-20.
[104] Liebig, *Organic Chemistry*, p. 188.
[105] Moore, *Capitalism*, p. 107.
[106] James Finlay Weir Johnston, 'The Present State of Agriculture in its Relations to Chemistry and Geology. A Lecture delivered before the Society at the Meeting in York', *Journal of the Royal Agricultural Society of England*, 9 (1848), pp. 200-36 (200).
[107] Liebig, *Chemical Letters*, p. 520; emphasis in original. Liebig continued – 'and which will be based upon the immutable foundation of OBSERVED FACT and PHILOSOPHICAL INDUCTION' (p. 520; emphasis in original). This claim for inductive reasoning hid a largely deductive chemistry, examined more fully in chapter 4. As is obvious from Liebig's arguments regarding animal manure, the logic of his inorganic mineral theory challenged diverse areas of farming experience, rather than this experience informing the construction of his theories.

kinds of soils' in 'every country' for production. This is the science behind the globalising agriculture of the mid-nineteenth century, seen in the Canadian Agricultural College where Jem Wilson finds work at the end of *Mary Barton*. Capital and chemistry thus intersect, offering 'a way of organising nature' able to network the soil fertility of the entire globe in the creation of a capitalist world-ecology.[108]

While opening the world's soil fertility for agriculture, the imbricated logic of chemistry and capital at the same time penetrated to the molecular. The monetary economy here met and was supported by the providential logic of nature's economy. As explained in chapter 2, mid-nineteenth-century chemistry and Providence were mutually supporting in envisioning a circulatory chemical system of growth and decay.[109] In his 1855 paper 'On the Sewage of London', John Bennet Lawes examined wheat growth across the previous decade at his Rothamsted farm in Hertfordshire. His aim was to isolate the nutrients important for plant growth that sewage might provide, and he understood his results in terms of a providential circulation of chemical elements in various molecular combinations:

> The term *manure* includes a great variety of substances, from the disgusting mass of corruption, […] to the purest and most delicate crystallised salts. It is not one of the least of the many beautiful arrangements which we see around us whereby the Almighty has endowed the same particles of matter with the property of entering into a variety of forms […] In this ever changing circle, nothing is without its value, nothing is lost.[110]

Lawes's providential chemical cycle is a closed system. Ordained by 'the Almighty', this 'ever changing circle' of molecular transformation becomes a 'beautiful arrangement' when isolated through scientific inquiry. Chemical analysis here becomes the methodology required to uncover the workings of nature, understood to be in harmonious balance at the molecular level, with matter 'entering into a variety' of chemical combinations underpinning a providential natural economy, of which sewage is a crucial part.

If sewage flowing out to sea in the Thames severed a link in this natural economy, the prospect of harnessing it successfully for agriculture promised financial opportunity. As particles of matter 'enter into a variety of forms', Lawes wrote, they have an 'absolute value when considered in a scientific point of view' as well as a 'proper money equivalent' as 'articles of commerce'.[111] Forming part of a providential closed system, Lawes viewed

[108] Moore, *Capitalism*, p. 2.
[109] Hamlin, 'Providence and Putrefaction'.
[110] John Bennet Lawes, 'On the Sewage of London', *Journal of the Society of Arts*, 3 (1855), pp. 263-84 (263; emphasis in original).
[111] Lawes, 'Sewage', p. 263; emphasis in original.

manures as inexhaustible sources of fertility with the potential to generate correspondingly limitless commercial wealth. Conflating scientific and financial understandings of value and loss, this molecular understanding of a providential nature is entangled with capitalist economics. With grass fertilised by sewage manure 'peculiarly adapted for the production of milk' – one of 'few articles with which the inhabitants of the metropolis are so inadequately supplied' – the providential circulation of chemical elements through soils, plants, animals and people creates financial wealth by supposedly restoring healthy populations.[112] The manure trade is here brought under the legitimising hand of Providence, the social and ecological co-created as 'capital and power […] develop through the web of life'.[113] The logic of capital circulation and flow thus penetrates to the molecular, with providential chemistry underwriting, while simultaneously being directed by, capitalist economics.

Commercial opportunity saw Lawes enter the chemical-fertiliser industry in the 1840s. By mixing 'bones dissolved in sulphuric acid' with other organic materials, he manufactured his patented 'Super Phosphate of Lime' at a factory in London's Deptford, arriving independently at a process that Liebig had also suggested in 1840.[114] This commercial success, allied with his revolutionary Rothamsted field trials, led to Lawes being appointed a commissioner on the *Royal Commission on the Sewage of Towns* (1857-65). His early work with the Commission was reported in *Household Words* at the height of the Great Stink in July 1858, with Dickens publishing a second article in the same month advancing the providential chemical worldview to which Lawes adhered:[115]

> [G]rass, to be good for anything as nutriment, must itself be nourished and fattened up by fertilising atoms which have already served in the frame of some previous living organism. The physical circle whose laws we are compelled to obey, whether we like them or not, is a never-ending round of absorption, digestion, assimilation, and rejection; of birth, growth, increase, life, death, decomposition, and dispersion; and then of life and growth again.[116]

In articulating this vision of circulatory chemical combination, the article reported that London's sewerage system failed to adhere to the 'wisdom of Providence'.[117] 'A]llowed to

[112] Lawes, 'Sewage', p. 277.
[113] Moore, *Capitalism*, p. 26.
[114] See Brock, *Liebig*, pp. 121-29; E. John Russell, *A History of Agricultural Science in Great Britain* (London: George Allen & Unwin, 1966), pp. 92-97.
[115] For the work of the commission see Anon., 'A Way to Clean Rivers', *Household Words* (10 July 1858), pp. 79-82 (81).
[116] Anon., 'Dirty Cleanliness', *Household Words*, 24 July 1858, pp. 121-23 (122). In this idea of 'dirty cleanliness' there is once again the suggestion that purity could be found in and through soils, as examined in chapter 2.
[117] 'Dirty Cleanliness', p. 122.

flow into the river', sewage was 'a loss to the community' at once financial, agricultural and, potentially, terminal for the health of the nation.[118] If it was not possible 'to get rid of [sewage] usefully' as manure, the article argued, 'the whole machinery of agricultural and horticultural production must stop', resulting in 'utter sterility' and 'famine'.[119] As I show in my next section, these issues of sustainable sewage disposal, agricultural production, and food consumption find expression through a chemical discourse strikingly similar to Lawes's in *Our Mutual Friend*.

Yet, through the 1850s, Liebig became increasingly concerned by what can be seen today as the ecological implications of capitalism's treatment of soil nutrients. His writing on soil exhaustion both diverged from and upheld the established understanding of chemical circulation, suggesting what I call his thermodynamic awareness. As is evident from his theory of decay as eremacausis, Liebig's chemistry related to questions that soon came to occupy the field of energy physics. In 1852, William Thomson published a paper explaining how the usable – or 'potential' – energy available in systems always reduces over time.[120] Although Thomson didn't use the term entropy (it would not be coined until 1867), he described what would come to be the second law of thermodynamics.[121] In 'On the Dynamical Theory of Heat', published just months earlier, Thomson had highlighted statements in Liebig's work that, in his words, 'virtually imply the convertibility of heat into mechanical effect'.[122] Thomson was not alone in using Liebig's science to think through the questions of emerging thermodynamics.[123] While I agree with Libb Thims that energy physics began to have a profound effect on chemistry from the 1870s, (when thermodynamics revolutionised how chemical reactions were understood in terms of energy and entropy), so Liebig's chemistry was important for those such as Thomson who were thinking through the relations between matter and energy two decades earlier.[124] Critical work on nineteenth-century chemistry has, thus far, emphasised Liebig's foundational role in

[118] 'Dirty Cleanliness', p. 122.
[119] 'Dirty Cleanliness', p. 122.
[120] William Thomson, 'On a Universal Tendency in Nature to the Dissipation of Mechanical Energy', *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science*, 47 (1852), pp. 304-06 (306).
[121] See Gold, *Thermopoetics*, p. 8.
[122] William Thomson, 'On the Dynamical Theory of Heat, with numerical results deduced from Mr. Joule's equivalent of a Thermal Unit, and M. Regnaults Observations on Steam', *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* (July 1852), pp. 8-21 (10).
[123] James Joule's writings on sewage, for example, contain numerous references to Liebig's ideas on combustion. James Joule, 'On the Utilization of the Sewage of London and other large towns', *Memoirs of the Literary and Philosophical Society of Manchester*, 15 (1860), pp. 146-60.
[124] Libb Thims, *Human Chemistry*, vol. 2 (Morrisville: Lulu, 2007), pp. 78-86.

propagating the providential view of chemical circulation.[125] I do not dispute this, but also believe that certainty in the closed chemical system was, for Liebig himself, undercut by his nascent awareness of thermodynamic energy transfer, which led to his concerns over soil exhaustion.

The outline of Liebig's thermodynamics awareness is evident in the 1842 edition of *Animal Chemistry*. It was this text that Thomson was referring to in 'On the Dynamical Theory of Heat', and Liebig's exact wording is as follows: 'When we kindle a fire under a steam-engine, and employ the power obtained to produce heat by friction, it is impossible that the heat thus obtained can ever be greater than that which was required to heat the boiler'.[126] By 1859, in a new chapter written for the fourth edition of *Chemical Letters*, Liebig was drawing on the pioneering work of physicist Robert Mayer to offer a clear expression of the first law of thermodynamics: any 'apparent annihilation' of energy was really 'only a conversion into some other form', he explained.[127] Matter is understood here in terms of energy transformation. Liebig's knowledge of the first law of thermodynamics does not automatically imply that he understood the second and the implications of entropic decay, of course. But at the same time, his chemistry certainly moved in the direction of thermodynamics, as evidenced by Thomson referring to his writing only three months before publishing his own revolutionary theory of energy degradation.

With matter understood in terms of energy transfer, Liebig's certainty in closed chemical cycles seems to have been undermined by the suggestion of irreversible energy change through the system. This is suggested in a letter he wrote in 1859, on the subject of sewage, to the English agriculturist John Mechi. Published in *The Times*, Liebig bemoaned 'indifference to the future' within the British agricultural community, arguing that sewerage infrastructure was leading to an 'irretrievable' waste of nutrients:[128]

> [Farmers] think that they may continue to take from the field as long as there is anything left, and that it will be time enough to provide for this necessity [of soil restoration] when it knocks at their doors. They do not, of course, know how large

[125] See Hamlin, 'Providence and Putrefaction'.
[126] Justus von Liebig, *Animal Chemistry or Organic Chemistry in its Applications to Physiology and Pathology* (London: Taylor and Walton, 1842), p. 33.
[127] Justus von Liebig, *Familiar Letters on Chemistry, in its relations to Physiology, Dietetics, Agriculture, Commerce and Political Economy*, trans. by William Gregory, ed. by John Blyth, 4th edn (London: Walton and Maberly, 1859), p. 172. For more on this relationship between Mayer's and Liebig's science see Kenneth L. Caneva, *Robert Mayer and the Conservation of Energy* (Princeton: Princeton University Press, 1993).
[128] Justus von Liebig, 'Baron Liebig and Alderman Mechi', *The Times*, 23 December 1859, p. 6.

> their stock [of nutrients] on hand is nor are they aware that […] what they have wasted is irretrievable.[129]

Soil degradation moves in this passage from a transitory state of depletion to a terminal condition of exhaustion. MacDuffie is right to point out that Victorian theories of nutrient cycling often 'miss[ed] the irreversible dynamics of a new kind of energy economy', but Liebig here moves beyond the dominant discourse of chemical circulation in his fear of 'irretrievable' soil exhaustion.[130] This thermodynamic anxiety manifests as soil temporalities diverge. The harmony and balance of chemical circulation, where farmers always have 'time enough' to restore their land, is disrupted because soil change occurs not only via short-term molecular transformations.[131] As energy flows through soils but is not replaced in the form of manure, change occurs also in terms of longer-term energy depletion, with every harvest 'take[n] from the field' removing potential energy from the soil. For Liebig, if existing practices continued, 'complete exhaustion' was inevitable across Europe's soils within fifty years.[132]

I believe that reading *Bleak House* may thus have helped Liebig arrive at a conclusion at odds with chemistry's dominant understanding of nutrients circulating within a closed system. At the intersections of chemistry and thermodynamics, two ontologies appear at odds in both Dickens's novel and Liebig's science. *Bleak House* can be viewed as an examination of the relations between the chemical circulation of matter and what will soon become thermodynamic exhaustion – an investigation, as I have shown, that plays out through soil. Historians of science have revealed that Liebig's understanding of energy physics developed through the 1850s as he was exposed to work in the emerging field of thermodynamics.[133] For Brock, it was visiting Ireland in 1851 that 'first prompted Liebig's Malthusian views on the relationship between agriculture, prosperity, and the circulation of the elements'.[134] *Bleak House*, as a contemporaneous investigation of agricultural exhaustion, offers another

[129] Liebig, 'Baron Liebig and Alderman Mechi', p. 6.
[130] MacDuffie, *Energy*, p. 126.
[131] For further examination of soil temporalities see Maria Puig de la Bellacasa, 'Making time for soil: Technoscientific futurity and the pace of care', *Social Studies of Science*, 45.5 (2015), 691-716. For this relationship between closed renewal and restoration set against open violence and extraction, read via the respective ontologies of chemistry and thermodynamics, see Jim Scown, '*Our Mutual Friend* and the Chemistry of Sewage, Soils, and Circulation', *Journal of Literature and Science*, 13.1 (2020), pp. 1-17 (15).
[132] Liebig, 'Baron Liebig and Alderman Mechi', p. 6. For the bearing of Liebig's thinking on Karl Marx's understanding of metabolic rift see Kohei Saito, 'Liebig and *Capital*', in *Karl Marx's Ecosocialism: Capital, Nature, and the Unfinished Critique of Political Economy* (New York: New York University Press, 2017), pp. 141-75.
[133] Vance M. D. Hall, 'The Role of Force or Power in Liebig's Physiological Chemistry', *Medical History*, 24 (1980), pp. 20-59; Caneva, *Mayer*.
[134] Brock, *Liebig*, p. 109.

plausible influence.[135] In the novel, as usable energy is seen to deplete through open systems, so the narrative troubles a chemical understanding of soil as a closed system where production may always be restored by inputting fertile matter. This imaginary of exhaustion clearly speaks to Liebig's understanding of 'complete exhaustion' above.

Read as an ecology of literature and science, Dickens's and Liebig's investigations of soil suggest mutual two-way influences at work across the construction of scientific knowledge and literary form. It is important to note that this claim is more tentative than that made in chapter 4 where, by placing Liebig's writing on scientific method alongside George Eliot's and George Lewes's theories of realism, I am able to trace such links with greater certainty. Nevertheless, if Liebig read *Bleak House,* (and there is strong reason to believe that he did), then he would have found an imaginary of exhaustion that clearly speaks to the developing direction of his science through the 1850s.

Yet while Liebig's concern over 'irretrievable' exhaustion suggests he held some thermodynamic awareness, his solution stepped abruptly away from a full avowal of entropic energy degradation. Arguing that sewage-manuring could circulate 'elements […] collected without loss, and every year returned to the fields', he brought the old certainties of providential chemistry to bear on his thermodynamic anxieties. These fields 'would then retain the power to furnish every year to the cities the same quantity of corn and meat', he wrote.[136] Liebig's closed system is a thermodynamic impossibility, but sewage appears as a route to reconciling the diverging ontologies of chemistry and thermodynamics. In his letter to *The Times*, nutrient cycles are neither entirely circular (chemistry) or linear (thermodynamics), but a mixture of the two; while failure to adhere to providential circulation leads to entropic soil degradation, uniting elemental fertility with soils indefinitely prevents thermodynamic exhaustion. There is a suggestion of what Gold calls 'thermodynamic optimism' here, with Liebig viewing local sewage-manuring as capable of resisting the universal drive to entropic degradation.[137]

Mechi published another letter on sewage manure from Liebig in 1863. Though chemical analyses suggested that sewage held quantities of ammonia and potash, they

[135] 'I am a friend of English literature, and I read almost more English than German works', Liebig wrote in 1867; 'Was Lord Bacon an imposter?', *Fraser's Magazine*, April 1867, pp. 482-95 (484). Sheridan Muspratt seems to have confirmed this when writing to Dickens in August 1851, although I have been unable to source Muspratt's original letter to find his exact wording. If these pieces of evidence are to be trusted, it is hard to imagine a novel such as *Bleak House* would have escaped Liebig's attention.
[136] Liebig, 'Baron Liebig and Alderman Mechi', p. 6.
[137] Gold, *Thermopoetics*, pp. 10-11. At the same time, although Liebig's knowledge of energy physics is clearly uncertain, his thermodynamic anxieties seem to suggest something of chemistry's coming thermodynamic revolution identified by Thims; *Human Chemistry*, pp. 78-86.

showed it to be deficient in phosphorous. Liebig argued that this was because animal bones, rich in this chemical element, could not find their way into the sewers.[138] Because Lawes's 'Super Phosphate of Lime' was rich in phosphorous, Liebig argued that combining this fertiliser with sewage would make an 'efficient and valuable' manure.[139] Other agriculturists went further, stating that lime could be used to separate fertile sewage matter from water, as an article published by Dickens in 1858 reported:

> London drainage on each side of the Thames could then be planned [… with sewage] to be carried directly into great reservoirs then precipitated with lime and got rid of: partly by the flow of the clear and practically harmless liquid into the stream of the Thames, partly by distribution of the deodorised mud for agricultural use.[140]

Liebig was rightly sceptical about the possibilities of precipitating sewage from water, (as was Lawes), but his 1863 paper similarly suggested that sewage might be rendered more valuable in molecular combination with lime-based fertiliser. Such chemical unions often evoked a sense of providential marriage, as in the 1858 *Punch* poem, 'Mechi the Mourner'. While an imagined Mechi laments 'phosphates […] going to the sea', he dreams of 'Ammonia / […] to a proper acid wed', hoping that his 'fallow fields' might provide a 'bridal bed'.[141] As my next section shows, this discourse of chemical marriage, and the wider agricultural tensions between chemistry and thermodynamics, find expression in *Our Mutual Friend*'s courtship plot through the 'union[s]' (812) of Lizzie Hexam and Eugene Wrayburn, Bella Wilfer and John Harmon.

But before turning to Dickens's novel, if the logic of economic liberalism was hardwired into Liebig's chemistry, then Liebig also become increasingly suspicious of laissez-faire economics when it came to the global trade in nutrients. His science thus occupied a point of tension between a productionism underwritten by Providence and an ecological awareness of depletion and finitude. At times, in fact, it becomes hard to distinguish between the two in Liebig's writing. His undoubted commitment to 'the concept of recycling' – his belief that Britain could produce all the food it required by using sewage as manure – also occludes the detail of the argument he presented in *The Times*, where he wrote that previous experience ought to have taught the farmer:[142]

---

[138] Justus von Liebig, 'Utilisation of Sewage', *Journal of the Society of Arts*, 11 (1863), pp. 655-57 (656).
[139] Russell, *Agricultural Science*, pp. 91-96; Liebig, 'Utilisation', p. 656.
[140] 'Clean Rivers', p. 81.
[141] quoted in Kingsley, 'Victorian high farming', p. 136.
[142] Brock, *Liebig*, p. 272.

> in what a condition of perpetual fertility he might have preserved his fields if the elements of the guano which he has transported in the shape of meat and products of his fields into cities were recovered and brought in a form which would admit of their being restored to his fields every year.[143]

Liebig's 'perpetual fertility' – a supposedly inexhaustible nutrient cycle that will be seen again in *Our Mutual Friend* – is founded here upon global nutrient extraction. Work on the nineteenth-century guano trade has demonstrated how the extraction and exhaustion of bird dung from Peruvian islands stimulated interest in sewage as manure.[144] In my chapter's epigraph, and in Liebig's writing above, 'guano' shifts from referring to a resource imported from abroad to 'home-made sewage'.[145] But as the signifier 'guano' shifts referents, the co-development of chemical science and capitalist economics, shaping and being shaped by nutrient circulation, elides nutrient extraction from across the globe.

As an 1865 article Dickens published in *All The Year Round* explained, it was not only guano but bones and mineral phosphates that offered farmers 'portable manure […] imported from South America'.[146] 'The trade in imported and artificial manures has becomes enormous', the author of 'Artificial Fertility' explained; it is this relationship, between the regional circulation of nutrients and their transcontinental extraction, that is important for understanding the circulation of dust and sewage in *Our Mutual Friend*.[147]

Circulating Nutrients in *Our Mutual Friend*

Questions of sustainable soil use in Dickens's final completed novel relate to a long history of critical readings of waste in *Our Mutual Friend*.[148] More recently, scholars have turned attention from the novel's prominent dust mounds to its river and sewage.[149] Bringing these critical perspectives together, Catherine Gallagher has shown 'the book's obsession with the place of human bodies inside systems of economic accumulation and exchange'.[150] As Jules Law writes, 'bodies in the novel are placed in circulation, and fluids are the medium of that

[143] Liebig, 'Baron Liebig and Alderman Mechi', p. 6.
[144] Kingsley, 'Victorian high farming', pp. 126, 138.
[145] 'Restoration of Our Soil, part II', p. 318.
[146] Anon., 'Artificial Fertility', *All the Year Round*, 11 March 1865, pp. 157-64 (159).
[147] 'Artificial Fertility', p. 160.
[148] Sucksmith, 'Dust-Heaps'; Metz, 'Reclamation of Waste'; Toker, 'Decadence and Renewal'.
[149] Michelle Allen, *Cleansing the City: Sanitary Geographies in Victorian London* (Athens, OH: Ohio University Press, 2008); Mary L. Shannon, 'The country in the city: Dickens and the idyllic river', in *Victorian Sustainability in Literature and Culture*, ed. by Wendy Parkins (London: Routledge, 2018), pp. 105-25; Ursula Kluwick, 'The cultural sustainability of Victorian waste', in *Cultural Sustainability: Perspectives from the Humanities and Social Sciences*, ed. by Torsten Meireis and Gabriele Rippl (London: Routledge, 2019), pp. 183-92; Jules Law, *The Social Life of Fluids: Blood, Milk & Water in The Victorian Novel* (Ithaca, NY: Cornell University Press, 2010), pp. 46-68.
[150] Gallagher, *Body Economic*, p. 93.

circulation'.[151] When it comes to nutrients, it is the relationship between the regional focus of the upper Thames and the more international focus of the lower Thames that my reading examines; even amidst Oxfordshire farmland, Dickens reminds his reader, 'the river […] flow[s] on to the vast ocean' (736), suggesting a global extension of nutrient circulation. I reveal that this relationship between the regional and the global is examined in the novel's marriage plots. In exposing this focus of Dickens's novel, my reading also differs from existing studies by situating *Our Mutual Friend*'s imaginary of waste and recycling within a global context. Thus, while I agree with claims made by Schülting and many others that 'an economy of recycling […] is of crucial importance for the novel', I am less optimistic about the socioecological implications of the novel's efforts to harness the waste of capitalist economics.[152]

The novel begins with Lizzie Hexam and her father, Gaffer, 'float[ing] on the Thames' (1). Taylor rightly notes that *Our Mutual Friend* offers little direct description of the excrement that filled the river, but here 'the filthy water' leaves Gaffer with 'wet and dirty arms' (3) in what Michelle Allen notes is a clear allusion to sewage.[153] Father and daughter make their 'living' (3) by removing anything of value from the water. The excremental foundations of this economic relationship are suggested in Gaffer's clothing, seemingly 'made out of the mud' (2), with the pair 'allied to the bottom of the river […] by reason of the slime and ooze' (1) in which humans and boat are covered. Material connections between bodies and sewage are affirmed as Gaffer tells Lizzie that 'the very river' is 'meat and drink' (3) to her.[154] His words slip between the literal and metaphoric, drawing on the idea of Thames sewage as wasted manure in linking the river's excremental filth with its potential fertility. As Ursula Kluwick argues, 'the Thames emerges as extraordinarily fertile', but the Hexams are sustained within a nutrient cycle that shifts in scale as Gaffer discovers a body, later (wrongly) identified as John Harmon's.[155] Formerly a 'farmer' (15) in South Africa, Harmon's past suggests colonial agricultures linked to London via the 'tiers of shipping' (1) lining the river in which his supposed corpse is found. In taking coins from this body's pockets, Gaffer draws sustenance from a river where productivity is enmeshed within geographies stretching far beyond the parameters of Southwark and London Bridges,

[151] Law, *Social Life of Fluids*, p. 55.
[152] Schülting, *Dirt*, p. 32.
[153] Taylor, *London Fog*, p. 60; Allen, *Cleansing the City*, p. 86.
[154] This has also been read in terms of cannibalism. See: Law, *Social Life of Fluids*, pp. 54-55; Gallagher, *Body Economic*, p. 94.
[155] Kluwick, 'Victorian waste', p. 189.

'between' (1) which the novel's opening chapter is nominally set. The Hexams are thus sustained upon waste inherent to the globalising economics of mid-century agriculture, trade believed to make Thames sewage, as Liebig was reported as stating in *Household Words*, 'the most valuable manure in the world'.[156]

Our Mutual Friend's second chapter turns from the river to a high-society dinner. The Veneering family's butler is here introduced as 'a gloomy Analytical Chemist; always seeming to say, after "Chablis sir?" – "You wouldn't if you knew what it's made of"' (10). Michael Cotsell here correctly draws attention to the role of Victorian chemists in detecting adulterated food, but the novel's chemical analysis is meant to extend far beyond food adulteration, as Lady Tippins's experimental chemistry suggests:[157]

> Lady Tippins has made a series of experiments on her digestive functions, so extremely complicated and daring, that if they could be published with their results it might benefit the whole human race. Having taken in provisions from all parts of the world, this hardy old cruiser has last touched at the North Pole. (11)

Dickens applies chemical investigation to both food and excrement, as did Lawes; as Jules Law notes, 'the Veneering parties begin to sound like a chemical experiment'.[158] The chemical poetics of the novel's experiment extend beyond Lawes's science, however, by beginning to isolate the locations where fertility originates and – once consumed by Tippins – to where it might disperse. Tippins is sustained upon globalised agricultures as she digests food and drink 'from all parts of the world', linking her consumption to the excremental river of the first chapter. In the midst of her 'experiments', she introduces a discussion of Harmon's origins as a 'small proprietor, farmer, grower' (15). The analytical method with which she is associated here 'fix[es] him with a local habitation' in 'the country where they make the Cape wine' (13). Chemistry thus analyses both wine and sewage as related links in a global nutrient cycle shaped by capitalist economics, bringing agricultural produce to London only to see fertility disperse in the Thames.

The 'Analytical Chemist' remains ever-present as Tippins enjoys 'the fruits of the earth' (411) and consequently suffers from a 'chronic state of inflammation' (618; see also 121, 209, 250-53, 619). He serves quantities of 'claret' (14), 'madeira' (15), 'curacao' (118), and 'champagne' (120, 626), names that etch transatlantic economic links between London dinners and agricultures in Europe, the Caribbean, and Africa. His name is later shortened to

[156] Anon., 'The True Tom Tiddler's Ground', *Household Words*, 27 December 1851, pp. 329-32 (331).
[157] Michael Cotsell, *The Companion to Our Mutual Friend* (London: Allen and Unwin, 1986), pp. 26-27.
[158] Law, *The Social Life of Fluids*, p. 60.

'the Analytical' (114), a contraction that Nancy Metz writes 'illustrates metaphorically the process he is called upon to perform';[159] as he serves agricultural produce imported from across and beyond the British empire, the chemical method he represents traces links within these networks that begin to invoke what Moore terms 'modernity's projects and processes […] as environment-making processes'.[160] Wine is drunk as Cape wine production is discussed, linking dinner in a London borough and agriculture in Southern Africa such that consumption in the former drives environmental change in the latter. The extent of this change becomes clear when it is remembered that vines were imported to South Africa from Europe in the seventeenth century. Glimpsed here is what Kathryn Yusoff calls 'the massive transformation of ecologies in the movement of peoples, plants, and animals across territories, coupled with the intensive implantation of monocultures of […] "alien" ecologies'.[161] To analyse Chablis and discuss Cape wine, then, is to suggest the action of imperialism and capitalism on human and non-human ecologies across vast expanses of space and time.

Within London, Dickens's chemical poetics draw *Our Mutual Friend*'s famous 'Dust' (13) into the novel's agricultural investigations. While the presence of excrement in the dust mounds has been hotly contested, of greater interest here are the broader links between 'dust' and agriculture.[162] Cotsell notes that the novel's 'vegetable-dust' (13) was used as manure, and to this can be added the novel's 'bone-dust' (13).[163] As *All The Year Round* reported in March 1865 during the novel's serialisation, 'bone-dust restores to pastures the very constituents – phosphate of lime – that are removed by milk, butter, and cheese'.[164] Bones were valuable because of their phosphate content and were sold to manufacturers of artificial fertiliser, such as Lawes, who required phosphates (as the article also reported) to make 'super-phosphate' at his factory in Deptford.[165] Although Lawes's fertiliser had by the 1860s replaced bones with mineral phosphates, Liebig of course argued that combining this phosphatic fertiliser with sewage would make an 'efficient and valuable' manure.[166]

---

[159] Metz, 'Reclamation of Waste', p. 65.
[160] Moore, *Capitalism*, p. 34.
[161] Kathryn Yusoff, *A Billion Black Anthropocenes or None* (Minneapolis: University of Minneapolis Press, 2018), p. 17.
[162] For this debate see Sucksmith, 'Dust-Heaps'; Cotsell, *Companion to Our Mutual Friend*, pp. 30-33; Allen, *Cleansing the City*, pp. 86-87; Kluwick, 'Victorian Waste', p. 191. For more on this critical history, see Schülting, *Dirt*, pp. 44-45, fn. 69.
[163] Cotsell, *Companion to Our Mutual Friend*, p. 33.
[164] 'Artificial Fertility', p. 158.
[165] 'Artificial Fertility', p. 159. It was 'bone dust', as John Russell details, that Lawes began experimenting with on turnips in the late 1830s: Russell, *Agricultural Science*, pp. 91-96.
[166] Russell, *Agricultural Science*, pp. 91-6; Liebig, 'Utilisation', p. 656.

In *Our Mutual Friend*, as Leona Toker argues, to describe and process the contents of the dust mounds is to 'analyse' their contents in order to bring them into economic circulation.[167] Links to agriculture come to the fore as Silas Wegg reads to Mr. Boffin from Merryweather's *Lives and Anecdotes of Misers* (1850). Wegg details how 'one of Mr Dancer's richest escretories was found to be a dungheap in the cowhouse; a sum but little short of two thousand five hundred pounds was contained in this rich piece of manure' (482). '[B]ank notes and gold' are also found, but the most valuable source of wealth is clearly the 'rich piece of manure' (482) itself. This fertile matter realises financial value only when released from the miser's grip, the circulation of nutrients becoming entangled, as it was for Liebig and Lawes, within imbricated natural and capitalist economics.

Early in the novel, one of *Our Mutual Friend*'s principal characters, Eugene Wrayburn, introduces a discussion of 'Energy' (20) that further complicates this analysis of nutrient circulation. Dickens's capitalisation offers what John Parham terms a 'deliberate allusion' to thermodynamics.[168] MacDuffie goes further, uncovering how Eugene's words conflate scientific and economic definitions of waste and work as he flounders 'within a system of conservation and expenditure'.[169] Yet it remains to be noted that, while Eugene travels by coach through London to Limehouse, his thermodynamic discourse immediately precedes the novel's one direct reference to sewage:

> The wheels rolled on […] by the Docks; down by Ratcliffe, and by Rotherhithe; down by where accumulated scum of humanity seemed to be washed from higher grounds, like so much moral sewage, and to be pausing until its own weight forced it over the bank and sunk it in the river. (20-21)

The sewage that flows through this passage becomes 'moral' in its associations with energy physics. Fertile sewage matter disperses in the Thames, and this is simultaneously a 'moral' loss in its associations with the poor of Ratcliffe, Rotherhithe, and Limehouse. With links between sewage and chemistry already established, this population should be thought of within a 'residuum' discourse. Sarah Alexander shows how this term developed newly thermodynamic applications from the mid-1860s, when 'residuum' shifted from referring to a waste 'deposit or sediment' to suggesting that 'England's underclass' might be as 'irredeemable' as the chemical residue left by combustion.[170] The thermodynamic suggestion

[167] Toker, 'Decadence and Renewal', p. 51.
[168] John Parham, 'Dickens and the City: Science, Technology, Ecology in the Novels of Charles Dickens', *19: Interdisciplinary Studies in the Long Nineteenth Century*, 10 (2010), pp. 1-23 (8).
[169] MacDuffie, *Energy*, pp. 122-25.
[170] Sarah C. Alexander, 'The Residuum, Victorian Naturalism, and the Entropic Narrative', *Nineteenth-Century Contexts*, 35.2 (2013), pp. 99-120 (99).

of sewage as wasted energy is here applied to the proximate poor, identifying this population in terms of lost economic productivity. The simultaneous implication is that, as sewage disperses in the Thames, fertile nutrients might not deplete from chemical circulation temporarily, but disappear from human use entirely.

Eugene has long been seen to 'fade away' (122) through the novel, to wear down, and this depletion can be thought of as a dissolution of energy entangled with the flow of river. This is evident as Eugene and Mortimer Lightwood drink sherry in a pub on the Limehouse riverbank, a 'locality' afflicted by excess sewage:

> Lightwood helped him to some more of that stuff, but it had been cooling, and didn't answer now.
>
> "Pooh," said Eugene, spitting it out among the ashes. "Tastes like the wash of the river."
>
> "Are you so familiar with the flavour of the wash of the river?"
>
> "I seem to be to-night. I feel as if I had been half-drowned and swallowing a gallon of it."
>
> "Influence of locality," suggested Lightwood. (164)

Energy degradation is described above in the transfer of heat from sherry to its surroundings. In Eugene's earlier 'Energy' (20) passage, entropic depletion is linked to sewage via metaphor, whereas here Dickens uses the homonym 'Pooh'; Eugene's involuntary disgust at the cooling drink indicates, as Mortimer's subsequent question confirms, the excremental 'wash of the river'. As heat is lost from the sherry, potential fertility flows in the Thames, dissipations of energy meeting in the 'half-drowned' Eugene. In highlighting the thermodynamic similarities between the dissolution of Eugene's energies and the wasting of potential fertility in the river, boundaries between Thames water and human body begin to dissolve.

Eugene, Mortimer, and a Police Inspector here embark on what is described as an 'elaborate […] lime fiction' (162). They are attempting to apprehend Gaffer Hexam at his home in Limehouse because he is believed to be guilty of John Harmon's murder. The policeman suggests Eugene and Mortimer adopt disguises as 'two lime merchants' (160) to avoid arousing suspicion. Their disguise is suitable because 'the lime trade' fuels the Limehouse economy, with 'lime barges', 'lime-burners' and 'shipper[s] of lime' (160-1) all noted through the chapter. Though this lime draws on the imagery of disguise and illumination suggested by 'lime lights' (162), there is also a rich agricultural imaginary yet to be drawn out here. Limehouse lies near Deptford, where Lawes manufactured his 'Super Phosphate of Lime', and as Dickens invokes 'the principle which matrimonially unites

contrasts' (34) by having Lizzie and Eugene meet 'among the ooze' (164) of the riverbank, so begins a courtship that develops around a chemical discourse of precipitation centring on the excremental Thames.

In contrast to Eugene, Lizzie is remarkably 'firm' and 'fixed' (67) in her character. This 'fixed' nature suggests an ability to 'fix' Eugene chemically, depriving him of 'volatility and fluidity' in their union as a chemical compound.[171] A resident of Limehouse, Lizzie 'concentrate[s]' (235) Eugene's attention when they are 'brought into contact' (237), chemical stimulus evident in an earlier 'intensification' (166) of his character. Their bodies begin to merge as Eugene notes how 'that lonely girl with the dark hair runs in my head' (162); Lizzie herself senses changes in Eugene 'to be inseparable from some touch of their opposites in her own breast' (236). Precipitation culminates upstream where the Thames flows through Oxfordshire's 'pastoral and blooming' (522) farmland. Scholars have noted that the river links rural and urban in Dickens's work, and these 'deep green fields of corn, so prospering' (689), embody agricultural productivity (in metropolitan sewage) soon to be accessed in Lizzie and Eugene's chemical union.[172] Eugene's antagonist, Bradley Headstone, is jealous of this potential union, and his sudden attack, 'mashing [Eugene's] life' (698) on the bank of the Thames, seeks to dissolve distinctions between body and river completely (698). Eugene's blood forms 'dark red streaks' (700) in the water, but as bodily matter disperses in the Thames, Lizzie extracts his unconscious form from the river. Bodily dissolution continues in the days that follow, Eugene's brow moving 'like a shape made in water' (736) as his consciousness rises like 'a drowning man, to sink again' (740) in death. Lizzie's rescue and continued 'touch' (740) here denote chemical contact that restores Eugene amidst this dissolution. As she utters the words 'my dear husband' (753), a marriage 'blessed' by 'Providence' (742) secures the chemical bond between precipitate and matter suspended in solution.

As Bradley Headstone is drawn into this courtship plot, the novel develops Goethean chemical metaphors. Scholars have long understood Goethe's *Elective Affinities* (1809) as applying a discourse of chemical attraction and displacement to sexual unions.[173] Holly Furneaux, though not explicitly developing the chemical lineage of the term, uses the language of elective kinship to 'reveal the flexibility with which the Victorian family could

[171] 'Fix, *v.*', in *The Oxford English Dictionary* [online], < https://www.oed.com/view/Entry/70815> [Accessed 11 May 2021].
[172] Allen, *Cleansing the City*, p. 114.
[173] See Andrew M. McKinnon, 'Elective Affinities of the Protestant Ethic: Weber and the Chemistry of Capitalism', *Sociological Theory*, 28.1 (2010), pp. 108-26 (112-16); Thims, *Human Chemistry*, pp. 395-410.

simultaneously accommodate both heterosexual and homosexual eros' in Dickens's fiction.[174] A heterosexual Goethean chemical poetics direct the interactions of Lizzie, Eugene, and Bradley. Lizzie's rejection of Bradley's marriage proposal is prefigured as she 'detect[s] something that repel[s] her in [his] momentary touch' (229); while Bradley remains 'under the influence of some tremendous attraction' (397), he fails to 'form the connexion' (231) with Lizzie because the chemical bond between her and Eugene is stronger. This is because Lizzie and Eugene, as Lizzie's friend Jenny Wren identifies, are not of the same 'sort' (347). Bradley may be closer to Lizzie in social standing, but the class differential highlighted here provides the basis for chemical marriage. As Andrew McKinnon writes of *Elective Affinities*, 'those substances that have a "very remarkable" affinity for one another may interact not because they are the same, but despite being different'.[175] With elemental difference the basis for precipitation, Dickens's courtship plot develops the Goethean chemical tradition by bringing Eugene as dissolving matter 'into contact' (237) with Lizzie as suitable precipitate.

Our Mutual Friend's flows of energy deepen this examination of nutrient circulation. Living 'among the ooze' (164) in Limehouse and sustained upon the fringes of the capitalist economy, Lizzie has been seen to 'evoke the spectre […] of the prostitute'.[176] Implicated within the novel's thermodynamic residuum discourse, descriptions of Lizzie as 'a dark combination of traitor and pickpocket' (294), a 'horrid female waterman' (816) and a form of 'corruption' (339), unsettle her status as a symbol or 'purity' (695). (Although their class positions are different, Lizzie is not unlike *North and South*'s Margaret Hale, whose purity is brought into question but ultimately confirmed in contact with soil.) A resident of Limehouse, Lizzie is reminiscent of Lawes's manures, ranging from the 'mass of corruption' to the 'purest […] salts', and there is a parallel between the fertility Lawes finds in the 'disgusting mass' and Lizzie's release from the threat of 'moral sewage'.[177] While Lizzie describes how she is unable to 'make [a lady] of such materials as myself' (348), marriage to Eugene forms a productive compound that enriches both in linked moral, financial and biological senses. Lizzie's 'purity' is secured in marriage, akin to pure water flowing from precipitated Thames sewage. Read by Mary Poovey in terms of 'economic agency', if Lizzie is seen as a soil to be improved – 'I will try to improve myself' (753), she tells her new

[174] Holly Furneaux, 'Charles Dickens's Families of Choice: Elective Affinities, Sibling Substitution, and Homoerotic Desire', *Nineteenth-Century Literature*, 62.2 (2007), pp. 153-92 (158).
[175] McKinnon, 'Elective Affinities', p. 114
[176] Allen, *Cleaning the City*, p. 100; see also Gallagher, *Body Economic*, p. 116.
[177] Lawes, 'Sewage', p. 263.

husband – then Eugene's education moves her from the margins to the mainstream of the capitalist economy.[178] As for Eugene, he simultaneously accesses an internal 'mine of purpose and energy' (754) that signals both the economic productivity of the worker and stores of potential fertility precipitated from Thames water. (His improvement thus also suggests something of Margaret Hale's narrative, as hitherto inaccessible productivity is unleashed in chemical marriage.)

In this merging of chemical and thermodynamic discourses, the novel echoes Liebig by invoking the local application of sewage as a means to restore degraded soils. Bradley's attack leaves Eugene 'exhausted' (738), yet marriage to Lizzie restores him to 'energy' (754) and new life amidst 'blooming' (522) and 'prospering' (689) farmland. Bradley is similarly 'exhausted' (639) and depleted of 'resources' (395), but instead drowns with Rogue Riderhood 'under the ooze and scum' (802) of the upper Thames, in the midst of countryside figured as a 'white and yellow desert' (801). As signalled by their death in Thames mud, Headstone and Riderhood embody an entropic rupture of nutrient circulation, whereas Lizzie and Eugene's union, 'blessed' by 'Providence', secures a regional nutrient cycle between country and city.

I thus disagree with Gallagher's claim that 'Dickens's almost exclusive focus on London and its suburbs, combined with his desire to make a sensation and yet maintain his regard for "decency", led him away from the topic of manure'.[179] *Our Mutual Friend*'s movement between London and the upper Thames is in fact central to the novel's investigation of sewage, Lizzie and Eugene's marriage plot offering a way to examine the more indecent aspects of nutrient circulation; as my thesis shows, this is a recurring feature of mid-century realist novels, where courtship plots repeatedly offer examinations of the improvement ethos in its links to soils and dirt.

As Matthew Ingleby writes in discussion of Dickens's *The Haunted Man* (1848), 'Dickens saw chemists such as Lawes and Liebig as part of a liberal-progressive alliance in which he himself participated'.[180] This is true in *Our Mutual Friend*, where chemical precipitation offers a way to improve both sanitation and soil fertility. The technoscientific solutions presented by *Household Words* in 'Minerals That We Eat', potential remedies for

[178] Mary Poovey, *Making a Social Body: British Cultural Formation, 1830-1864* (Chicago: University of Chicago Press, 1994), p. 169.
[179] Gallagher, *Body Economic*, p. 108.
[180] Ingleby, 'Chemistry versus Biology', p. 109.

the soil exhaustion that afflicts *Bleak House*, become, in Dickens's latter novel, permanent solutions to agricultural production:

> Fleets traverse the oceans, labourers hew at beds of coprolite, […] and cunning chemists compound various forms of superphosphate, that the fields may receive this much needed nutriment. The full solution is not yet worked out; but its successful demonstration will restore to our exhausted lands and famished population, the agricultural riches and plenty which smile upon the virgin plains of the New World.[181]

It is this systemic incorporation of the world's nutrients into a global economy that, as I now show, gives *Our Mutual Friend* cause for hope regarding future soil fertility; Bella and John Harmon's marriage is essentially a scaling up of Lizzie and Eugene's solution to agricultural productivity. But it is also dependent on an economic liberalism that, as in Gaskell's and Brontë's fiction, achieves the appearance of a sustainable system by externalising harm.

Scholars have long seen similarities between the novel's courtship plots, with both John and Eugene escaping death in the Thames and being reborn through marriage.[182] When viewed chemically, however, John and Bella's courtship invokes a different method of 'proving' (373, 379, 772). Rather than forming a marital compound via precipitation, this chemical discourse aims to analyse Bella's 'quality' and 'content' before marriage.[183] John realises that a loveless marriage to Bella – though securing his inheritance and satisfying her 'mercenary' (208) desire to be rich – would 'degrade' each of them 'in the other's mind' (372). When Mr Boffin learns of John's true identity as heir to the dust business, he forms a plan to expose Bella to the corrupting influences of wealth, metaphorically applying 'the furnace of proof' to 'prove' (461) her innate goodness. Boffin is known throughout as 'The Golden Dustman', and his immense wealth stems from his expertise and experience in 'sort[ing] a lot of dust' (577) – isolating and analysing, among other things, the agricultural fertility held in 'vegetable' and 'bone dust'. This shift in chemistry's processes, from precipitating chemical combination to isolating elemental constitution, mirrors the ways Bella and John's courtship focuses the novel's analysis on nutrient cycles as they extend beyond Britain. Their marriage attempts a systemic extension of Lizzie and Eugene's precipitation, suggesting that the novel's wastes, in sewage and dust, might be harnessed in the form of agricultural fertility, imported to Britain from across the world.

---

[181] 'Minerals That We Eat', p. 438.
[182] Ermarth, *Realism*, pp. 204-05; Levine, *Dying to Know*, p. 153.
[183] 'Proof, *v.*', in *The Oxford English Dictionary* [online], < https://www.oed.com/view/Entry/152580> [Accessed 11 May 2021].

Long before she marries John, Bella enjoys dinner 'overlooking the river' (318) in Greenwich. Understood by scholars as reflecting 'the naval and mercantile pre-eminence of the British nation' and 'a place of benevolence and connection between strangers', the lower-Thames here offers an analysis of global nutrient circulation.[184] While Bella eats and drinks 'wine', she watches the 'ships and steamboats' that will extract this produce from other continents sail past her window. As these vessels make 'their way to the sea with the tide', she dreams of journeying with John 'to look after their vines' in South Africa, then of marrying 'a merchant […] so enormously rich that everything […] upon the river […] belonged to him', and finally of voyaging herself 'to fetch a cargo of sweet-smelling woods' from 'among the coral reefs and cocoa-nuts' (318-19). Paul Young argues that Dickens's fiction describes modern capitalism's 'chaotic, uneven, yet powerful imbrication of the local and the global', and Bella's reverie here blurs topographic and temporal scales as it entangles global natures, capitalist agricultures, and a London dinner.[185] This imbrication extends to 'the beggar-boys below the window', who 'put their heads in the mud' (319) in a futile search for sustenance. These children occupy, what WReC would call, a peripheral position on capitalist economics – a site where '"local" and "global" forces come together in conflictual and unsteady flux'.[186] Immersed in Thames sewage, they come into contact with nutrients imported to Britain but made inaccessible for human consumption as nutrient cycles become enmeshed with capitalist economics. The lower-Thames thus offers an image of the world's soil fertility channelled through London by a laissez-faire capitalism extracting, and wasting, nutrients from across the world.

As a former colonial farmer, John's associations with the river offer another perspective on this nutrient economy. When he is immersed in the lower Thames, John is 'driv[en] fast with the tide' amidst the global fertility that the river's 'tidal mud' (369-70) contains. This image is prefigured early in the novel, as news of his apparent murder spreads:

> Thus, like the tides on which it had been borne to the knowledge of men, the Harmon murder […] went up and down, and ebbed and flowed, now in the town, now in the country, now among palaces, now among hovels, now among lords and ladies and gentlefolks, now among labourers and hammerers and ballast-heavers, until at last […] it got out to sea and drifted away. (31)

Featuring in the same chapter as the novel's description of 'moral sewage', this passage functions by tracing sewage's dispersal once 'sunk […] in the river' (21). Lizzie and

[184] Allen, *Cleansing the City*, p. 89; Shannon, 'The country in the city', p. 110.
[185] Young, 'Dickens's World-System', p. 713.
[186] WReC, *World-Literature*, p. 67.

Eugene's marriage may evoke sewage harnessed as manure, but here it flows in 'town' and 'country' to no productive effect before dispersing 'out to sea'. As each independent clause suggests, while sewage may be the accumulated produce of all, its waste disproportionately affects certain populations; Shannon is right to note that Dickens's tidal river complicates links between rural and urban, but here it also disturbs distinctions between global and regional nutrient circulation.[187] Describing the local impact of global forces, these tides tie both Harmon and sewage to geographies beyond London. Local flows of nutrients, and their effects on local populations, are entangled with agricultures far beyond British shores.

Bella and John's marriage suggests a systemic harnessing of this nutrient fertility for agriculture. This is embodied in the birth of their 'inexhaustible baby' (755, 756, 766, 774), conceived as Bella's 'proving' nears completion. John tests for his wife's former mercenary characteristics once more, offering her a carriage so as not 'to soil' (681) her shoes, but Bella refuses, now preferring contact with soils – as her 'weeding and trowelling and other small gardening' (682) indicates. These small-scale associations with soils extend globally as Bella conveys news of her pregnancy to John via a description of an approaching child, borne 'by a ship upon the ocean' (688, 755). Recalling imagery introduced during the global Greenwich dinner, reproductive fertility here simultaneously signals agricultural fertility. Bella's proving mirrors the sifting of 'vegetable' and 'bone dust' for use as manure, and together with John's immersion in global sewage, they unite the novel's agricultural wastes in a fertile marriage. As part of *Our Mutual Friend*'s imaginary of nutrient waste, by averting the 'degrading' union John earlier fears, chemical combination addresses the threat of entropic soil degradation.

This is in effect what Anna Tsing would call a capitalist 'scaling up' of Eugene and Lizzie's solution to agricultural productivity, maintained via precipitation at the regional level.[188] The image is as 'Artificial Fertility' reported in *All The Year Round* six months before the novel's serialisation concluded – one of 'bones […] imported from every corner of the world'.[189] As the novel's dust and sewage meet in Bella and John's marriage, their fertility merges Liebig's hopes for sewage manure – enhanced with 'Super Phosphate of Lime' and offering 'perpetual fertility' – with the globalising forces of capitalist agricultural chemistry.[190] In an extension of 'the Analytical' focus supplied by the Veneering butler, the

[187] Shannon, 'The country in the city', p. 114.
[188] Anna Tsing, *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins* (Princeton: Princeton University Press, 2015), pp. 37-43.
[189] 'Artificial Fertility', p. 159.
[190] Liebig, 'Baron Liebig and Alderman Mechi', p. 6.

shortening and capitalisation of the baby's name to 'The Inexhaustible' (774, 777, 807-08) emphasises this in a formulation designed to underline the systemic harnessing of the world's so-called inexhaustible nutrients to sustain food production.[191]

My final section exposes the imperial violence that supports this vision of limitless agricultural productivity. But first, there is what Law calls a 'Dickensian surrealism' at work in *Our Mutual Friend*'s 'Analytical' butler, and the same might be said for the novel's 'Inexhaustible' baby.[192] Dickens's fiction again offers an irrealism that provides insight into a 'modern world system' inaccessible to everyday observation.[193] Where the 'ashes' that remain of Krook's combusted body offer the visible evidence of soil exhaustion in *Bleak House*, *Our Mutual Friend* re-instantiates the nutrient cycle, interrupted by Krook's shop as Chancery as extractive capitalism, by combining these inorganic remains with the organic matter of sewage. In the latter novel, the inductive investigation is structured across marital unions that serve as chemical unions; where Ada and Richard's failed marriage signals an unsustainable agricultural economy, marriage in *Our Mutual Friend* moves from systemic investigation to systemic solution.

But there is also the danger that this inductive realism can hide aspects of experience that are dangerous to ignore, and ultimately smuggle in the violence Dickens is trying to resist. For while *Bleak House* opens a tension between the circulation of matter in a system that seems to be closed and the dissolution of energy in a system that turns out to be open, *Our Mutual Friend* addresses this tension by working to close the wasteful economy by recycling waste. This is of course a laudable aim. But like Liebig in the early 1860s, Dickens's latter novel steps away from the more troubling implications of entropic decay by resorting to the established chemical narrative of providential nutrient circulation. In what Jameson calls Dickens's 'supremely "liberalist" and free-market society', this solution cannot help but export the violence of unsustainable nutrient extraction elsewhere.[194]

[191] This reading might be profitably extended to other characters in the novel. As Gallagher writes, 'Venus buys and sells body parts and also labors on them to make them dry, stable, and hence valuable. Of course, he also has a few fleshy organisms (various preserved babies), but most of his trade is in turning bodies into inorganic representations of themselves. […] The same drawing out of value from the organic body and storing it up, suspending it in inorganic forms, characterizes Jenny Wren's doll-making trade'. Gallagher, *Body Economic*, p. 96. For more on Venus and bones see Schülting, *Dirt*, pp. 37-38.
[192] Law, *Social Life of Fluids*, p. 60.
[193] WReC, *World-Literature*, pp. 77, 50
[194] Jameson, *Antinomies*, p. 129.

World-ecology in 'The World's Metropolis'

While suggesting inexhaustible fertility harnessed in Bella and John's union, *Our Mutual Friend*'s 'inexhaustible baby' is of course more accurately 'Inexhaustible' in her consumption and production; she produces an awful lot of noise and, presumably, excrement. As with the 'inexhaustible stores' (329) of paper that fill Krook's shop in *Bleak House*, apparent inexhaustibility in one place means extraction elsewhere. Baby Johnny – the other child to whom Mr and Mrs Boffin are devoted – offers *Our Mutual Friend*'s counterpoint to the 'inexhaustible' capitalist logic of globalised agriculture. Bella journeys from her Greenwich dinner to Johnny's bedside, where he dies as 'all the rest of his family' (198) have done before. The poor become the victims of economics that channel nutrient fertility from across the world only to distribute it unevenly; as John and Bella enjoy their wedding dinner, 'the boys down below' continue 'put[ting] their heads in the mud' (670) in search of sustenance. This inequality is emphasised by the fate of Johnny's grandmother, Betty. She looks to escape London to find work in a 'market-' or 'hop-garden' (384), but these 'market-gardens […] will soon die under [the railways]' (218), Dickens's narrator explains, and Betty's death in Lizzie's arms suggests that such small-scale agricultures are unlikely to survive for long alongside their globalising capitalist counterparts.

Mr Podsnap, whose fortune is made in 'Marine Insurance' (128), looks to 'Providence' to explain such 'people […] lately died in the streets of starvation' (140). While he is 'sustained upon commerce with other countries' (128), the poor live off 'fragments of orange-chests and mouldy litter' (730), the waste inherent to the global capitalist agricultures his business facilitates. Dickens's metaphor of degraded human life as 'rejected cabbage-leaf […] and damaged orange countenance' (729) draws further links between capitalism's wasteful channelling of soil fertility and the poverty that afflicts only certain populations in London.

Yet the novel, in its presentation of a systemic solution to this poverty, perpetuates the inequalities inherent to extractive agricultures. Tsing's work is pertinent here, identifying how 'seemingly scalable' capitalist modes of agriculture reshape ecologies.[195] In scaling from regional precipitation to the systemic harnessing of nutrients from across the globe, *Our Mutual Friend* does not eliminate inequalities and unsustainable extractions but exports them elsewhere; Thames sewage, although harnessed as manure having been digested by London's

[195] Tsing, *Mushroom*, pp. 37-43.

populous, remains the extracted 'fruits of the earth' (411).[196] Contrary to Schülting's recent argument, then, 'Harmon's trade in the leftovers, the refuse, and the excrement of London' cannot in fact be separated from 'international trade'.[197] Just as Podsnap's unerring capitalisation of London as 'The World's Metropolis' (132) seeks to collapse global and regional into a single formulation, the nutrient cycle the novel instantiates is tied to, and indeed predicated upon, the existing capitalist world-ecology for its ongoing productivity.

The entrenchment of this world-ecology is evident as John and Bella inherit the dust business at the end of the novel. They spend their newfound fortune on, among other things, 'tropical birds and beautiful flowers' (767); wealth here circulates globally, glinting in 'sunlight' after 'a long, long rust in the dark' (778). This financial circulation corresponds exactly with the instantiation of the nutrient cycle. John and Bella take possession of their fortune 'on the very day when the last waggon-load of the last Mound was driven out at the gates of Boffin's bower' (779). The logic of laissez faire once more penetrates to the molecular as it organises nature, nutrient and financial wealth brought into the 'sunlight' as crops and capital grow together. Capitalism and nature are thus co-constituting, seen as Bella and John return to Greenwich on their wedding day to eat 'whitebait' described as 'specimens of all the fishes that swim in the sea' (668). The systemic harnessing of nutrient fertility their marriage evokes enmeshes soils, plants, and animals into, what Moore would call, 'a web of life whose connections are much denser, more geographically expansive, and more intimate than ever before'.[198] *Our Mutual Friend*, detailing what might first seem to be an urban population isolated from agricultural production, presents instead a world-ecology where laissez-faire capitalism associates lives across the world through soils and their exploitation.

At this point, before continuing this reading with *Bleak House*, there are three points concerning *Our Mutual Friend* that I would like to make. The first addresses Karen Barad's challenge to representationalist realism; once more, the mid-nineteenth-century realist novel offers a world where material and discourse become co-shaping, in this case in the co-creation of an inorganic and inert nature and a particularly rapacious version of capitalism.[199]

[196] 'Restoration of Our Soil, part II', p. 318.
[197] Schülting, *Dirt*, p. 33.
[198] Moore, *Capitalism*, p. 12.
[199] As Parham writes, Dickens's 'melodramatic narratives dabble incessantly with the dark presence of an intangible, spectral, and menacing materiality in everyday life'. Parham's reading of *Bleak House* is especially valuable in response to Barad because, drawing on work by Lucy Bell, he keeps in mind 'that the "materiality of the social" is "inseparable from the sociality of the material"'; 'Bleak intra-actions', pp. 118, 116. Discourse acts in and through matter, in other words, just as matter acts in and through discourse, as I show in Gaskell's *Mary Barton* in chapter 2.

The novel as representation thus offers a valuable investigation of capitalism in nature and nature in capitalism, the movement that, Moore would argue, underlies socioecological breakdown in the modern world. This relates to my second point; recalling the narrative solutions of *Jane Eyre*, *Mary Barton*, and *North and South*, there is an unquestioned burden again placed on women to restore, renew, and reproduce life through marriage.[200] The twin threats of Lizzie's potential 'corruption' and Bella's 'mercenary' character are isolated and removed by a masculinist discourse of chemical science.[201] Chemistry's implicit subjugation of these women, and their transgressive qualities, is closely related to the subjugation of fertile natures for agriculture.[202] Which brings me to my third point; in *Our Mutual Friend*, precipitation serves as an 'elaborate […] lime fiction' (162), not only because the process ultimately failed to work, but because as a narrative solution it does not eliminate the extraction and violence the novel opposes but exports it elsewhere. As a fiction that elides exploitation, the novel's technoscientific solution to poverty externalises the harm it seeks to eliminate.[203] The novel is realist, then, because it captures lives lived in the Anthropocene, where each act has unforeseen, unintended, and often damaging consequences.

Such consequences, of course, are the abiding focus of *Bleak House*. 'What connexion can there be', the novel asks, 'between the place in Lincolnshire, the house in town, the Mercury in powder, the whereabout of Jo the outlaw with the broom, who had that distant ray of light upon him when he swept the church-yard step?' (256). Here again is Dickens's inductive movement between particulars to arrive at universal truth. This is complicated in *Bleak House*, however, because the novel is constructed of two narratives. If these questions of connection are the focus of Esther's account, she is not positioned so as to ask them outright as the novel's omniscient narrator does above. As I now show, her narrative

[200] Silvia Federici's analysis of capitalism's 'primitive accumulation' is pertinent here, uncovering how the 'sexual division of labour subjugat[es …] women's reproductive function to the reproduction of the work-force'. Silvia Federici, *Caliban and the Witch: Women, the Body, and Primitive Accumulation* (1998; New York: Autonomedia, 2017), p. 12. *Our Mutual Friend* thus reinforces dominant conceptions of male-female relations, with heteronormative marriage and male economic employment as moral restoration within capitalist economics. A similar argument regarding regeneration and renewal may be made for both Esther and Ada at the conclusion of *Bleak House*.

[201] As Levine writes, 'women are not experimenters but the object of experiment' in *Our Mutual Friend*. *Dying to Know*, p. 168.

[202] The novel's chemical courtship plots evoke conceptions of 'nature' and of 'wife' that, to borrow Val Plumwood's words, create a 'subordinate other encompassing and representing the sphere of materiality, subsistence and the feminine'. Val Plumwood, *Feminism and the Mastery of Nature* (London: Routledge, 1993), p. 3. See also Stacy Alaimo, *Undomesticated Ground: Recasting Nature as Feminist Space* (Ithaca, NY: Cornell University Press, 2000).

[203] Where Val Plumwood links the domination of women and nature, she highlights too how 'the labour of colonised non-western, non-white people' also 'gets subsumed […] into nature'. *Our Mutual Friend* is notable for the absence of these people, silenced in a world-ecology that exploits natures, and the lives playing out within them, for agricultural production. Plumwood, *Feminism*, p. 4.

investigation offers an inductive ecology of London life that both confirms and exists in tension with the novel's arguments regarding imperial improvement.

It is through Esther that *Bleak House* exposes the violence inherent in the improving cultivation of soil and people both at home and abroad. Early in the novel, Esther visits Mrs Jellyby's home, where she first hears of Jellyby's attempts at 'cultivating coffee and educating the natives of Borrioboola-Gha' (53). Jellyby works with 'a view to the general cultivation of the coffee berry – *and* the natives – and the happy settlement, on the banks of the African rivers, of our superabundant home population' (49-50; emphasis in original). As in Brontë's and Gaskell's fiction, the improvement ethos cultivates humans and natures across the world so as to sustain a 'superabundant home population' while also exporting this population to distant lands. For Jellyby, 'the coffee-bearing power of Borrioboola-Gha' (772) becomes a way to transcend Malthusian limits to growth, non-Europe a place to sustain Europe. Thus, as Jem Wilson and Mary Barton do the work of improvement in Canada, so Jellyby thinks of little else but 'manufacturing families anxious to understand the details of the Native and Coffee Cultivation question' (384) in Africa. Her fellow philanthropist, Mr Quale, even has 'a project for his teaching the coffee colonists to teach the natives to turn piano-forte legs and establish an export trade' (57). While the humour is typically Dickensian, the assimilation of people and nature into a capitalist world-ecology is clearly the aim.[204]

The scheme fails, Esther stresses, for two reasons. 'Borrioboola-Gha […] turned out a failure in consequence of the King of Borrioboola wanting to sell everybody – who survived the climate – for Rum' (987). Biting satire once more reveals the terrible propensity of this capitalist world-ecology towards violence. The manufacturing population of Northern England, 'one hundred and seventy families […] averaging five persons in each (381), are killed by the climate, while rum, presumably imported from the Caribbean, enacts the violence of transatlantic slavery in reverse by destroying the health of Africa's indigenous population with the produce of the colonial plantation.

[204] Coffee becomes an important signifier of Dickens's suspicions of improving cultivation through the narrative. Esther describes how 'Mrs Jellyby, sitting in quite a nest of waste paper, seemed to drink coffee all the evening' (58; see also 216, 477). Throughout the narrative, the characters associated with the consumption of coffee create little but disorder and waste. Harold Skimpole, who I come to below, also enjoys 'coffee' (673). Mr Turveydrop, whose 'Deportment' is 'improved by cultivation' (379), 'is very particular about his coffee' (231); Sir Leicester Dedlock is fond of 'coffee' (646) too, while Mr Tulkinghorn likes to have 'his steak or chicken brought in from the coffee-house' to accompany his 'old port' (352). Perhaps the only surprise is that Mrs Pardiggle, unstinting in her efforts to 'improve' (133) the Brickmakers and their families, and whose children are forced to give their 'pocket-money […] to the Tockahoopo Indians' (124), is not described as consuming coffee herself.

Yet Esther's principal critique is aimed closer to home. Mrs Jellyby – 'her attention […] absorbed by a young Borrioboolan on its native shores' (772) – neglects her own children. Esther describes them as the 'dirtiest little unfortunates' (51); living close to Holborn, the 'mud' of the novel's opening invades the family home, 'collecting dirt' (476) that coats the children (54, 216) and gives the rooms a 'marshy smell' (55), Esther implies, reminiscent of the 'climate' (54) of Africa. Disorder at home and disorder abroad are thus mutually constituted in and through the improvement ethos. One of Jellyby's children, 'self-named' (54) Peepy, is forced to wear the 'boots of a ploughman' (217), for though not stated by Esther directly, the 'raw sewage' of Holborn hill is collecting in the Jellyby household.[205] Thus, as Esther comments that Mrs Jellyby should 'begin with the obligations of home, […] and that, perhaps, while those are overlooked and neglected, no other duties can possibly be substituted for them' (83), her words refer principally to 'Peepy and the housekeeping' (58); but equally, they serve as a comment on the need to harness London's sewage for domestic agriculture before any thought can be given to the cultivation of coffee in Africa. There is, indeed, something of Liebig's coming arguments for agricultural self-sufficiency in Esther's 'attempt[s] to establish some order amongst all this waste and ruin' (480) in the Jellyby home. Once more, order can be achieved amidst the chaos of entropic decay, but only within a small and bounded system.

It is also Esther who realises the exploitative nature of Harold Skimpole's activities. Skimpole extracts funds by 'squeez[ing] Esther and Richard like a couple of tender young Saint Michael's Oranges' (101);[206] it is precisely this violence that he is forever seeking to hide in claiming to be 'a mere child' (89). 'Some men want legs of beef and mutton for breakfast; I don't', he explains. 'Give me my peach, my cup of coffee, and my claret; I am content. I don't want them for themselves, but they remind me of the sun' (673). Even were extraction to be sourced to the soil it is hidden by the sun, for Skimpole always denies the material production involved in what he consumes. His 'spontaneous' (89) consumption – notably of 'hot-house peaches' (284) and 'hot-house nectarines' that he inevitably refuses to pay 'some amiable gardener' (673) for – represent another 'fatally imbalanced economy' quite as destructive as Krook's.[207] Skimpole not only 'influences' (671) Richard's profligacy but introduces him to Vholes for the present of five pounds (605). And like the literary

[205] Taylor, *London Fog*, p. 35.
[206] Jarndyce here momentarily realises Skimpole's true nature, as Mr Bucket will later; 'Whenever a person proclaims to you "In worldly matters I'm a child," you consider that the person is only crying off from being held accountable' (875), he informs Esther.
[207] MacDuffie, *Energy*, p. 101.

tradition to which he alludes in framing 'this present shepherd, our pastoral Richard', as 'full of poetry' (593), Skimpole conceals the violence of his practices with the fiction of Chancery as 'a golden prospect' and a suitor 'bounding over the landscape' (604). His claims to having 'no idea of money' (90) are indeed akin to Vholes's claims to not being 'a man of capital' – useful fictions that hide the work of extraction.[208] Vholes's 'poor digestion' is another such fiction, Esther realises, as she watches the lawyer metaphorically 'swallow […] the last morsel of his client' (976) moments before Richard's death. Such fictions hide the violence inflicted on peoples and natures in the process of extraction.

These fictions are so destructive because they not only distract attention from systemic violence but allow it to continue and proliferate. 'Take the case of the Slaves on the African plantations' (295), says Skimpole. 'I dare say theirs is an unpleasant experience on the whole; but they people the landscape for me, they give it poetry for me' (295). He repeats this aesthetic rendering of plantation labour when discussing Jellyby's scheme: 'I can lie down on the grass – in fine weather – and float along an African river, embracing all the natives I meet, as sensible of the deep silence, and sketching the dense overhanging tropical growth as accurately, as if I were there' (91). Skimpole's focus on the aesthetics of distant lands and peoples is calculated to 'silence' indigenous and indentured perspectives on the colonial violence that sustains him. Yet while Esther comments on Skimpole's relationship with those such as Richard, whose exploitation is immediately obvious in its damaging effects, the closest her inductive investigation comes to condemning the violence of imperial extraction is in describing Mrs Jellyby's husband: 'As Mr Jellyby never spoke a word, he might have been a native, but for his complexion' (57). There is an implicit comment here on the silencing of exploited African peoples, but it is certainly not Esther's focus.[209] A tension thus begins to open in *Bleak House*, between Esther's inductive investigation, where the focus is on domestic improvement inside both the home and the nation, and a larger narrative whole where, as Ermarth states, 'the world entire […] is intelligible'.[210]

Before briefly unpacking this tension, it is important to note that Dickens is undoubtedly critical of the improvement ethos, especially as advanced under the guise of

[208] Jarndyce's failure to hold Skimpole 'an accountable being' (496) is thus part of the problem, as his own fiction about the east wind shows; 'he used the pretence to account for any disappointment he could not conceal, rather than he would blame the real cause of it, or disparage of depreciate any one' (102), Esther explains, offering characteristic insight into processes of extraction within the narrative once more.
[209] There are echoes of Major Bagstock's 'Native' in *Dombey and Son* here, 'whose silent suffering embodies the violence implicit in the operations of empire', Grener notes. 'Mapping', p. 125.
[210] Ermarth, *Realism*, p. 182.

religion.[211] The reverend Mr Chadband, for example, is 'rather a consuming vessel' and 'attached to no particular denomination' (303), *Bleak House* makes clear – the criticism being for all 'improving' (305, 314) religion focused abroad.[212] Religious faith here obscures the violence of imperialism with a providential narrative of effortless and spontaneous production; 'we derive the strength that is necessary for our limbs', Chadband preaches, 'from butter which is churned from the milk, which is yielded unto us by the cow, from the eggs which are laid by the fowl' (307). This is a fiction comparable to Skimpole's, hiding the labour of production and thus the terrible destruction that can accompany consumption:

> 'My friends,' says Chadband, 'we have partaken, in moderation' (which was certainly not the case so far as he was concerned), 'of the comforts which have been provided for us. May this house live upon the fatness of the land; may corn and wine be plentiful therein; may it grow, may it thrive, may it prosper, may it advance, may it proceed, may it press forward!' (313)

'Millions died', writes Mike Davis of the latter nineteenth century, 'not outside the "modern world system", but in the very process of being forcibly incorporated into its economic and political structures'.[213] If 'they died in the golden age of liberal capitalism', as Davis argues, then here is the providential logic of improvement and expansionism that sustained the economics of laissez faire at the ideological level.[214] Chadband's 'conversion of nutriment of any sort into oil' (307) has been noted by many scholars as a mirror of the 'stagnant sickening oil' left after Krook's combustion.[215] Thus, as he 'invests a little capital of supper in the oil-trade' (314), he simultaneously converts 'corn, wine, and oil' into 'what is much the same thing, money' (826). As with Krook, then, Chadband signals the extractive and wasteful economics of a capitalist world-ecology in its destruction of peoples and natures across the world.

Yet the violence of imperial improvement is not the primary focus of *Bleak House*. Dickens is not arguing that the improvement ethos is inherently problematic, I think, but that it is wrong to focus on the work of imperialism abroad when so much remains to improve at

---

[211] For more on this see Levine's reading of Bradley Headstone in *Dying to Know*, pp. 153, 155, 166.
[212] Dickens's satire is damming of organisations such as 'the Society for the Propagation of the Gospel in Foreign Parts'; Jo 'has no idea, poor wretch, about the spiritual destitution of a coral reef in the Pacific, or what it costs to look up the precious souls among the cocoanuts and bread-fruit' (258). As 'a vessel, Chadband is occasionally mistaken by strangers for a gentleman connected with navigation' (303), and thus serves a similar role in *Bleak House* to Podsnap's commerce, Bella's global Greenwich dinners, and Mrs Tippins's fondness for the 'fruits of the earth' in *Our Mutual Friend*, all of which trace networks of capitalist extraction.
[213] Mike Davis, *Late Victorian Holocausts: El Niño Famines and the Making of the Third World* (London: Verso, 2001), p. 9.
[214] Davis, *Victorian Holocausts*, p. 9.
[215] There are even resonances of eremacausis as Chadband is described 'dabbing his fat head for some time – and it smokes to such an extent that he seems to light his pocket-handkerchief at it' (412).

home. 'Better for the national glory that the sun should sometimes set upon the British dominions, than that it should ever rise upon so vile a wonder as Tom' (710), explains his omniscient narrator, describing the novel's famous East End slum, Tom-all-Alone's. While *Bleak House* is concerned with exposing violent relationships between extraction and exploitation as they play out through soil, this investigation is principally aimed domestically. This insular narrative focus is confirmed by the novel's account of crossing-sweeper Jo – 'not a genuine foreign-grown savage; he is the ordinary home-made article' (724). Spending his days in a futile struggle with the sewage of Holborn Hill, Jo is 'very muddy' (176) and 'dirty' (715). With his clothes 'like a bundle of rank leaves of swampy growth, that rotted long ago' (713), and his body 'like a growth of fungus or any unwholesome excrescence produced there in neglect and impurity' (714-15), the child is both site and sufferer of zymotic disease – which he contracts and then transmits to Esther via Charley.[216] Jo dies of 'fever' and 'starwation' (725) and Dickens, like Gaskell, thus registers the lived effects of metabolic rift as experienced by the English poor.[217] But like Gaskell's industrial fiction, in drawing the focus domestically, the novel cannot ultimately resist the violence it seeks to eliminate – and may even, inadvertently, help to perpetuate.

Jo 'afford[s] a subject which Mr Chadband desires to improve' (409). Living 'among the mud' (259), he seems similar to *Our Mutual Friend*'s Lizzie Hexam, perhaps even earthy Jane Eyre or purified Margaret Hale – a 'subject […] to improve' in contact with soil. But Jo, known in Tom-all-Alone's as 'the Tough Subject' (359), turns out to be a 'very, very tough subject […] to improve' (409). Constituted as the putrefying matter of the city, (as against the 'improve[d]' (576) lands of the Dedlock estate), Jo is more akin to Esther in *Mary Barton*; he too has internalised a discourse of putrefaction which acts alongside the material in the making of body and character – '*he feels that it is in his nature* to be such an unimprovable reprobate' (415; my emphasis). If Chadband, as he claims to be, is 'a harvest-labourer', then

[216] Jo, 'deplorably low and reduced' (724), shows again the pervasive discourse of 'low fever' (338) examined in my last chapter.

[217] Although my focus is not on Liebig's zymotic analogy in this chapter, it is important to note that this exploration follows a chemical imaginary, familiar from Gaskell's fiction, that draws once more on Liebig's science. Christopher Hamlin and Louise Henson have both rightly argued that, with its 'soiled' and 'decaying' (256) houses, Tom's propagates 'fever' (257, 338, 358, 493) that acts in terms of Liebig's chemical pathology; 'the people "have been down by dozens," and have been carried out, dead and dying "like sheep with the rot"' (358), the novel explains, using a simile that registers the action of putrefaction in the aetiology of urban fever while suggesting the agricultural resonances of zymotic disease. For as in Gaskell's fiction, if nutrients are not circulated for agriculture they putrefy in the city, forming 'stagnant […] mud' (711) that acts chemically across the urban population: 'There is not a drop of Tom's corrupted blood but propagates infection and contagion somewhere. It shall pollute, this very night, the choice stream (in which chemists on analysis would find the genuine nobility) of a Norman house' (710), *Bleak House* explains. See Henson, 'Victorian Chemistry', pp. 19-21; Hamlin, 'Providence and Putrefaction', p. 390.

his failed attempts at 'enrichment' (410) suggest not only 'an unimprovable reprobate' (415) but a soil beyond the means of cultivation. Jo's death again signals extinction as the reverse logic of improvement. It is this that draws Dickens's ire, leading to a critique of the improvement ethos, but in an exclusively English context:

> [Jo] is not one of Mrs Jellyby's lambs, being wholly unconnected with Borrioboola-Gha; he is not softened by distance and unfamiliarity; he is not a genuine foreign-grown savage; he is the ordinary home-made article. Dirty, ugly, disagreeable to all the senses, in body a common creature of the common streets, only in soul a heathen. Homely filth begrimes him, homely sores are in him, homely rags are on him: native ignorance, the growth of English soil and climate, sinks his immortal nature lower than the beasts that perish. (724)

While Dickens's omniscient narrator here reiterates Esther's domestic focus on 'English soil', Jo is of course not 'wholly unconnected with Borrioboola-Gha' – quite the reverse, in fact. The problem is that this focus, in its artificial distinction of 'homely filth' and 'native ignorance' from their 'genuine foreign-grown' iterations, can only glimpse how the violence this capitalist world-ecology perpetuates within London is inseparable from the 'growth' of identical violences on other continents.[218]

Parallels may be drawn here between Jo and Bertha Mason in *Jane Eyre*, or with John Boucher in *North and South*. Jo occupies a 'liminal' identity – between 'life and death', as critics have explained, but also 'all a going mad-like' (490) between colonising and colonised identities as he is rendered 'unimprovable' (415) by Chadband.[219] Yet this liminal position is also partly of the novel's making; Jo is a member of a 'tribe in […] difficulty' (716), *Bleak House* makes clear, but as a white English child at once 'not a genuine foreign-grown savage' (724). If Dickens is far more critical of the improvement ethos than either Brontë or Gaskell, his criticism seems less for the explicit act of pioneering on other continents, than aimed at those, (such as *Jane Eyre*'s St John Rivers), who expend their efforts on distant populations when so much remains to be improved at home. The novel thus seems caught within the thinking of the world-ecology it seeks to resist, perpetuating a domestic logic of improvement

[218] For more on this see Emily Waples, 'Breathing Free: Environmental Violence and the Plantation Ecology in Hannah Craft's *The Bondswoman's Narrative*', *Victorian Literature and Culture*, 48.1 (2020), pp. 91-126 (92). Hannah Craft's *The Bondswoman's Narrative*, written in the mid 1850s but not authenticated until 2002, was heavily influenced by *Bleak House* – containing 'explicit allusions […], revisions, and verbatim quotations' from Dickens's novel, Waples explains. If, as Waples argues, 'Craft's transatlantic transplantation of *Bleak House* posits the plantation as an open ecology in which both black and white subjects are constituted by the violence of slavery and its systems of transplantation', then to read the plantation back through Dickens's novel suggests how the open system of *Bleak House* struggles to contain the violence of the plantation economy, even as it tries to circumscribe Jo as a 'Native savage'.

[219] Schülting, *Dirt*, p. 91. Another of the novel's liminal characters is of course Nemo – or no one – and an argument might be extended in this colonial context that focuses on his use of opium.

that is co-dependent on the 'improving' work of cultivation, and of course extinction, abroad.[220]

Conclusion: Ecological Tensions

In socioecological terms, this makes Esther's retreat to Yorkshire with Allen Woodcourt a particularly ambivalent conclusion to the novel. Read favourably, with Esther 'intent upon the perfect working of the whole little orderly system' (603), the only way to resist the violence of the London-centred world economy is to step back from it. Esther knows all too well the suffering that exists, (she bears the scars of urban fever herself), but in an extractive and exploitative system, the individual can only address systemic violence within deliberately circumscribed bounds.[221] Viewed in this light, the novel is aware of its own limitations, and the move to Yorkshire serves as a comment on the economic system rather than an acquiescence to that system. Perhaps more so that Jane Eyre and Rochester at Ferndean, or Mary Barton and Jem Wilson in pastoral Canada, *Bleak House* is then aware of the contrived nature of this narrative closure – a closed system so obviously at odds with the open systems of extraction the novel repeatedly reveals and condemns. Read in terms of soil, order is restored within a local system where fertile matter is replenished. Such soil systems are in fact glimpsed throughout – the 'profusion' of Boythorn's 'kitchen garden' (288), the 'order' of Bleak House's 'farm-yard' (115), the 'market gardens down by Deptford' (317), all exist as small systems that for the time being resist the destructive logic of extraction. Within an extractive economy, such an argument runs, this is the best one can do. Read one way, then, the novel is aware of the open nature of extractive systems and suggests that, while the wider economy remains governed by extraction, personal solutions can only succeed in artificially bounded contexts.

But there must always be this awareness of continuing violence and exploitation, of the depleting health of natures and peoples within the capitalist world-ecology that Esther and Woodcourt seek to leave behind. 'He seems half inclined for another voyage', muses John Jarndyce, on Woodcourt's return from serving as a surgeon on a ship bound for India, 'but that appears like casting such a man away' (776). This ultimately seems to be Dickens's

[220] This can be viewed in line with a recent reading of *Dombey and Son* by Paul Young: 'Dickens's metropolitan, racially discriminative perspective on the modern world-system served to sanction and sustain the imperial forms of primitive accumulation, exploitation, and violence that were so central to the way in which the Victorians penetrated and networked the world', he argues. Young, 'Dickens's World-System', p. 705.
[221] In the thermodynamic contexts of waste and work, this is Gold's argument regarding *Bleak House*, a novel concerned, she argues, with 'the building of better engines' in a narrative context. Gold, *Thermopoetics*, pp. 187-223 (189).

view. Woodcourt's 'compassionate interest' (711) is better employed on those suffering at home. The danger here, as with Esther prioritising domestic improvement, is that England is seen as a closed system cut off from the imperial violences of colonialism and laissez-faire capitalism. Viewed another way, then, *Bleak House* seeks to remove its models of social good from the sites of exploitation, failing to recognise that such a removal is impossible – this world-ecology penetrates everywhere. Dickens thus falls back on a discourse of improvement within the circumscribed space of the home and the nation. If the London of *Bleak House* is synonymous with the world, Yorkshire represents little England, a retreat from the concerns of empire, and a failure to address the violence as it extends through the exploitative world system as gradually revealed by the novel's inductive investigation.

An analogy may be drawn here, as Parham has shown, between Esther's work as 'housekeeper' and the work of 'tending the environment'. He writes that 'her character represents […] the necessity of acting, however hesitant and contingent those actions might be, towards developing material *and* social ties that nurture rather than wither human and nonhuman life'.[222] Esther's inductive narrative method seeks to enact this ethic of care in writing. To be close to soil is to have a truthful understanding of the world; such is Esther's proximity to putrefying matter, in fact, that it is finally inscribed onto her pox-marked face via the smallpox she contracts in caring for Jo.

The violence of urban disease, inflicted here on the knowing self, reflects Esther's embodied position within the novel's inductive ecology. Her ethic of care might then also be approached in epistemological terms. As Esther is at pains to stress, her narrative is not 'invested with the merit of the whole system' (575), far less its apprehension. Even Inspector Bucket, 'cognisant of everything' (722) and with the famed ability to 'mount a high tower in his mind, and look out, far and wide' (864), cannot possibly perceive the vast extent of available relationships that form the novel, as his failed attempts to save Lady Dedlock's life demonstrate. The same is true, ultimately, for the novel's omniscient narrator, through which the violence *Bleak House* clearly opposes is smuggled back into the narrative in a colonial rather than domestic context. As Caroline Levine argues, 'the network's formal capacity for extension and contiguity pushes against even Dickens's deliberate nationalism'.[223] To know this network in its entirety is impossible, then, and to act with the confidence that one does is likely to result in unforeseen harm. As Levine puts it in *Forms*, '[b]y repeatedly offering and

[222] Parham, 'Bleak Intra-actions', p. 127; emphasis in original.
[223] Caroline Levine, *Forms: Whole, Rhythm, Hierarchy, Network* (Princeton: Princeton University Press, 2015), p. 125.

also suspending a knowledge of the networked social world, [Dickens] hints that his novel is not – and indeed never could be – complete or encompassing'.[224]

In a narrative split between Esther's situated account and a narrator that purports to omniscience, the epistemic tensions between networks that must escape total apprehension and the totalising aims of narrative closure are embedded at the heart of *Bleak House*. These tensions can be appreciated via the singular and comparatively straightforward narrative of *Our Mutual Frien*d. In *Dying to Know*, George Levine explains John Harmon's efforts 'to achieve the condition of the narrator – the only position within the narrative that, unobserved itself, allows vision of everything. Only from an omniscient standpoint can the action of the narrative, in all its complicated relations, be made comprehensible'.[225] If this vision of narrative complexity is substituted for the networked agency of socioecological complexity, however, any such view from nowhere is of course an impossibility. Thus, where Grener finds 'a purported omniscience that can represent connections between individuals and the social whole' in *Dombey and Son*, it is precisely the claim to know the world system in totality that, ecologically speaking, is the trap *Our Mutual Friend* falls into.[226] If the novel's visions of recycling appear sustainable, it is because, as with Thornton's dinner scheme in *North and South*, the focus falls on the local relationships and not the world system in which the novel's technoscientific solution sits.

But while making knowledge in *Our Mutual Friend* is all about 'being nowhere', for Esther understanding the world is always a question of interpreting, what Donna Haraway would call, 'views from somewhere'.[227] Esther never makes claims to total knowledge; 'I want to understand it', she says of the disorder of the Jellyby household, 'and *I can't understand it all*' (58; my emphasis). These words encapsulate the methodological underpinning of her inductive ecology – how Esther's narrative serves as an investigation of networked agency situated within the novel's 'web of different lives' (732). Her investigation runs parallel to the omniscient narrative, but without making the same claims to total apprehension, offering knowledge of the world that is contingent, partial, and subject to further revision. There are, indeed, echoes of Jane Eyre's 'felt experience' and Margaret Hale qualifying Thornton's hard 'science of trade' in the ways Esther's narrative qualifies the

[224] Levine, *Forms*, p. 130.
[225] Levine, *Dying to Know*, pp. 160-61.
[226] Grener, 'Mapping', p. 123.
[227] Levine, *Dying to Know*, p. 159; Donna J. Haraway, 'Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective', *Feminist Studies*, 14.3 (1988), pp. 575-99 (590).

objective perspective supposedly provided by *Bleak House*'s omniscient narrator.[228] To borrow Haraway's words, then, Esther attempts a 'better account of a world, in order to live in it well and in critical, reflexive relation'.[229]

A tension thus opens between the situated perspective of Esther Summerson, whose single consciousness must struggle to apprehend the world in which she is enmeshed, and the omniscient narrator, tasked with bringing the novel's vast array of characters, plots, and actions to a unified close. *Bleak House* is structured upon the relations between situated and universal knowledge. In this way, the novel fractures across two narrative wholes, one that adheres to partiality and the other to totality. This appears as a fault-line, recurring across mid-century realist novels, between the ecological conclusions they offer at the level of experience and the world systems they uncover and assimilate themselves to at the level of structure. Put another way, this is a tension between a novel's world as open ecology – what Beer calls 'activity [… that] ranges out towards infinity' – and a novel form governed by the need for narrative coherence and closure.[230] This tension lies at the heart of George Eliot's *Middlemarch*, a novel 'experiment' into the vexed relations at work across the open contingencies of the field and the closed investigations of the laboratory, as my final chapter now examines.

[228] Peter Garratt, *Victorian Empiricism: Self, Knowledge, and Reality in Ruskin, Bain, Lewes, Spencer and George Eliot* (Madison: Fairleigh Dickinson University Press, 2010), p. 29; Elizabeth Gaskell, *North and South*, ed. by Angus Easson, intro. by Sally Shuttleworth (1854-55; Oxford: Oxford University Press, 1998), p. 226. As Brooke D. Taylor argues, 'Dickens subordinates empirical science to other forms of cognition'; 'Spontaneous Combustion', p. 172.
[229] Haraway, 'Situated Knowledges', p. 579.
[230] Beer, *Darwin's Plots*, p. 40.

Chapter 4. Between the Ideal and the Real: Laboratory and Field in the Vital Soil of Eliot's Loamshire

> There is no one we are more charmed with than Liebig. Mr Lewes had no letter to him – we merely met him at an evening party – yet he has been particularly kind to us, and seems to have taken a benevolent liking to me. We dined with him and his family yesterday […] He looks best in his laboratory with his velvet cap on, holding little phials in his hand and talking of Kreatine and Kreatinine in the same easy way that well bred ladies talk of scandal.
>
> George Eliot, 'Letter to Sara Hennell', 10-13 May 1858.[1]

> Continued Respiration. Interrupted by a visit from Liebig who came to invite us to dinner today. […] Dinner very pleasant, and pleasant chat over coffee. Liebig gave me the proofs of some new Chemische Briefe to read, and on parting begged that he might see us very often "for you interest yourself in the same ideas, & like the same works of art and literature that I like."
>
> George Lewes, 9 May 1858.[2]

When George Eliot and George Lewes arrived in Munich in 1858, Justus von Liebig made a memorable impression on them both. Lewes's journal recalls that Liebig was quick to regale them with 'one of his recent discoveries in agricultural chemistry' when they met at dinner on April 24th.[3] Ten days later they spent 'one hour & a half' in Liebig's laboratory, where the chemist explained 'silver-mirror manufacture' and 'a new acid discovered in the urine of a dog'.[4] Far from discouraging future visits, Eliot and Lewes would regularly call on Liebig over the next few months, their discussions ranging far beyond chemistry to include 'all sorts of topics, scientific and philosophic', as Lewes put it.[5] And as Lewes's diary entry for May 9th shows above, Liebig was as delighted to discuss literature and art with Eliot and Lewes as they were to hear of his scientific work in the laboratory. These as yet unexplored intellectual associations mark a pivotal moment in each of their careers. In summer 1858, Eliot was putting her ideas regarding rural realism into practice in *Adam Bede*, Lewes was turning from

[1] George Eliot, 'Letter to Sara Hennell, 10-13 May 1858', in *Selections from George Eliot's Letters*, ed. by Gordon S. Haight (New Haven: Yale University Press, 1985), pp. 189-91 (190).
[2] George Henry Lewes, 'Journal X, 1856 July 24 – 1859 March 31', Yale University, Beinecke Rare Book and Manuscript Library, George Eliot and George Henry Lewes Collection, GEN MSS 963, Box: 37 (p. 100; emphasis in original).
[3] Lewes, 'Journal', p. 96.
[4] Lewes, 'Journal', p. 99.
[5] Lewes, 'Journal', p. 103.

literature and philosophy to the science of physiology, and Liebig was under increasing pressure regarding his chemistry in its applications to agriculture. In this chapter, I use their meeting as a staging point for an investigation of literary realism and chemistry in the Loamshire soils of Eliot's *Middlemarch* (1871-72).

Eliot's knowledge of nineteenth-century science, knowledge she shared with George Lewes, was unparalleled among the English realist novelists of the mid-nineteenth century. Her awareness of contemporary scientific discussions has been thoroughly examined in foundational studies by Gillian Beer, George Levine, and Sally Shuttleworth.[6] In more recent years, readings of Eliot's fiction have taken an increasingly ecological turn.[7] Yet, in this portrayal of a novelist immersed in the sciences and cultures of her time, it is easy to lose sight of the fact that, before she became George Eliot, Mary Ann Evans grew up on a farm. Her father was an agricultural manager in rural Warwickshire, seen by some as an influence on *Middlemarch*'s Caleb Garth.[8] Despite her links to farming, however, little work has been done on Eliot's engagement with the emerging mid-century science of agriculture, with those studies that do examine farming in her novels focusing almost exclusively on the labour and economics of the agricultural situation.[9]

By grounding Eliot's writing in the soils of Loamshire, I offer new insight on her work while speaking to the issues that have long occupied scholars of her fiction. My primary argument is that the ethical and epistemological concerns of *Middlemarch* must also be seen in terms of the practical work of managing the soil. The movement from Humphry Davy's *Elements of Agricultural Chemistry*, discussed in the novel's second chapter, to Fred Vincy's paper on the 'Economy of Cattle-Feeding and Cultivation of the Green Crops', described in the finale, captures so much of the novel. In the transition between these two texts, one real and the other fictional, there is a movement from eminent to ordinary, laboratory to field,

[6] Gillian Beer, *Darwin's Plots: Evolutionary Narrative in Darwin, George Eliot and Nineteenth-Century Fiction* (1983; Cambridge: Cambridge University Press, 2009), pp. 137-95; George Levine, *The Realistic Imagination: English Fiction from Frankenstein to Lady Chatterley* (Chicago: University of Chicago Press, 1981), pp. 252-316 (253-4); Sally Shuttleworth, *George Eliot and nineteenth-century science: the make-believe of a beginning* (Cambridge: Cambridge University Press, 1984).
[7] Devin Griffiths, *The Age of Analogy: Science and Literature Between the Darwins* (Baltimore: Johns Hopkins University Press, 2016), pp. 166-210; Jayne Hildebrand, '*Middlemarch*'s Medium: Description, Sympathy, and Realism's Ambient Worlds', *ELH*, 85.4 (Winter 2018), pp. 999-1023; John MacNeill Miller, 'The Ecological Plot: A Brief History of Multispecies Storytelling, from Malthus to *Middlemarch*', *Victorian Literature and Culture*, 48.1 (2020), pp. 155-85.
[8] Alan Mintz, *George Eliot and the Novel of Vocation* (Cambridge, MA: Harvard University Press, 1978), p. 136.
[9] Chinnie Ding, '"Myriad-Headed, Myriad-Handed": Labor in *Middlemarch*', *Studies in English Literature, 1500-1900*, 52.4 (Autumn 2012), pp. 917-36; Jayne Elisabeth Archer, Richard Marggraf Turley and Howard Thomas, '"Moving Accidents by Flood and Field": The Arable and Tidal Worlds of George Eliot's *The Mill on the Floss*', *ELH*, 82.2 (Summer 2015), pp. 701-28.

deduction to induction, ideal theory to real practice – arcs across Davy's and Vincy's scientific agricultures that correspond to other areas of the narrative. As *Middlemarch* examines the socioecological issues that extend from a Loamshire soil being rationalised by chemistry, so the epistemic tensions of the emerging science of agriculture, the relations between theory and practice, also occupy the form of the novel. *Middlemarch*, I show, is structured as a field experiment that negotiates between the ideal conditions of the controlled laboratory and the lived conditions of the field.[10] As Devin Griffiths puts it, Eliot's novel is concerned with 'the complex and not entirely happy adjustment between […] scientific models and social situations they can never perfectly grasp'.[11] In my reading, these social situations include the enmeshed human and non-human worlds of Loamshire's soils, an agricultural environment that penetrates and is constituted by the characters that inhabit it.

Similar tensions between scientific theory and the practical arts, such as farming and medicine, have recurred throughout my thesis. They are there, for example, as John Thornton favours a discourse of experiment when referring to his dinner scheme in *North and South*; 'I have no theory; I hate theories', he tells Mr Bell, 'I expect you will pay my experiment the respect of silence'.[12] In the context of agriculture, Gaskell's Mr Harrison values a farmer's 'practical knowledge and experience' over Mr Bullock's 'fine names and theories' concerning 'the nature of different manures' in a direct dismissal of Liebig's chemistry.[13] Dickens highlighted limits to Liebig's science along similar lines in *All The Year Round* with an account of a 'distinguished and angry foreign chemist, who, great in general principles, has always failed miserably when descending to give practical advice'. [14] In *Household Words*, meanwhile, he celebrated John Bennet Lawes as 'one of the most famous practical chemists of his age'.[15] Turning from agriculture to medicine in *Bleak House*, Dickens's narrator praises Allen Woodcourt for his practical efforts to help the poor of Tom-all-Alone's, where disease spreads according to 'somebody's theory but nobody's practice'.[16] And the spirit of social amelioration that Dickens's fiction shares with Gaskell's comes

[10] A similar tension between ideality and reality emerged across the respective epistemological structures of botany and organic chemistry in chapter 1. Here similar tensions emerge within the science of chemistry as pursued in different locations, the ideal conditions of the laboratory and the lived, or real, conditions of the field.
[11] Griffiths, *Analogy*, p. 204.
[12] Elizabeth Gaskell, *North and South*, ed. by Angus Easson, intro. by Sally Shuttleworth (1854-55; Oxford: Oxford University Press, 1998), p. 363.
[13] Elizabeth Gaskell, *Mr Harrison's Confessions* (1851; London: Hesperus Press, 2014), p. 35.
[14] Anon., 'Artificial Fertility', *All the Year Round*, 11 March 1865, pp. 157-64 (157).
[15] Charles Dickens, 'The Poor Man and His Beer', *All the Year Round*, 30 April 1859, pp. 13-16 (13).
[16] Charles Dickens, *Bleak House*, ed. and intro. by Nicola Bradbury, preface by Terry Eagleton (1852-53; London: Penguin, 1996), p. 710.

through perhaps most powerfully at the moment of Jo's death: 'Dead, men and women, born with Heavenly compassion in your hearts', Dickens's narrator exclaims, 'And dying thus around us, every day'.[17] Viewed in this light, the realist novel becomes a site of practical intervention set against the inaction and errors of high theory, and it is this relationship that Eliot, looking back on the mid-century realist project in its proximity to soils, comments on in *Middlemarch*.

The novel is thus also an investigation of the mid-century science of agriculture. The text Lewes refers to in the second of the epigraphs above is *Chemische Briefe*, published in English as *Familiar Letters on Chemistry* from 1843. Eliot and Lewes owned a German copy of the third 1851 edition – the text Lewes referred to when criticising Krook's spontaneous combustion in *Bleak House*. Liebig was working on the fourth edition, published in 1859, when they became friends in Munich, and it is the 'proofs' of this edition that he gave Lewes to read on May 9th. Liebig used *Chemical Letters* to outline his chemistry to a wider audience. The third edition discussed chemical principles for farming at length, containing chapters on soils, agricultural science, manures, and the assimilation of carbon, phosphates and nitrogen by plants. Liebig also used *Chemical Letters* to attack those who disagreed with his methods and theories, such as English agriculturist John Bennet Lawes and chemist Joseph Henry Gilbert. Lawes and Gilbert (who had earned his doctorate under Liebig in 1842) worked together on Lawes's farm at Rothamsted, in Hertfordshire, from 1843 to 1900. Their science differed from Liebig's exclusively laboratory chemistry by merging laboratory analysis with long-term field trials. Lewes would become an increasingly vocal supporter of Rothamsted science into the 1860s, corresponding with Lawes and Gilbert and praising their research in his physiological writings. As I show below, the methodological concerns of science applied to agriculture were of interest to Eliot in *Middlemarch*, where the epistemic relations of laboratory and field occupy the novel at the level of both form and content.

My chapter's first section, 'Thinking Method in Munich', reads Eliot's 'Natural History of German Life' (1856) and *Adam Bede* (1859), Lewes's 'Realism in Art' (1858) and *Physiology of Common Life* (1859), and the third edition of Liebig's *Chemical Letters* (1851). Here I argue that Eliot's early rural realism engages with Liebig's science, largely diverging from his ideas regarding chemistry's applications to agriculture. Investigating an ecology of literature and science built upon conceptual disagreement and shared friendship, I also show that Liebig developed his scientific method into the 1860s by drawing on Eliot's and Lewes's

[17] Dickens, *Bleak House*, p. 734.

theories of realism. Section two, '*Middlemarch* and the Lab/Field Culture', examines Tertius Lydgate's and Fred Vincy's contrasting scientific fortunes, investigating the tensions of theory and practice in the work of both the doctor and the farmer. In section three, '"Vital Connexion" in the Field', my attention shifts to the form of *Middlemarch* as I expose how the relations between laboratory and field come through in the courtship plot, where the discourse of organic chemistry charts and resolves the relations between marital bodies as a chemical reaction sequence. Here I also challenge readings of *Middlemarch* as an 'enterprise of totalization', as J. Hillis Miller put it long ago, arguing that Eliot's narrative offers a world that is unknowable in the whole through Dorothea Brooke's situated perspective.[18] This is important for section four, 'Care in the Unknowable Web', which draws out Eliot's argument for a reduced ethos of improvement, where, as global capital networks Loamshire's soils, caring for others involves acknowledging the possibility of doing unforeseen harm elsewhere. In an extended conclusion, serving as a final word on the thesis, I offer a conception of mid-nineteenth-century literary realism as 'Dirty Realism', a novel form conceived and advanced in proximity to the dirt of lived experience, but at the same time also soiled and imperfect in its perspectives and courses of action.

Thinking Method in Munich

Published in 1856 in the *Westminster Review*, Eliot's 'Natural History of German Life' reviews two works by Wilhelm Riehl. Her thoughts on Riehl shape a larger argument about the role of literary realism in representing 'the real characteristics of the working-classes' – the rural working-classes in particular.[19] She praises Riehl for 'paus[ing] a little from theorising, and see[ing] what is the material actually present for theory to work upon'.[20] This 'inductive process' she calls 'the natural history of […] social classes', an idea embodied in the claim that one can 'distinguish a district by its rustic names as we do its Flora and Fauna'.[21] Her contrast between deduction, as in theorising from general principles, and induction, as in working from detailed observation of particular instances, forms a central concern of 'Natural History', a concern invoked in the scientific terminology Eliot draws on throughout the article.

[18] J. Hillis Miller, 'Optic and Semiotic in *Middlemarch*', in *The Worlds of Victorian Fiction*, ed. by Jerome H. Buckley (Cambridge, MA: Harvard University Press, 1975), pp. 125-45 (125).
[19] George Eliot, 'The Natural History of German Life', *The Westminster Review*, July 1856, pp. 51-79 (52).
[20] Eliot, 'Natural History', p. 70.
[21] Eliot, 'Natural History', pp. 68, 59.

Chemistry underpins much of the article's scientific language. Devin Griffiths has shown how this discourse borrows from mathematics, with Eliot critiquing statisticians and the erroneous belief 'that the relations of men to their neighbours may be settled by algebraic equations'.[22] Further on, she writes that 'systematic co-operation' is 'as foreign to the mind of the peasant as logarithms or the doctrine of chemical proportions'.[23] Although Eliot had not yet met Liebig when writing 'Natural History' in 1856, a similar analogy between chemistry and mathematics is made in the third edition of *Chemical Letters*. Liebig wrote that while mathematical and chemical inquiry may be 'analogous', as chemistry 'makes discoveries' it forms a language all of its own – the chemical 'book of nature' noted in chapter 3:[24]

> Chemistry […] teaches the methods of discovering and determining the qualities of the various substances of which the crust of the earth is composed, and which form the constituents of animal and vegetable organisms. […] All our observations, taken collectively, form a language. Every property, every alteration which we perceive in bodies, is a word in that language.[25]

Eliot draws on Liebig's conception of a chemical language throughout her article, describing science as an effort to 'construct a universal language on a rational basis'.[26] The chemical terminology permeating 'Natural History' renders this scientific discourse in chemical terms. This is 'a patent de-odorized and non-resonant language', she describes, 'which effects the purpose of communication as perfectly and rapidly as algebraic signs'.[27] The *OED* notes the emergence of the terms 'deodorizing' and 'deodorization' in 1856 – the same year Eliot is writing here – as relating to the extraction of sewage matter for agricultural use.[28] This was of course understood as a chemical process of precipitation. Like Liebig, then, Eliot renders a 'universal' scientific discourse in chemical form, though for quite different ends.

Eliot invokes this chemical language as a contrast to the ways an inductive literary realism might understand the interrelated processes of rural society. This 'language may be a perfect medium of expression to science', she continues, but 'will never express life, which is a great deal more than science', lacking as it does 'vital qualities as an expression of

[22] Griffiths, *Analogy*, p. 188; Eliot, 'Natural History', p. 55.
[23] Eliot, 'Natural History', p. 66.
[24] Justus von Liebig, *Familiar Letters on Chemistry, in its relations to Physiology, Dietetics, Agriculture, Commerce and Political Economy*, trans. by William Gregory, 3rd edn (London: Walton & Maberly, 1851), pp. 5, 7.
[25] Liebig, *Chemical Letters*, p. 8.
[26] Eliot, 'Natural History', p. 69.
[27] Eliot, 'Natural History', p. 69.
[28] 'Deodorize', in *The Oxford English Dictionary* [online], < https://www.oed.com/view/Entry/50149> [Accessed 11 May 2021].

individual character'.[29] Intriguingly, there is a suggestion here of the arguments Dickens made against Liebig's science in his 1853 letter to Lewes defending Krook's spontaneous combustion in *Bleak House*, as examined in chapter 3; Eliot's words also draw a contrast between the deductive theorising deemed typical of chemistry and the inductive investigations, for her of rural rather than urban life, that literary realism might provide.

The difficulties of applying chemical investigation to agriculture were well documented in the mid-nineteenth century, and this is a debate Eliot draws on to support her inductive literary realism:

> [T]he unwillingness of the peasant to adopt innovations [in farming] has a not unreasonable foundation in the fact, that for him experiments are practical not theoretical, and must be made with money instead of brains – a fact that is not, perhaps, sufficiently taken into account by agricultural theorists, who complain of the farmer's obstinacy.[30]

Liebig addressed this issue in *Chemical Letters*, labelling farmers 'alchemists' for their failure to understand scientific principles.[31] In *Organic Chemistry* he had gone even further, dismissing a generation of farmers 'which recoils with seeming distrust and aversion from all means of assistance offered it by chemistry'.[32] Eliot's words are particularly pointed, then, in a discussion of rural Germany, unmistakably placing Liebig as her paradigmatic 'agricultural theorist'. Alluding to the difficulty of applying chemical investigation to agriculture, her example highlights problems with the indiscriminate application of deductive theory to rural life.

Liebig was a fierce advocate for a theoretical chemistry of agriculture through the 1840s. Setting out scientific principles for farming in *Chemical Letters*, he sought to explain how soils provide 'plants […] with certain inorganic matters indispensable for their nutrition'.[33] This inorganic mineral theory led Liebig to downplay the importance of farmyard manures and crop rotations, both of which he thought might be abolished with the judicious use of inorganic fertilisers.[34] Theory also contradicted practice as Liebig came to argue that all plants 'derived' their nitrogen from the atmosphere, pitching him into a twenty-

[29] Eliot, 'Natural History', p. 69.
[30] Eliot, 'Natural History', pp. 59-60.
[31] Liebig, *Chemical Letters*, p. 474.
[32] Justus von Liebig, *Organic Chemistry in its Application to Agriculture and Physiology*, trans. by Lyon Playfair (London: Taylor, Walton, and Maberly 1840), p. 161.
[33] Liebig, *Chemical Letters*, p. 494.
[34] See William H. Brock, *Justus von Liebig: The Chemical Gatekeeper* (Cambridge: Cambridge University Press, 1997), pp. 120-21, 147-48, 165, 170.

year feud with Lawes and Gilbert at Rothamsted.[35] Rather than following Liebig's laboratory programme, Lawes and Gilbert demonstrated the benefits of adding nitrogenous matter to soil through long-term field trials combined with laboratory analysis.[36] Liebig would not admit his error until the late 1850s. Part of the reason he defended his theory of nitrogen assimilation for so long was because admitting defeat meant questioning his laboratory method along with his ideas.

The 'theoretical' and 'practical' agricultural experiments Eliot references in 'Natural History' thus correspond broadly to Liebig's deductive laboratory theory and Lawes and Gilbert's inductive field trials.[37] Once again, *Chemical Letters* offers a possible source for Eliot's comparison. Liebig singled out 'the experiments of Mr Lawes' as 'entirely devoid of any value, as the foundation for general conclusions'.[38] Situated in particular fields, any knowledge derived from such trials was suited only 'for certain places' and thus, according to Liebig, fundamentally lacking in 'scientific principles'.[39] His argument was that only chemistry pursued in the laboratory could provide the necessary theoretical knowledge – 'certain rules for the exercise of the ART' of farming.[40] Yet as Lawes and Gilbert's work on nitrogen was beginning to show, the future direction for agricultural science lay in combining deductive and inductive investigation across laboratory and field.

By distinguishing between 'theoretical' agricultural experiments and 'practical' trials, Eliot introduces parallel tensions concerning deduction and induction to her 1856 article on rural realism. Critics have noted similar tensions elsewhere in her work. Sally Shuttleworth, for example, argues that Eliot's novels gradually replace 'the methods of natural history [... with] those of experimental physiology' as their methodological foundation into the 1870s.[41] As I will show with *Middlemarch*, another way to approach this methodological refinement is as a movement from an exclusively practical frame for agricultural experiment to one that also incorporates the theoretical; important here is how 'Natural History' aligns practice and theory with induction and deduction. In the following passage, quoted at length for it reveals

[35] Liebig, *Chemical Letters*, pp. 514-17.
[36] See E. John Russell, *A History of Agricultural Science in Great Britain* (London: George Allen & Unwin, 1966), pp. 102-07.
[37] It must be admitted that Lawes, a wealthy landowner, was certainly not a 'peasant', itself a problematic term that Eliot uses throughout 'Natural History'. I have taken it here as Eliot herself seems to have meant it – to refer to a member of the agricultural labouring class.
[38] Liebig, *Chemical Letters*, p. 479-80.
[39] Liebig, *Chemical Letters*, p. 485.
[40] Liebig, *Chemical Letters*, p. 484.
[41] Shuttleworth, *George Eliot*, p. xii.

much about Eliot's conception of scientific reasoning in the 1850s, deductive science explains the 'general' and inductive science approaches the 'special':

> [I]n the various branches of Social Science there is an advance from the general to the special, from the simple to the complex, analogous to that which is found in the series of the sciences, from Mathematics to Biology. To the laws of quantity comprised in Mathematics and Physics are superadded, in Chemistry, laws of quality; to these again are added, in Biology, laws of life; and lastly, the conditions of life in general, branch out into its special conditions, or Natural History, on the one hand and into its abnormal conditions, or Pathology, on the other. […] the more general science will not suffice to solve the problems of the more special. Chemistry embraces phenomena which are not explicable by Physics; Biology embraces phenomena which are not explicable by chemistry; and no biological generalization will enable us to predict the infinite specialities produced by the complexity of vital conditions.[42]

To move 'from the general to the special' is to reason deductively, approaching 'special conditions' by way of 'laws' or theories. Eliot instead argues for the reverse movement; if 'the more general science will not suffice to solve the problems of the more special', it is necessary to begin with 'the complex' and reason inductively. Approached via her earlier rejection of agricultural theorists, it follows that the deductions of chemistry cannot alone hope to explain the 'infinite specialities produced by the complexity of vital conditions' in the field.

This discourse of vitality recurs throughout 'Natural History'. There is complexity in the agricultural environment, Eliot suggests, that scientific deduction is unable to access. As Liebig admitted in *Chemical Letters*, the underlying causes of life, which he described in terms of 'vital phenomena' and 'vital force', were unknown from a chemical perspective.[43] Vitalism was a tradition Liebig vehemently rejected in his theory of soil but retained in his physiology – as I come to below. In terms of soil, his inorganic mineral theory opposed what he termed the 'now abandoned humus theory', a collection of earlier ideas understanding plants as deriving their carbon and nitrogen directly from soils containing the decaying organic matter of dead plants and animals.[44] Translated to the more metaphysical terms of *Naturphilosophie*, death was seen to stimulate life, a vitalist belief incompatible with Liebig's attempts to define a rational chemistry of the soil, as seen in chapter 1.

[42] Eliot, 'Natural History', p. 71.
[43] Liebig, *Chemical Letters*, p. 166.
[44] Liebig, *Chemical Letters*, p. 491. For more on the humus theory see Pat Munday, 'Sturm und Dung: Justus von Liebig and the Chemistry of Agriculture' (unpublished doctoral thesis, Cornell University, 1990), pp. 170-175, 188-197; Brock, *Liebig*, pp. 68, 148.

Eliot's vital discourse forms a counterpoint to Liebig's inorganic mineral theory, 'Natural History' conceiving of vitality within agricultural landscapes, rural societies, and ultimately soils. She praises Riehl's identification of '[social] ranks', such as the 'peasantry or agricultural class', 'which have their roots deep in the historical structure of society, and are still, in the present showing vitality above ground'.[45] This imagining of class growth and history in terms of plant growth and soil suggests a 'vital' imbrication of individual and society, landscape and people. Eliot thus diverges from Liebig's reductionism by arguing that only an inductive approach leads to an understanding of complex 'vital' phenomena, described in terms of 'the gradual operation of necessary laws'.[46] While her words address historical change in rural society rather than chemical action in soils, they praise Riehl's sociology in a discourse that draws once more on the concerns of agricultural chemistry: 'He sees in European society *incarnate history*', she writes, 'and any attempt to disengage it from its historical elements must, he believes, be simply destructive of social vitality'.[47] To remove the object of study from the 'elements' of which it is formed is to miss the complex interplay of local conditions with general laws, just as to study the growth of crops in a laboratory might misunderstand how biochemical processes active in certain soils contribute towards the 'vitality' of plants in a particular field. Vitality thus inheres through connections and associations.

These ideas are inscribed in the place name 'Loamshire', an agricultural region named for its soil and the fictional backdrop for many of Eliot's novels. Merging soil and place, 'Loamshire' instantiates vitality in the interconnections of landscape and society, individual and environment – the subjects of Eliot's realism. This is true of *Adam Bede*, for example, as Eliot's narrator defends the depiction of 'Loamshire' farmhand, Kester Bale: 'I am not ashamed of commemorating old Kester: you and I are indebted to the hard hands of such men – hands that have long ago mingled with the soil they tilled so faithfully'.[48] As Shuttleworth explains, 'Kester does not die but mingles with the soil, confirming his position within the cyclical rhythms of nature of which his life style is presumed to be a part'.[49] Kester's representation draws on Eliot's childhood in rural Warwickshire, but it also echoes the humus theory and its cycles of life and death as it seeks to fulfil a commitment to show the 'roots' of

[45] Eliot, 'Natural History', p. 75.
[46] Eliot, 'Natural History', p. 69.
[47] Eliot, 'Natural History', p. 68; emphasis in original.
[48] George Eliot, *Adam Bede*, intro. and notes by Doreen Roberts (1859; Ware: Wordsworth Classics, 1997), p. 445.
[49] Shuttleworth, *George Eliot*, p. 33.

the agricultural classes alongside their 'vitality above ground'. In this way, Loamshire in *Adam Bede* becomes the site for an inductive investigation of agricultural conditions, a society rooted in place and embodied in terms of a vital connection to soil.

Eliot thus defines her 1850s rural realism against Liebig's chemistry. She draws on his chemistry's perceived limitations in its applications to agriculture to make the case for her own literary investigations of rural life. In sections two and three, I examine how *Middlemarch* refines this conception of scientific method, and with it the methodological foundations of Eliot's realism, by drawing on the mixed deductive-laboratory and inductive-field culture of developing agricultural science. But first, I consider Liebig's and Lewes's investigations of vitality, and the ways Liebig also developed his methodology to better understand life in the agricultural environment, doing so with recourse to Eliot's and Lewes's ideas on realism.

Lewes and Liebig became firm friends in early summer 1858. They discussed questions of chemistry and physiology together every few days, with Lewes's journal entry for May 17th typical of his stay in Munich: 'Read Liebig's new Chemische Briefe. Continued Animal Heat', he begins, referring to an article for *Blackwood's Magazine* that would later form a section of *Physiology of Common Life*; 'Called on Liebig and propounded to him a difficulty respecting Animal Heat. After discussing the matter he proposed we should institute an experiment in his laboratory'.[50] Lewes was clearly thrilled to research alongside Liebig, and the collaboration was likely as stimulating for the world-renowned chemist as for the budding physiologist. *Chemical Letters* proposed that 'a fusion of physiology with chemistry' was urgently required to investigate 'the study of the vital phenomena in their natural succession'.[51] Liebig's chemistry sought to reduce these 'vital phenomena' into two categories within the 'animal economy', the generation of bodily heat and the formation of bodily tissue.[52] It was these questions of physiological vitality, in the contexts of respiration and bodily heat, that formed the majority of Lewes's scientific writing and research while in Munich.

Lewes soon began to define his physiology in opposition to Liebig's chemistry. His journal recalls a discussion where Liebig 'amused' him by labelling physiologists 'imperfect chemists [who] yet ventured to contravene his chemical theories of physiology, he not seeing

[50] Lewes, 'Journal', p. 105.
[51] Liebig, *Chemical Letters*, pp. 248, 250. For more on Liebig's physiological vitalism see Timothy O. Lipman, 'Vitalism and reductionism in Liebig's physiological thought', *Isis*, 58 (1967), pp. 167-85.
[52] Liebig, *Chemical Letters*, pp. 316, 344-45.

that his own imperfect physiology renders all his chemical theories suspicious'.[53] He expanded on this point in *Physiology*, referring to both third and fourth editions of *Chemical Letters*. Questions of nutrition and bodily heat were 'a vital problem, not a chemical problem', he explained, and thus 'far too complex to be embraced by any chemical hypothesis'.[54] Defending his ideas in *Blackwood's Magazine* a year later, Lewes reiterated that 'Chemistry cannot cope with truly vital questions', urging physiologists to 'employ chemistry as a means of *exploration*, not of *deduction*'.[55] The essence of Lewes's argument, then, was that while chemical analysis could help understand processes of vitality, the complex biochemistry of the living body could never be reduced to a purely chemical process.

In making this argument, he recalled Lawes's and Gilbert's investigations into 'the animal economy' at Rothamsted, explaining that 'Liebig's theory was […] proved at fault in every direct experiment in cattle-feeding'.[56] Writing privately to Lawes in January 1861, Lewes noted once more that their results were 'a serious objection to Liebig' and praised their methodology in near-identical terms; 'even those who may question your results', he wrote, 'must admit that you have entered upon the only fruitful method – that of experimental investigation of a direct kind'.[57] Lewes thus chimed with Eliot's 1850s realism in advancing an inductive method for investigating vital phenomena. For both, there is complexity in the agricultural environment that the reductive analyses of laboratory chemistry cannot alone hope to understand.

Liebig thus faced ever more questions regarding his organic chemistry in its applications to both physiology and agriculture in the 1850s. His rejection of field trials had led to the failure of his manufactured fertilisers, which were launched in the mid-1840s.[58] When applied to fields by enthusiastic farmers, they failed to dissolve in rainwater and lay uselessly on the surface – as Liebig would have found if he had tested them in the field

[53] Lewes, 'Journal', p. 103.
[54] George Henry Lewes, *The Physiology of Common Life* (Edinburgh and London: William Blackwood & Sons, 1859), pp. 73, 74. In a link back to chapter 1, Lewes edited a posthumous edition of James Finlay Weir Johnston's *The Chemistry of Common Life*, first published in 1853, for William Blackwood. Blackwood then commissioned Lewes to write a series of articles along a similar theme, but in the context of physiology, for *Blackwood's Edinburgh Magazine* that would become *The Physiology of Common Life*.
[55] George Henry Lewes, 'Theories of Food: A Letter to the Editor', *Blackwood's Edinburgh Magazine*, December 1860, pp. 676-87 (676, 677; emphasis in original).
[56] Lewes, *Physiology*, p. 73; Lewes, 'Theories of Food', p. 682.
[57] George Henry Lewes, 'Letter to John Bennet Lawes, 10 January 1861', Harpenden, Rothamsted Archives, Papers of Sir Henry Gilbert 1817-1901 (GIL), GIL3.
[58] Brock, *Liebig*, pp. 120-24, 160-68.

himself.[59] Instead it was Lawes, with his Superphosphate rigorously tested in the field, who captured the early chemical-fertiliser market. Seen here are something of Liebig's difficulties negotiating between science and the wider economy, a relationship that is of central concern also in *Middlemarch*, as my next section examines.[60]

Responding in 1856 to Lawes and Gilbert's experiments on nitrogen assimilation by plants, Liebig admitted to mistakes regarding these failed chemical fertilisers, which had cost him the respect of many British farmers a decade earlier. '[T]he idea of these manures could only have arisen and taken root in the brain of a man of science', he wrote, 'penetrated and inspired by the truth of his doctrines, but who had before his mind's eye not the actual state of things, but an ideal agriculture'.[61] This conception of an 'ideal agriculture' – unsuited to 'the actual state of things' but nevertheless founded on truthful scientific 'doctrines' – suggests an open definition of 'truth' relative to the 'actual' field and the 'ideal' laboratory. Liebig's mistake might thus be summed up as a refusal to negotiate between the ideal conditions of the controlled laboratory experiment and the lived conditions of the field. As he found, even if manufactured fertilisers contained the inorganic elements that plants required in theory, they would remain useless if they were unable to take into account environmental conditions beyond the laboratory.

Lewes and Eliot were examining a similar relationship between reality and ideality in their writing on realism during the summer of 1858. Thoughts that would shape Lewes's 'Realism in Art' were clearly at the forefront of his mind when he was experimenting alongside Liebig and reading *Chemical Letters*, for he praises this text early in the article:

> The most celebrated of living chemists is also one of the most popular writers; we cannot expect that all chemists should have the bright intellect of a Liebig, but we have a right to demand that, as authors, they should not bestow less pains, less industry than he does.[62]

Having established Liebig's writing as a model of 'ideas […] clearly expressed', Lewes outlines literary realism in terms familiar from Eliot's 'Natural History'.[63] 'Art always aims at the representation of Reality, i.e. of Truth', he writes; 'Realism is thus the basis of all Art, and its antithesis is not Idealism, but *Falsism*'.[64] For Lewes, 'Art' can only hope to represent

[59] Munday, 'Justus von Liebig', pp. 261-62.
[60] For more on Liebig's relationship with commerce and industry see Brock, *Liebig*, pp. 115-44.
[61] Justus von Liebig, 'On some points in Agricultural Chemistry', *Journal of the Royal Agricultural Society of England*, 17 (1856), pp. 284-326 (315).
[62] George Henry Lewes, 'Realism in Art: Recent German Fiction', *The Westminster Review*, October 1858, pp. 488-518 (490).
[63] Lewes, 'Realism in Art', p. 490.
[64] Lewes, 'Realism in Art', p. 493.

reality, a gap inevitably existing between reality and perception, which means 'Truth' is therefore defined by the proximity of this representation to the world. In this way, Lewes's arguments for literary realism also speak to scientific realism, identifying the point where idealism becomes falsism in science – where scientific truth becomes scientific error. The writer of literary realism and the scientific investigator are thus engaged in parallel searches for truth, with an analogy to be drawn between the methods each employs. Lewes continues that '[i]t matters not whether a portrait be daguerreotyped from the streets, or created by the imagination, it matters not how familiar or exceptional […] – if truly drawn, it will be enduring'.[65] His argument that realism and idealism (the 'familiar' and the 'exceptional') are not opposed in literature offers a parallel reading in terms of scientific method; truth may be accessed through induction and observation, knowledge metaphorically 'daguerreotyped from the streets', or through an experimental construction, 'created by the imagination' in the laboratory to test a deductive theory.

Put in the terms of Liebig's chemistry, the idealism of the laboratory only succeeds as an epistemological project if faithful to the realism of the field; knowledge arrived at via controlled experimentation becomes truthful in relation to the world. The realism of the field and the idealism of the laboratory are not opposed, then, but require careful negotiation by passing through the arc of inductive and deductive reasoning, methods that become complementary in their efforts to describe reality as truthfully as possible.

It is plausible that Liebig read 'Realism in Art', for it not only praised his writing but likely discussed those 'same ideas' and 'same works of art and literature' that he professed to enjoy, following dinner, on 9th May 1858.[66] As an avid reader of fiction in English, it is also possible that Liebig read *Adam Bede*, where he would have found ideas similar to Lewes's.[67] In her famous chapter on the novelist's craft, Eliot cautions against 'that lofty order of minds who pant after the ideal' but find no relation between their idealised imaginings and 'their everyday fellow-men' (158). 'All honour and reverence to the divine beauty of form' (153), comments her narrator, 'but do not impose on us any aesthetic rules which shall banish from the region of Art those old women scraping carrots with their well-worn hands, […] It is so needful we should remember their existence, else we may happen to leave them quite out of our religion and philosophy, and frame lofty theories which only fit a world of extremes' (154). While I cannot be certain that Liebig read either *Adam Bede* or 'Realism in Art', the

[65] Lewes, 'Realism in Art', p. 497.
[66] Lewes, 'Journal', p. 96.
[67] See Brock, *Liebig*, p. 305.

suggestion that these ideas on realism and idealism formed part of the 'scientific and philosophic' discussions he enjoyed with Eliot and Lewes is harder to dismiss. Eliot's sense of 'lofty theories which only fit a world of extremes' captures perfectly the problems of Liebig's mineral theory, formulated in the ideal conditions of the laboratory but unable to speak to what *Adam Bede* calls 'the rough work of the world' (154), the lived experience of the field.

As George Levine describes Lewes's and Eliot's thesis, 'science and language created ideal patterns that were at best abstract symbols of the feelings prompted by an assumed but indescribable reality'.[68] Liebig would come to argue similarly. In 'Lord Bacon as Natural Philosopher', published in *Macmillan's Magazine* in 1863, he wrote that poetry and science shared an 'ideal mental direction' (264) linked by the imagination.[69] As Lewes put it in a notebook kept while in Munich, 'Imagination is as active in Science as in Art, but it is not allied with the emotions, and it moves in more prescribed direction [*sic*]'.[70] In Liebig's words, 'the mental faculty which constitutes the poet and the artist is the same as that whence discoveries and progress in science spring'.[71] This was because both sought truth imperceptible to the senses:

> Every phenomenon, every occurrence, forms always a whole, of whose component parts our senses know nothing. We perceive the rusting of iron, the growth of a plant; but we know nothing of air, of oxygen, nothing of the soil; of all the processes that take place nothing is known to our senses.[72]

This allusion to agricultural science is followed by a footnote that makes a disparaging comparison between Baconian induction and Lawes's and Gilbert's field trials.[73]
Yet if Liebig does not seem to appreciate the insights Lewes's and Eliot's thoughts on ideality and reality held for laboratory and field science, he notes that the ideal space of imagination is pivotal for scientific investigation of processes that exists beyond unaided perception. This conception of a scientific imagination is of course similar to John Tyndall's

[68] George Levine, 'George Eliot's Hypothesis of Reality', *Nineteenth-Century Fiction*, 35.1 (June 1980), pp. 1-28 (6).
[69] Justus von Liebig, 'Lord Bacon as Natural Philosopher', *Macmillan's Magazine*, July and August 1863, pp. 237-49, 257-67 (264).
[70] George Henry Lewes, 'Notebook, 1857 Feb', Yale University, Beinecke Rare Book and Manuscript Library, George Eliot and George Henry Lewes Collection, GEN MSS 963, Box: 49 (n.p.).
[71] Liebig, 'Bacon as Natural Philosopher', p. 265.
[72] Liebig, 'Bacon as Natural Philosopher', pp. 262-63.
[73] Liebig, 'Bacon as Natural Philosopher', p. 264.

in 1868, long seen as an influence on Eliot's writing but arrived at here, by Liebig, five years earlier.[74]

These imaginative faculties became part of an inductive imagination in 'Induction and Deduction', published in September 1865 in the *Cornhill Magazine*. (Lewes may have been consulted on the article before publication, for although he had given up the editorship of the *Cornhill*'s 'Literature and Science' section a year earlier, he seems to have retained something of an unofficial advisory role.)[75] Liebig writes that 'the deductive commences with general principles, the inductive with special facts', the two methods now complementary and linked via a scientific imagination:[76]

> [M]issing facts, which make deductive reasoning impossible [the naturalist] is obliged to seek by induction; that is, through combination of his imagination. His work now consists in letting those means of things which seems appropriate to his purpose act upon each other according to the rules of experimental art; and from the reactions or phenomena thereby called forth, to draw conclusions as to the existence or non-existence of the fact in question.[77]

Experimentation aims at 'calling forth' certain 'reactions or phenomena' constituting reality, but undetectable to the senses, for description by the scientific investigator. To address a gap between reality and perception, Liebig proposes, deductive and inductive reasoning must be united via a scientific imagination. Truth is therefore to be defined by the proximity between reality and the theory or depiction seeking to represent it, a statement that, for Liebig, Eliot, and Lewes, applies to realism as the underpinning for both science and literature.

Liebig does not seem to have taken the final step in reasoning that, if deduction and induction were complementary, then so were laboratory and field. At the same time, his revised scientific method offers the framework for a mixed lab/field scientific culture, explaining in philosophical terms the methodological underpinnings of Lawes's and Gilbert's scientific successes at Rothamsted. Eliot and Lewes, pivotal interlocutors at a crucial point in his career, here had an enduring stamp on Liebig's developing philosophy of science.

I now argue that Liebig's revised method offered Eliot a foundation for scientific inquiry in *Middlemarch*. John Tyndall's 1868 speech on imagination in science has been seen as foundational for Eliot's portrayal of Tertius Lydgate. I show that Liebig's 'Induction and Deduction', published three years earlier in the *Cornhill*, (a periodical with which Eliot was

[74] Levine, *Realistic Imagination*, pp. 258-59; Beer, *Darwin's Plots*, p. 141.
[75] Rosemary Ashton, *G.H. Lewes: A Life* (Oxford: Clarendon Press, 1991), pp. 216-17, 224.
[76] Justus von Liebig, 'Induction and Deduction', *Cornhill Magazine*, September 1865, pp. 296-305 (296).
[77] Liebig, 'Induction and Deduction', pp. 299-300.

familiar following Lewes's editorship), offers another possible influence. As will become clear over the next two sections, the concerns of laboratory and field, theory and practice, ideality and reality – the lab/field culture – occupy both the content and form of Eliot's novel. *Middlemarch*'s extraordinary depth of 'scientific thought', as Sidney Colvin referred to it in his 1873 review, has been noted ever since the novel's publication;[78] but it has, to my knowledge, yet to be noted that discussions of science in the context of agriculture bookend the narrative. Where the links between agricultural chemistry and the economy were important in Lawes's successes and Liebig's failures with manufactured fertilisers, relations between science, society, and economics are central too in *Middlemarch*, a novel where the scientific success story, against all the odds, turns out to be the gentleman farmer rather than the accomplished experimentalist.

Middlemarch and the Lab/Field Culture

The second chapter of *Middlemarch* opens with 'Sir James Chettam's remark that he is studying Davy's "Agricultural Chemistry"':[79]

> 'I am reading the "Agricultural Chemistry",' said this excellent baronet, 'because I am going to take one of the farms into my own hands, and see if something cannot be done in setting a good pattern of farming among my tenants. Do you approve of that Miss Brooke?' (15)

A discussion ensues on the merits of scientific theory in practice. Having gone 'into science a great deal myself at one time', Mr Brooke views such 'fancy farming' as 'a great mistake' (16), mainly because of the cost. Dorothea Brooke, to whom Chettam makes his appeal, intervenes against her uncle, telling him that 'it is not a sin to make yourself poor in performing experiments for the good of all' (16). Brooke, in his roundabout way, then concedes to 'hav[ing] always been in favour of a little theory' – although not before qualifying his thoughts with the remark, 'Young ladies don't understand political economy, you know' (16), and introducing what David Carroll calls that 'radical work of *laissez faire* economics', Adam Smith's *The Wealth of Nations*.[80] The debate between Chettam and Brooke offers what Griffiths calls one of the novel's 'complex and not entirely happy adjustments between forms and the conditions they address'.[81] The adjustment here concerns

[78] Sidney Colvin, 'Critical Notices: *Middlemarch. A Study of Provincial Life*. By George Eliot. Blackwood and Sons.', *Fortnightly Review*, January 1873, pp. 142-47 (142).
[79] George Eliot, *Middlemarch*, ed. and notes by David Carroll, intro. by Felicia Bonaparte (1871-72; Oxford: Oxford University Press, 2008), p. 15. (All further references to *Middlemarch* are to this edition and are given parenthetically in the body of the chapter.)
[80] David Carroll, 'Explanatory Notes', in *Middlemarch*, p. 787.
[81] Griffiths, *Analogy*, p. 204.

the relationship between laboratory and field, as drawn out in my previous section, probing too at the relations between deduction and induction. It also introduces this pervasive tension between scientific investigation and the wider economy, whereby scientific theory comes into dialogue with practical arts such as agriculture or medicine.

It is the chance to move between these worlds that appeals to general practitioner and biologist, Tertius Lydgate. He has 'the conviction that the medical profession as it might be was the finest in the world; presenting the most perfect interchange between science and art' (136). This relationship between theory and practice structures Lydgate's science. 'There was fascination in the hope that the two practices would illuminate each other: the careful observation and inference which was his daily work, the use of the lens to further his judgement in special cases, would further his thought as an instrument of larger inquiry' (137). Lydgate aims for a harmonious merger of practice and theory by oscillating between inductive medicine and deductive 'biology' (141), scientific methods working together in reciprocal relation.

Lydgate's science here seems to have been influenced by Liebig's scientific imagination. As an art progresses into a science, Liebig argued in the *Cornhill*, 'fantasy […] subordinates itself to the understanding, and become its useful and willing servant'. In this way, 'reason and fantasy are equally necessary for science' in Liebig's mature thought, for as scientific understanding progresses, inexplicable phenomena can be approached by an inductive imagination directed by the rational application of deductive theory.[82] Lydgate's conception of an experiment as a 'construct' uniting a 'disciplined' 'imagination' with deductive reasoning so as to 'test' a hypothesis is almost identical to Liebig's:

> Fever had obscure conditions, and gave him that delightful labour of the imagination which is not mere arbitrariness, but the exercise of disciplined power – combining and constructing with the clearest eye for probabilities and the fullest obedience to knowledge; and then, in yet more energetic alliance with impartial Nature, standing aloof to invent tests by which to try its own work. (154)

Lydgate, like Liebig, harnesses an inductive imagination in the pursuit of scientific understanding. In 'the ideally illuminated space' (154) of the controlled laboratory experiment, (the construction of which is informed by the doctor's daily observations), fever's 'obscure conditions' can be understood, generating theories to direct future medical practice.

[82] Liebig, 'Induction', p. 306.

In this way, Lydgate oscillates between deduction and induction. Catherine Gallagher finds this movement in the novel's structures of characterisation, whereby Eliot 'carries the reader through the arc of induction and deduction, deduction and induction that gives generalities weight and substance'.[83] Similar arcs of reasoning underpin the novel's science, as seen through Lydgate and, more surprisingly perhaps, through Fred Vincy. Lydgate's experimentation is a model of scientific endeavour, 'offering the most direct alliance between intellectual conquest and the social good' (136); but to be of value, *Middlemarch* argues, the inductive imagination and the deductive understanding must be applied sensitively to the daily world, which requires the delicate negotiation of those points of contact between theory and practice, laboratory and field.

This is where Lydgate fails. Scholars have long appreciated, to borrow George Levine's words, that 'Lydgate is a failure to live up to science, not a failure of science itself'.[84] If Liebig's revised method influenced Lydgate's scientific imagination, there is something also of Liebig's failures in Lydgate's career – a difficulty moving between an 'ideal agriculture' and 'the actual state of things' reflected in Lydgate's idealised imaginings of medical reform and marital bliss, the lived experience of which check the doctor's progress. In this way, Lydgate is also a failure to live up to the mid-century realist project in its proximity to soil. Much might be learnt from studying the environmental factors active in the spread of zymotic disease and thus, of all Lydgate's errors, perhaps the most revealing is that he fails to visit the muddy road, the 'unsanitary' (225) street where Fred Vincy contracts 'typhoid fever' (244). As Kirsty Blair notes, 'it is never suggested that [Lydgate] is particularly interested in changing the environment in which the poor live'.[85] While recognising the mutual interdependence of laboratory and field, then, Lydgate does not follow his method in practice. And as he fails to move sensitively from the laboratory to the daily life of marital and town politics, there is this sense that to be far from soil is to be far from truth, whereas to be situated within the dirt of lived experience, and cognisant of one's necessarily partial and imperfect perspective, is to have a faithful understanding of the world.

I now turn my attention from medicine to agriculture. Where Lydgate's failure partly stems from 'bad economy' (333), an inability to manage his money, Fred Vincy acquires the

[83] Catherine Gallagher, 'George Eliot: Immanent Victorian', *Proceedings of the British Academy*, 94 (1997), pp. 157-72 (160).
[84] George Levine, ed., *One Culture: Essays in Science and Literature* (Madison: University of Wisconsin Press, 1987), p. 23.
[85] Kirstie Blair, 'Contagious Sympathies: George Eliot and Rudolf Virchow', in *Unmapped Countries: Biological Visions in Nineteenth Century Literature and Culture*, ed. by Anne-Julia Zwierlein (London: Anthem Press, 2005), pp. 145-54 (153).

proper method by gradually learning to husband his resources. This allows him to succeed where Lydgate fails – to negotiate the links between practice and theory, which in Vincy's case link science, the art of farming, and the capitalist economy. Elaine Freedgood notes that 'the proper procedure for determining value is largely worked out in the novels content', and it is this procedure that Vincy learns from Caleb Garth.[86] A 'valuer' of farmland, Garth is a mediator between the capitalist economy and soil fertility. Vincy famously makes the mistake of looking to 'land', which he believes will be forthcoming in Featherstone's will, 'as a future means of paying off present debts' (101); the method he acquires from Garth thus allows him to better manage those economies of soil shown, in chapter 3, to be so closely associated with the financial economy.[87] Throughout the novel, Vincy's actions are determined by the prospect of value held in soil; if he at first fatally misreads these prospects, he finds redemption by slowly recovering what Freedgood calls 'a realistic […] relationship to money' that is also, and crucially, a realistic relationship to the land.[88]

What Vincy learns, then, is how to manage the soil bank account. Early in the novel, having lost money gambling, he is indebted to horse dealer, Mr Bambridge, who holds a bill signed by Garth for Vincy's debt. Vincy is soon gifted one hundred pounds from his uncle, money he treats '"as a sort of seed-corn, which, planted with judgement and watered by luck", might yield more than threefold – a very poor rate of multiplication when the field is a young gentleman's infinite soul' (220). Gifted with this stock of money, extracted from the soil he hopes one day to inherit, Vincy's economics are far from promising. The field where he invests his seed-corn is 'Houndsley horse-fair' (221), to which he travels with Bambridge and Mr Horrock, his aim being, 'by dint of "swopping"', to 'metamorphose a horse worth forty pounds into a horse that would fetch a hundred pounds' (215). He attempts to extract 'a genuine opinion' (224) of his horse's value from his famously untrustworthy companions: 'To get the advantage of being with men of this sort you must know how to draw your inferences', Vincy reasons, with a feeling that 'the stress of circumstances […] was sharpening his acuteness and endowing him with all the constructive power of suspicion' (225). But with an inductive imagination led astray by subjective suspicions, and with 'no standard of economy' (216) to guide his reasoning, the only thing Vincy constructs is an inflated value of a hunting horse, which he buys from 'a young farmer' (224) in the hope of

[86] Elaine Freedgood, *The Ideas in Things: Fugitive Meaning in the Victorian Novel* (Chicago: University of Chicago Press, 2006), p. 120.
[87] Scholars have long found links between Fred Vincy and Richard Carstone: Mintz, *George Eliot*, p. 144; Frederic Jameson, *The Antinomies of Realism* (London: Verso, 2013), p. 136.
[88] Freedgood, *Ideas in Things*, p. 119.

selling on for a profit. The horse turns out 'bad temper[ed]' and Vincy's expected sale falls through. Having bought the horse from a 'stable […] reached through a back street where you might as easily have been poisoned […] as in any grim street of that unsanitary period' (225), Vincy's failure to negotiate the economics of the agricultural fair is compounded as he contracts typhoid. As for Richard Carstone in *Bleak House,* a failure to manage money is once more also a failure to manage the bodily economy. In Vincy's case, this is also an inability to navigate the economies of soil – the putrefying matter from which he contracts zymotic disease, the discourse of growth and 'yield' that leads him to invest his seed-corn at the horse fair.

Garth seems an unlikely figure to teach Fred a better standard of economy. He has 'failed in the building business' (217) and is scolded by his wife for 'working without pay' (235). But by 'living narrowly, exerting himself to the utmost that he might after all pay twenty shillings in the pound', Garth's 'honourable exertions' (217) remedy the shame of bankruptcy. He also 'kn[ows] more of land, building, and mining than most of the special men in the country' (236):

> he was ready to accept any number of systems, if they did not obviously interfere with the best land-drainage, solid building, correct measuring, and judicious boring (for coal). In fact, he had a reverential soul with a strong practical intelligence. But he could not manage finance: he knew values well, but he had no keenness of imagination for monetary results in the shape of profit and loss: and having once ascertained this to his cost, he determined to give up all forms of his beloved 'business' which required that talent. He gave himself up entirely to the many kinds of work which he could do without handling capital. (236)

Garth comes to know his limitations, and his refusal to manage capital is part of his wider veneration of practical arts such as farming over 'any number of systems'. But as Chinnie Ding explains, while 'purely financial operations are barren' for Garth, he is nevertheless 'a gifted mediator' for others, employed as a 'converter of matter into value'.[89] He is asked by Dorothea Brooke, for example, to 'measure and value a piece of land belonging to Lowick Manor' (522), and by Bulstrode to 'look […] into the state of the land and stock' at Stone Court, 'and take a preliminary estimate' (651). Garth's business, in this sense, involves grounding expectations of capital in the productive potential of soil.

Garth also mediates between theory and practice. Chettam may read Davy's *Elements of Agricultural Chemistry,* but he employs Garth to put theory into practice on his farmland. Garth's labours – 'invent[ing] a new patten of gate' (360) and planning 'Chettam's new farm

[89] Ding, 'Labor in *Middlemarch*', pp. 927, 924, 927.

buildings' (219) – form part of the agricultural 'experiments' (16) ongoing on Chettam's land. And as Garth 'draw[s] up a rotation of crops' (377, 384) for the farms in Freshitt and Tipton, he constructs a form of field experiment himself, 'manag[ing]' (358) the land so as to gain the maximum yield and financial return without exhausting the soil. In this way, Garth's 'projects of improvement' (652) shape a nascent science of agriculture running through the novel.

Garth's veneration of 'the best land-drainage' (236) offers another iteration of this emerging scientific culture. Draining land opened soils for the growth of crops and livestock, unleashing existing fertility while paving the way for the application of chemical and guano manures that high farmers, such as Chettam, would begin to use from the 1840s.[90] Garth's drainage work continues through the novel (236, 490, 517, 693) and should be understood in terms of the mid-century poetics of flow. Where land drainage features prominently in a novel like *Wives and Daughters*, such efforts to improve soil form part of that common concern with relations between the individual and the social body, seen before in the soils of Gaskell's and Dickens's fiction:[91] 'Garth often shook his head in meditation on the value, the indispensable might of that myriad-headed, myriad-handed labour by which the social body is fed, clothed, and housed' (235). Draining land increased the amount of soil available for producing food. Given Garth's almost 'religious regard' for 'business' (235), (by which he means 'the skilful application of labour' (518)), it is unsurprising he should set such store on increasing the productive potential of land. Jules Law finds a 'broad-reaching and coordinated sense of the management of fluids and of the interaction between the private and the public body' in *Daniel Deronda*, and in *Middlemarch* a similar poetics acts through Garth and soil to simultaneously release nutrient and financial wealth.[92] As Garth values soils, then, he also increases their value.

Vincy learns from Garth the value of hard work done well. But for the budding farmer, this lesson has a deeper purpose, teaching him to navigate the economies of soil –

[90] Anon., 'Artificial Fertility', pp. 157-64 (160). For more on land drainage as an effort to unleash soil fertility in the nineteenth century see Isabella Tree, *Wilding: The Return of Nature to a British Farm* (London: Picador, 2018), p. 215.
[91] In *Wives and Daughters*, the Hamleys attend agricultural meetings in order to develop 'a practical knowledge of agriculture' and introduce various improvements impacting both farming and sanitation. These improvements take the form of land drainage, which in turn introduces echoes of the sanitary belief, examined in chapter 2, that 'well drained […] gravel-soil' was good for health and, in Gaskell's final novel, a suitable location to recover from 'influenza'. Elizabeth Gaskell, *Wives and Daughters*, in *The Works of Mrs Gaskell, Volume 10*, ed. by Josie Billington, 10 vols (1864-66; London: Pickering and Chatto, 2005), pp. 189, 262, 553.
[92] Jules Law, *The Social Life of Fluids: Blood, Milk & Water in The Victorian Novel* (Ithaca, NY: Cornell University Press, 2010), pp. 96-97.

how to invest his seed-corn more wisely. As Bulstrode looks for a tenant for Stone Court, Garth realises that managing the land might make 'an excellent schooling for Fred; he might make a modest income there, and still have time left to get knowledge by helping in other business' (649). The principal attraction of this arrangement is that he will be 'steady and saving' – and 'with saving, he might gradually buy the stock' (777); Vincy 'has a turn for farming' (777), which is to say he learns to manage his finances by 'managing the land' (776). As he comes to live at Stone Court through hard work and prudential saving, he learns a standard of economy that stretches from the soil balance to the financial bank account.

Symbolically, it is only by being near to the earth, which for Vincy equates to accepting a lower position on the social scale, that he can learn Garth's 'business' and, in so doing, repay his debt. '[Garth] would not himself have liked to be of any rank in which he had not such close contact with "business" as to get often honourably decorated with marks of dust and mortar, the damp of the engine, or the sweet soil of the woods and fields' (236). This understanding of labour once more evokes the sense that to be close to soil is to be close to truth, here in the suggestion of honourable exertion and responsibility that comes with fulfilling one's role in the social body. Eliot's narrator employs identical imagery on the day Fred takes to farming. As Garth's assistant is 'knocked down' (523) by farm labourers irate at the prospect of the oncoming railway, Vincy steps in to help value Dorothea's land, and 'heartily enjoyed a good slip in the moist earth under the hedgerow, which soiled his perfect summer trousers' (527). Having been destined for the clergy, contact with soil brings 'the needed touch' (527) that leads him to farming, a change in career that his father sees as 'go[ing] down a step in life' (533). Seen here is the logic of mid-century literary realism as it equates to soil: though it is 'rather harder work to learn surveying and drawing plans than it would have been to write sermons' (631), it is only by navigating the economies of soil that Vincy can gain honest employment and thus avoid the fate of Carstone in *Bleak House*.

Vincy's success at navigating these economies is captured in the novel's finale:

> He became rather distinguished in his side of the county as a theoretic and practical farmer, and produced a work on the "Cultivation of Green Crops and the Economy of Cattle-Feeding" which won him high congratulations at agricultural meetings. In Middlemarch admiration was more reserved: most persons there were inclined to believe that the merit of Fred's authorship was due to his wife, since they had never expected Fred to write on turnips and mangel-wurzel. (779)

Vincy's (and Mary's) investigations into the 'Economy of Cattle-Feeding' of course suggest the monetary economy; but with 'mangel-wurzel' grown as a fodder crop for livestock, they also nod to Liebig's investigations into the assimilation of nutrients into the 'Animal

Economy'.[93] Vincy's experiments on the 'Cultivation of Green Crops', meanwhile, investigate those plants, also known as green manures, grown for building and maintaining soil fertility. With green crops feeding a soil that is then able to grow fodder crops to feed livestock, Vincy's crop rotation approaches a closed agricultural system, satisfying the nutrient economies of both the soil and the animal body.

Unlike his uncles, Vincy 'never became rich' (781). This distinguishes him from Featherstone, who 'gained so much by manganese' (100), mined for use in Middlemarch's dyeing trade, and Bulstrode, 'a sleeping partner in trading concerns, in which his ability was directed to economy in the raw material, as in the dyes which rotted Mr Vincy's silk' (581). While engaging with agricultural chemistry, then, Fred Vincy's farming, by stepping back from his father's business, also steps back from the exploitation with which chemical agriculture, like other extractive industries, can be associated. I will qualify this statement in section four, but Vincy's farming approaches true sustainability. Learning the rules of economy, he finds that capital, soil, and the living body form an inextricable ecology where long-term financial viability depends on carefully husbanding nutrients as they circulate in soils, plants, animals, and people.

Vincy's experiments also serve as the successful climax to *Middlemarch*'s lab/field culture. He engages with Liebig's ideas – the chemical epistemology which, if applied sensitively to the agricultural environment, might provide insights into 'the economy of cattle-feeding', for example. As Lewes noted in *Blackwood's*, Liebig's laboratory chemistry was 'proved at fault in every direct experiment in cattle-feeding' conducted at Rothamsted by Lawes and Gilbert, who together had the expertise to move successfully between studies in the field and laboratory analysis; Vincy's science aims for a similarly direct experimental investigation of theory in practice. At the same time, it is important that he 'likes being on the land' (384) because, as Garth informs him, 'a good deal of what I know can only come from experience' (527). In this way, Vincy's understanding of green crops and rotations bears the hallmark of Garth's practical knowledge – according to Liebig, such rotations were not required, for the land could be made permanently productive with the use of inorganic fertilisers. Vincy rejects this logic and achieves a similar conceptual feat to Lawes and Gilbert at Rothamsted, developing his knowledge of 'land and cattle' (528) by merging the special conditions of the field with general rules for agriculture.

[93] Liebig, *Chemical Letters*, p. 341.

Middlemarch thus blurs the divisions between theory and practice, deduction and induction, noted in 'Natural History'. Vincy's science shares similarities with Lydgate's scientific method in the merger of laboratory and field. Oscillating between deduction and induction, his success as 'a theoretic and practical farmer' is embodied in a field experiment that investigates theory but refines it for practice, a paper that incorporates Liebig's 'Animal Economy' while rejecting his claims that crop rotations could be abolished. What Gallagher calls 'the wave-like rise and fall from instances to generalities and back again' is as important for the chemist and agriculturist as for the biologist and doctor.[94]

Lydgate and Vincy advance a scientific method that generates knowledge by negotiating the relations between deduction and induction, theory and practice. If the former's travails with money leave him 'blighted – like a damaged ear of corn' (719), the latter learns to invest his seed-corn more wisely; the doctor thus fails because he gets lost in a world of ideals, whereas the farmer learns how to navigate the dirt of lived experience. I turn my attention now from the novel's content to its structure, finding that the same relationship between the ideal and the real, the laboratory and the field, governs the form of Eliot's novel. Where Archer, Turley and Thomas find 'worked land […] written into the language and metaphors used to describe […] domestic, social and economic relationships' in *The Mill on The Floss*, it is the coming language of chemical agriculture that, in *Middlemarch*, captures and helps to delimit the relations that form the novel.

'Vital Connexion' in the Field

In recent years, *Middlemarch* has increasingly been read in ecological terms. What lies implicit in Beer's reading of the novel's webs has been drawn out by Jayne Hildebrand, who finds that Eliot and Lewes share 'a desire to expand the organism-environment relationship […] into a more complex network of relationships, symbiotic as well as competitive, enabled by a living, supportive medium – something, we might say, more closely resembling an ecology' (1012).[95] Devin Griffiths's reading of *Middlemarch* in terms of comparative historicism describes the novel as 'an ecological reading of the social world' (205), where 'meaning accrues not in isolated parts but in the relationships that exist between them'.[96] This is the attraction Will Ladislaw finds in Rome, for example, 'which made the mind flexible by constant comparison, and saved you from seeing the world's ages as a set of box-like

[94] Gallagher, 'George Eliot', p. 160.
[95] Hildebrand, '*Middlemarch*'s Medium', p. 1012.
[96] Griffiths, *Analogy*, p. 205.

partitions without vital connexion' (198). As I show in this section, if the novel's science builds knowledge in the oscillations between epistemic approaches, then the novel's subject of investigation, the town of Middlemarch and its surroundings, can only be understood via the associations, the 'vital connexions', that link the novel's characters. I argue that *Middlemarch* is structured as a field experiment, whereby 'Loamshire' (10) turns out to be remarkably like a soil. It is an environment where relations between bodies can be approached through a chemical discourse, not for the reductionist ends of chemistry, but to better understand the biochemical exchanges that give the novel's 'medium' its vitality. And for Dorothea Brooke, 'a visionary young lady who projects the ideal beings of her imagination onto very unlikely people', it is only by learning to navigate her situated perspective within this web of vital relations that she can acquire truthful knowledge of the world and her place within it.[97]

Before Chettam and Brooke debate Davy's *Elements of Agricultural Chemistry*, the concerns of theory and practice have already been introduced to the novel through Dorothea:

> Her mind was theoretic, and yearned by its nature after some lofty conception of the world which might frankly include the parish of Tipton and her own rule of conduct there; she was enamoured of intensity and greatness, and rash in embracing whatever seemed to her to have those aspects. (8)

Such 'rash' and 'intense' thoughts suggest a mind, to borrow the words of *Adam Bede*, likely to arrive at 'lofty theories which only fit a world of extremes'.[98] The danger, as becomes clear, is less the theories themselves than how they play out in practice: 'Such a wife might awaken you some fine morning with a new scheme for the application of her income which would interfere with political economy and the keeping of saddle-horses' (9). More to the point, 'Dorothea, with all her eagerness to know the truths of life, retained very childlike ideas about marriage' (10). Her idealised visions of a life serving 'the judicious Hooker, […] or John Milton when his blindness had come on' (10), lead to her disastrous marriage to Casaubon. But Dorothea's 'nature' is not entirely 'theoretic' – her 'plan[s] for some buildings' (11) to improve the living conditions of the rural poor suggest a practical focus. There is a mind beneath the 'outside tissues' (9) that 'is not always consistent' (14), her sister Celia realises, 'elements in the character of a marriageable girl' (8) that are worthy subjects of investigation. Once again, it is in the marriage plot where the discourse of organic chemistry comes to the fore in the realist novel.

[97] Gallagher, 'George Eliot', p. 207.
[98] Eliot, *Adam Bede*, p. 154.

If Lydgate's search for the 'primitive tissue' is influenced by Liebig's sophisticated experimental method, then Casaubon's essentialism, his 'Key to all Mythologies' (78), is associated with an outdated methodology founded on analysis. 'The subject Mr. Casaubon has chosen is as changing as chemistry', Will Ladislaw tells Dorothea, 'new discoveries are constantly making new points of view. Who wants a system on the basis of the four elements, or a book to refute Paracelsus?' (207).[99] Dorothea is understandably terrified that Casaubon, after his death, 'would expect her to devote herself to sifting those mixed heaps of material' that form his notes, an analysis aiming at 'the doubtful illustration of principles still more doubtful' (449):

> And now she pictured to herself the days, and months, and years she must spend in sorting what might be called shattered mummies, and fragments of a tradition which was itself a mosaic wrought from crushed ruins – sorting them as foison for a theory which was already withered in the birth like an elfin child. Doubtless a vigorous error vigorously pursued has kept the embryos of truth a-breathing: the quest of gold being at the same time a questioning of substances, the body of chemistry is prepared for its soul, and Lavoisier is born. But Mr Casaubon's theory of the elements which made the seed of all tradition was not likely to bruise itself unawares against discoveries. (450)

Casaubon's 'theory of the elements', arrived at by dubious analysis, is incorrect. 'He had undertaken to show […] that all the mythical systems or erratic mythical fragments in the world were corruptions of a tradition originally revealed' (22). This deduction is false, however, and associating his methodology with chemistry serves a similar purpose to Eliot's argument against a universal chemical language in 'Natural History'. *Middlemarch* opposes an essentialist analysis that, in destroying the vitality of its subjects, creates nothing more than a 'dried preparation, a lifeless embalmment of knowledge' (184) that cannot possibly express the truths of life and human experience.

But as in 'Natural History', chemistry retains an important place in the novel's arguments. Framed as an experiment, *Middlemarch* functions as an investigation of vitality in the field, a study of life in the provinces. One way to track relations in the field, as Lawes and Gilbert were showing to great effect at Rothamsted, was to analyse changes in elemental composition as chemical bodies came into contact in soils, plants, and the bodies of cattle. For Liebig, the chemical action of creatine and creatinine, which he explained to Eliot and

[99] With Casaubon's failure to consult the 'same materials' (207) as German philologists compared with the latest advances in chemistry, and Lydgate's fear that 'some "plodding fellow of a German"' might 'make the great, imminent discovery' (327), there seems to be an undercurrent of the work Liebig and Friedrich Wöhler would do in founding organic chemistry in the 1830s running through both the novel's searches for unitary truth.

Lewes in his laboratory in 1858, captured these chemical forces of decomposition and recomposition perfectly, as he outlined in *Chemical Letters*:

> Each [of kreatine and kreatinine] may be converted into the other. In contact with a strong acid, kreatine loses the elements of four equivalents of water, and kreatinine is produced, which neutralises a part of the acid. Kreatinine, when in the act of separating from its combination with chloride of zinc, takes up water, and is re-converted into kreatine.[100]

In close contact, molecular bodies combine and recombine to form different chemical compounds. This is the essence of chemical affinity, seen before in Dickens's fiction and to be drawn out shortly in *Middlemarch*'s marriage plot. But with both creatine and creatinine essential to muscular function and thus 'products of the vital processes', as Liebig put it, their biochemistry of exchange points to how vitality exists in the associations and transformations of matter within and between living bodies, precisely what the analytical focus of chemistry would always struggle to capture.[101] This is what Eliot noted in 'Natural History', what Lewes argued in *Physiology*, and what Casaubon's failed efforts to reduce epistemic diversity to a unitary tradition embody in *Middlemarch*. 'The conception that living bodies, fundamentally considered, are not associations of organs which can be understood by studying them first apart' (138) situates Lydgate's work in a tradition of French physiology, as shown by Shuttleworth.[102] The passage also captures Eliot's conception of vitality inhering through webs of interaction and exchange; be these webs of bodily tissue or narrative progression, the effect is to focus *Middlemarch*'s discourse of chemical affinity on the relations between bodies in the field of lived experience.

This discourse of organic chemistry is first evident as Casaubon courts Dorothea. Proposing via letter, he describes her as a 'rare combination of elements both solid and attractive' (40). While Casaubon's courting is more doubtful even than his theory of mythological tradition, his words speak to a 'union which attracted [Dorothea]' (27). This discourse of chemical affinity, familiar from *Our Mutual Friend,* figures Dorothea as an 'attractive' body in turn 'attracted' by Casaubon as they meet in 'marital union' (40). But where the introduction of Bradley Headstone firmly bonds Eugene Wrayburn and Lizzie Hexam, chemical bonds between organic bodies in *Middlemarch* are far more unstable. As Dorothea's 'life' takes on 'new form' in contact with Casaubon and Ladislaw, she undergoes

[100] Liebig, *Chemical Letters*, pp. 419-20.
[101] Liebig, *Chemical Letters*, p. 419.
[102] Shuttleworth, *George Eliot*, pp. 142-74.

a 'metamorphosis' which cannot be reduced to, yet nor can be understood without, a sense of biochemical exchange that associates beings in vital 'relation' (461).

The lived experience of marriage plays out differently from Dorothea's idealised imaginings, and she soon experiences a sense of 'repulsion' (184) from her husband. The emotional affect of repulsion is clearly more than chemical in such moments, but chemistry's forces of affinity and decomposition are part of the discourse with which Eliot negotiates Dorothea's changing feelings as she responds involuntarily to Ladislaw: 'There was a certain liquid brightness in her eyes, and Will was conscious that his own were obeying a law of nature and filling too' (210); the 'law of nature' Will's body obeys instantly acts on Dorothea, 'rising and walking a little way under the strength of a recurring impulse' (210). As their bodies draw near and become mutually receptive, the introduction of a third body threatens to disrupt the force that momentarily bonds their natures: 'The allusion to Mr Casaubon would have spoiled all if anything at that moment could have spoiled the subduing power […] of her noble unsuspicious inexperience' (210). Dorothea has asked Will to explain his earlier remark about Casaubon's subject 'being as changing as chemistry', and this sequence frames Dorothea and Will as attractive chemical bodies that threaten the marital union. This is immediately affirmed as Ladislaw feels pangs of jealousy: 'The poet must know how to hate, says Goethe; and Will was at least ready with that accomplishment' (210). This reference to the poem 'Elemente', whereby Goethe plays on the elements of matter, music, and love, emphasises the action of elective affinity. The lessening of Dorothea's bonds to Casaubon corresponds with the strengthening of her bonds to Ladislaw. In this way, Ladislaw experiences Dorothea's presence as 'every molecule in his body [passes] the message of a magic touch' (364); Casaubon in turn fears 'that [Dorothea] was ready to be attached to Will' (393), in the process 'severely repuls[ing] Dorothea's strong feeling' (446).

The play of chemical forces in *Middlemarch*'s marriage plot develops the Goethean tradition of elective affinities via Liebig's conception of chemical affinity. Chapter V of *Chemical Letters* was entitled 'Chemical Affinity' and explained 'that tendency of bodies to combine with each other', a chemical force only perceptible 'when bodies come into immediate contact'.[103] In *Middlemarch,* this chemical imaginary is most apparent towards the end of the novel, as Dorothea comes into close contact with Lydgate, Rosamond Vincy, and Ladislaw, 'those three lives which were touching hers' (747). Serving as the climax of the novel's investigation into 'social bonds' (547), the shifting relations between these four

[103] Liebig, *Chemical Letters*, pp. 78, 79.

bodies can be understood as a series of reaction sequences by which the novel's marriage plot is resolved.

Early in the novel, Rosamond finds that Lydgate's presence 'touch[es] her nature quite newly' (110). She in turn strikes Lydgate as 'a rare compound of beauty, cleverness, and amiability' (252), and it is a moment of close proximity, Lydgate finding himself suddenly 'very near to [her] lovely little face', that acts as a 'crystallizing feathertouch' (282) to form a marital compound:

$$RV + TL \longrightarrow RVTL$$

But as the couple fall into debt and suffer the miscarriage of their child, they find 'the closeness of love's bond' (624) becomes insufferable. It is only under the influence of Dorothea's 'noble nature' (717), under the influence of one who 'know[s] what sort of bond marriage is' (720), that Lydgate is able to speak freely of his problems. With Dorothea's 'influence […] beginning to act on Lydgate' (717) in this way, he entrusts her to go to Rosamond, hoping she might help to dispel his wife's 'impression […] of […] repulsion' (557). It is of course 'not in Rosamond's nature to be repellent' (613), and unbeknownst to both Lydgate and Dorothea, the introduction of another body threatens to displace Lydgate in her affections. On entering the drawing room of Lydgate's home, Dorothea 'saw Will Ladislaw: close by him and turned towards him […] sat Rosamond' (729), her hands clasped in his:

$$RVTL + WL \longrightarrow RVWL + TL$$

Dorothea's presence 'act[s] strongly' (726) on the newly formed compound. Affinity turns to decomposition, Rosamond 'snatch[ing] away her hands' with 'a spasmodic movement' as Will 'seemed changing to marble' (729). Dorothea, suddenly 'animated by a […] self-possessed energy' (730), is herself repulsed and passes 'quickly out of the room' (729). This force leaves Rosamond and Ladislaw 'motionless', before Rosamond, touching 'the tips of her fingers on Will's coat-sleeve', becomes a repellent force herself: 'Don't touch me!', Will cries, 'darting from her […] his whole frame tingling' (731), leaving Rosamond with 'no force' (734) to draw him back:

$$RVWL + DB \longrightarrow RV + WL + DB$$

Later that night, Dorothea finally realises that she loves Will and, while any hope of a life with him was now surely gone, 'that there might still be time to rescue [Rosamond] from the misery of false incompatible bonds' (747). Returning the following day, Dorothea once more

describes marriage as 'a bond', with 'something even awful in the nearness it brings' (748). As 'the two women clasped each other', Rosamond is 'taken hold of by an emotion stronger than her own – hurried along in a new movement' (749); Dorothea again acts as a chemical body, to borrow Liebig's words, by 'imparting the same condition of motion or activity in which its atoms are [invested] to certain other bodies […] with which it is in contact'.[104] Under Dorothea's influence, Rosamond is suddenly capable of 'repelling Will's reproaches' (750) by explaining that, when Dorothea had arrived the day before, Ladislaw was explaining that 'he loved another, that I might know he could never love me' (749). In this way, as Dorothea experiences a 'revulsion of feeling' towards Ladislaw, an emotion that would be 'joy when she recovered her power of feeling it', so Rosamond's 'affection was yearning back towards her husband' (750):

$$RV + WL + DB + TL \longrightarrow RVDB + RVTL$$

'The chemical affinity of the acting body causes the component parts of the body which is decomposed to combine so as to form new compounds, of which either both, or only one, combine with the acting body', wrote Liebig in *Organic Chemistry*.[105] 'The force with which certain characteristics in Dorothea impressed those around her' (447) situates Dorothea as the acting body within *Middlemarch*'s chemical courtship plot; the 'active force of antagonism within her' (726) decomposes and recomposes relations between those 'three lives whose contact with hers laid an obligation on her' (741). The complete reaction sequence looks something like this:

$$RVTL+WL=RVWL>TL \longrightarrow RVWL+DB=WLDB>RV \longrightarrow WLDB>RV+TL=WLDB+RVTL$$

At which point it becomes possible to see how *Middlemarch*, tracing shifting relations between organic bodies, has an ideal structure akin to the laboratory experiment. As Levine writes, drawing on Colvin's 1873 review, 'there is an "ideal" shape to the narrative'.[106] Like one of Lydgate's laboratory experiments, the courtship plot offers an 'ideally illuminated space' by which to witness the action of chemical bodies in close contact and from which to develop, what J. Hillis Miller calls, 'universal laws of human behaviour'.[107] But then, as Beer explains, describing Eliot's novel as a whole, 'in the very multiplicity of interconnection she simultaneously offers a critique of any attempt at unifactorial description of human

[104] Liebig, *Organic Chemistry*, p. 229.
[105] Liebig, *Organic Chemistry*, p. 218.
[106] Levine, *Realistic Imagination*, p. 256.
[107] Miller, 'Optic and Semiotic', pp. 126-27.

behaviours under varying conditions'.[108] A study of provincial life, *Middlemarch* traces the relations between human bodies, not in a controlled laboratory, but in the field. As Elizabeth Ermath puts it, 'the repetitive pattern is part of a rhythmic persistence that selects, binding together into common likeness and mutual dependence elements from a diversified field of conditions'.[109] In this way, with *Middlemarch* structured as a field experiment, human bodies in Loamshire stand as elements in the soil. Though an original insight, this argument also augments existing readings of the novel – revealing a narrative experiment that draws, to a remarkable degree, on contemporary science. Where I firmly depart from the critics above, however, is in now arguing that the novel's field of experience is not knowable in totality; it is this partial perspective that Dorothea must come to accept and, in time, learn to act upon.

Dorothea's development is intimately tied to the biochemistry of exchange that structures the novel's marital reaction sequence. Learning to negotiate her situated position within the experiment, she gains a method to understand the world around her. At the start of the novel, for all 'her eagerness to know the truths of life' (10), Dorothea is prone to error. Believing she 'looked deep into the ungauged reservoir of Mr Casaubon's mind' and 'understood from him the scope of his great work', all she in fact perceives, 'reflected there in vague labyrinthine extension', is 'every quality she herself brought' (22). Where Vincy is led astray by an overactive inductive imagination, Dorothea's observations are coloured by hasty deduction, 'her usual eagerness for a binding theory' (79). Casaubon's lifeless and fragmented analysis may be dangerous to one 'whose ardent nature turned all her small allowance of knowledge into principles […] and whose quick emotions gave the most abstract things the quality of a pleasure or a pain' (181). As incomplete data leads to erroneous theory, overwrought passions seem to make objective knowledge impossible. But while she is 'humiliated to find herself a victim of mere feeling, as if she could know nothing except through that medium' (186), Dorothea's capacity for feeling becomes the foundation of her knowledge-making.[110] With 'her view of Mr Casaubon and her wifely relation […] gradually changing' (182), she experiences 'life made a new problem by new elements' (184). As with the transformations of creatine and creatinine, her marital union is a problem that must be approached through relations, in this case between the elements of her experience.

[108] Beer, *Darwin's Plots*, p. 149.
[109] Elizabeth Deeds Ermarth, *Realism and Consensus in the English Novel* (Princeton: Princeton University Press, 1983), pp. 231-32.
[110] Seen here is George Eliot's belief 'in the connection of feeling to knowledge, of knowledge to moral action', as Levine puts it. *Realistic Imagination*, p. 265.

Vitality, and therefore understanding, lies in connections and associations. This is why Dorothea struggles against, and ultimately rejects, her position within the gentry. 'The country gentry of old time lived in a rarefied social air: […] they looked down with imperfect discrimination on the belts of thicker life below. And Dorothea was not at ease in the perspective and chillness of that height' (306). She is far happier, her sister Celia notices uneasily, 'going all about Tipton with Mr Garth into the worst backyards' (504):

> Dorothea's confidence in Caleb Garth's knowledge, which had begun on her hearing that he approved of her cottages, had grown fast […], Sir James having induced her to take rides over the two estates in company with himself and Caleb, who quite returned her admiration. (518)

In this way, as she comes to shape Chettam's agricultural experiments, *Middlemarch* again makes an argument about the sites and processes of knowledge creation. In contrast to the position and perspective demanded by her social position, 'look[ing] down with imperfect discrimination on the belts of thicker life below', the 'truths of life' are to be found within the mud of lived experience. As with Vincy, gaining the proper method is partly a question of understanding the economies of money and matter, which together denote a growing embeddedness within the world: Dorothea's plans for Tipton's and Freshitt's agricultural labourers, drawn from 'Loudon's' (29) *Observations on Laying Out Farms*, find favour with the practical Garth, and on becoming engaged to Ladislaw, her promise that she will 'learn what everything costs' (762) denotes a social descent from the upper to the middle class that, in the novel's epistemology, is also an ascent to knowledge. Adjusting her ideals to available materials, tempering her theories to experience, Dorothea learns to negotiate the relations of laboratory and field. She and Ladislaw leave the 'rarefied social air' of Middlemarch, as a shocked Celia exclaims, to 'live in a street' (771); humour aside, there is once more this sense that to be near to soil and dirt, both in literal and metaphorical terms, is to have access to truth.

'Ironically, then, Dorothea is the better scientist', writes Levine, comparing her successful repression of the subjective self with Lydgate's failure to do the same. Her success, I would suggest, is more due to her willingness to go 'into the worst backyards'. In the backstreet where Vincy contracts typhoid, in the fields of Freshitt and Tipton, and in Vincy's experiments at Stone Court, the soils of Loamshire are repeatedly shown to be important sites of knowledge creation. The necessity of these situated perspectives to complement the ideal perspective of the laboratory is reflected in *Middlemarch*'s structure. Whereas the biologist stands aloof with impartial nature, Dorothea's nature is enmeshed

within the experiment, meaning that coming to knowledge involves negotiating her own position as a reactive body in the marriage plot.

As she looks out on the agricultural landscape in one of the novel's most famous passages, having spent the night in turmoil believing Ladislaw has been unfaithful, Dorothea becomes vital in her associations:

> She opened her curtains, and looked out toward the bit of road that lay in view, with fields beyond, outside the entrance-gates. On the road there was a man with a bundle on his back and a woman carrying her baby; in the field she could see figures moving – perhaps the shepherd with his dog. Far off in the bending sky was the pearly light; and she felt the largeness of the world and the manifold wakings of men to labour and endurance. She was a part of that involuntary, palpitating life, and could neither look out on it from her luxurious shelter as a mere spectator, nor hide her eyes in selfish complaining. (741)

Dorothea learns to qualify her rash deductions with a reasoning that seems closer to induction; 'she chooses to learn to realise others by imagining their particularity', as Gallagher puts it.[111] But more than this, by drawing connections outwards from her own situated perspective, she realises the links between her own life and those of others, associations that together form 'that involuntary, palpitating life'. In one movement, she both becomes vital and is able to comprehend that vitality, albeit only partially. Knowledge, Dorothea learns, is situated.

This speaks to how ethical and epistemological responsibility become inseparable in *Middlemarch*. In the passage above, Dorothea begins to understand how she might act 'to rescue [Rosamond] from the misery of false incompatible bonds' (747), regaining her courage to intervene in the novel's marital reaction sequence. Her actions of course fall domestically, on 'those three lives that were touching hers' (747) in the marriage plot, but it would be wrong to view this as another of those movements, all too common in mid-century realism, away from imperial extraction and exploitation. Like Jane Eyre, Margaret Hale, and Esther Summerson, Dorothea comes to knowledge through 'felt' experience; but where Dorothea's knowledge-making differs, I think, is in striving to 'feel the largeness of the world'. She occupies a partial but unbounded perspective that allows for 'the reaching forward of the whole consciousness towards the fullest truth, the least partial good' (190). If realising the world in its 'largeness' means acknowledging one's always situated perspective within it, then striving to do 'the least partial good' means acknowledging the possibility of always doing harm elsewhere. In this oscillation between the epistemic and the ethical,

[111] Gallagher, 'George Eliot', p. 168.

knowledge-making again becomes a question of negotiating the relations between different ways of knowing and the beings these approaches seek to understand.

The novel's world, it would seem, is not knowable in totality. Levine and Beer both note the tendency of *Middlemarch* towards proliferation, but step back from the implications of this aesthetic for realist form, concluding that Eliot creates a unified whole. I agree that the novel's characters, 'moving with kindred natures in the same embroiled medium' (272), are immersed in a shared environment that unifies the novel's field of experience. It does not automatically follow, however, that the sum of networked relations forming *Middlemarch*'s ecology is therefore ultimately knowable. Ermarth's consensus and Miller's totalisation break down in ways captured by Matthew Beaumont, whose reading of aleatory realism brilliantly deconstructs Eliot's parable of the pier glass:

> Your pier-glass or extensive surface of polished steel made to be rubbed by a housemaid, will be minutely and multitudinously scratched in all directions; but place now against it a lighted candle as a centre of illumination, and lo! the scratches will seem to arrange themselves in a fine series of concentric circles round that little sun. It is demonstrable that the scratches are going everywhere impartially, and it is only your candle which produces the flattering illusion of a concentric arrangement, its light falling with an exclusive optical selection. (248)

'In the absence of this perspective', explains Beaumont, 'social reality is nothing more than a chaos of indiscriminate scratches, minute and multitudinous. The consensus collapses, and reality appears in the immediate, that is, unmediated, form of inchoate matter'.[112] If Levine is correct that the 'organism offers [Eliot] an ultimately intelligible universe', this is only true when life is considered in the closed and ideal space of the laboratory, not the lived relationality of the field.[113] As Eliot's narrator explains, 'there is no creature whose inward being is so strong that it is not greatly determined by what lies outside it' (784). Knowing the sum of human, non-human, organic, and inorganic actors whose relations form each other and the novel's 'medium' (785) is thus impossible in totality. Not only are what Raymond Williams called 'Knowable Communities' in important ways unknowable, then, but they become so partly in the movement that opens human society to the sociability – the dynamic intra-activity – of the non-human world.[114]

For Beaumont, 'even if she finally forecloses the idea that reality is chaotic, because she cannot accept its philosophical, its existential implications, Eliot nonetheless flirts for an

[112] Matthew Beaumont, 'Aleatory Realism: Reflections on the Parable of the Pier-Glass', *Synthesis: an Anglophone Journal of Comparative Literary Studies*, 0.3 (2011), pp. 9-17 (12).
[113] Levine, *Realistic Imagination*, p. 269.
[114] Raymond Williams, *The Country and the City* (1973; London: Vintage, 2016), pp. 239-61.

instant with the experimental potential of an aleatory realism'.[115] Yet such moments in fact recur throughout *Middlemarch*. 'A human being in this aged nation of ours is a very wonderful whole, the slow creation of long interchanging influences' (383), Eliot's narrator explains; these influences are 'incalculably diffuse', the novel's finale concludes, describing 'the effect of [Dorothea's] being on those around her' (785). If 'the fragment of a life, however typical, is not the sample of an even web' (779), then beings and the associations that form them come together as 'incalculable' wholes. *Middlemarch* is thus full of unthinkably complex ecologies. In this way, the novel's webs form 'open ecologies', as Griffiths and Deanna Kreisel have it, that 'pull toward […] a deep scepticism about easy claims to unity or interconnectedness'.[116] As she must, Eliot ignores that 'tempting range of relevancies called the universe' in favour of 'this particular web' (132), words that at the same time acknowledge how 'the fragment of a life' and the 'particular web' must be partitioned from the associations that constitute them so as to be understood. Viewed in this light, the novel's ecologies become ideal constructions that, at some level, deny the field of relations from which they have been taken and from which they derive their vitality.

As Caroline Levine writes, '"form" always indicates an arrangement of elements, an ordering, patterning, or shaping'.[117] *Middlemarch*'s marriage plot engages with its own construction, its own ideal form, through a relational discourse of chemical bodies that come together to form the novel's field of experience. 'What the novel imagines in its conclusion is really not an ending at all, but a beginning', Levine continues, in words meant for *North and South* but that surely nod to *Middlemarch* where, as Eliot concludes, 'Every limit is a beginning as well as an ending' (779).[118] This sense of openness applies to the whole mid-nineteenth-century realist project, I believe. While no other novel of the period engages quite so deliberately with its own artificial closure as *Middlemarch*, throughout this thesis I have shown novels struggling to unify a world that inevitably extends beyond the bounds of the provincial. Brontë, Gaskell, Dickens, and Eliot all gesture towards a world that is unknowable in the whole, in its multivalent relations and possibilities, even if such a whole exists beyond the bounds of human perception.

[115] Beaumont, 'Aleatory Realism', p. 15.
[116] Devin Griffiths and Deanna K. Kreisel, 'Introduction: Open Ecologies', *Victorian Literature and Culture*, 48.1 (2020), pp. 1-28 (2).
[117] Caroline Levine, *Forms: Whole, Rhythm, Hierarchy, Network* (Princeton: Princeton University Press, 2015), p. 3.
[118] Levine, *Forms*, p. 41.

Vitality lies in the associations, then, but these associations are unknowable in totality. *Middlemarch* arrives at a conception of life – as 'a process and an unfolding' (140) – similar to Tim Ingold in his book *Lines*, the world as 'a manifold woven from countless threads spun by beings of all sorts, both human and non-human, as they find their ways through the tangle of relationships in which they are enmeshed'.[119] It is to the novel's manifold web that I now turn, tracing these threads as they intersect around questions of colonialism, capitalism, and care, questions that emerge from *Middlemarch*'s enmeshed networks of human and soil.

Care in the Unknowable Web

The novel's social world extends from the provincial politics of the town's inhabitants to the soils of the Loamshire countryside. Chettam acts as another chemical body in the marriage plot – in proximity to Ladislaw, for example, as 'an incorporation of the strongest reasons through which Will's pride became a repellent force, keeping him asunder from Dorothea' (513). He also has a 'growing anxiety to "act on Brooke"' (363), as he puts it, a desire to see Tipton's landlord make the same agricultural improvements that he has begun in Freshitt. If Chettam's ethos of improvement stems in part from reading about soil processes as explained by Davy in 'Agricultural Chemistry' (15), then the unknowable web extends from the human to the non-human world, and from organic to inorganic nature. Loamshire's soils form associations that are as much a part of Eliot's narrative assemblage as the bonds that weave and cleave the novel's marriage plot.

Consider, for example, Mrs Cadwallader, 'busy about Miss Brooke's marriage' (54) – by which she hopes to see Chettam marry Dorothea. Yet she has been thwarted, for Dorothea, she has just learned, is to marry Casaubon, at which point Cadwallader turns her attention to a union between Chettam and Celia:

> Was there any ingenuous plot, any hide-and-seek course of action, which might be detected by a careful telescopic watch? Not at all: a telescope might have swept the parishes of Tipton and Freshitt, the whole area visited by Mrs Cadwallader in her phaeton, without witnessing any interview that could excite suspicion […] Even with a microscope directed on a water-drop we find ourselves making interpretations which turn out to be rather coarse; for whereas under a weak lens you may seem to see a creature exhibiting an active voracity into which other smaller creatures actively play […], a stronger lens reveals to you certain tiniest hairlets which make vortices for these victims while the swallower waits passively at the receipt of his custom. (55)

[119] Tim Ingold, *Lines: A Brief History* (2007; London: Routledge, 2016), p. 3.

As with Eliot's pier-glass, the play of networked association is as hard for the reader to decipher as it is for Cadwallader to navigate. Where in that other parable 'the scratches are events, and the candle is the egoism of any person now absent – of Miss Vincy, for example' (248), here it is Cadwallader's mind – 'active as phosphorous, biting everything that came near it into the form that suited it' (56) – that distorts social reality. Yet what is most unsettling, at least for the totalising project of the realist novel, is that these perspectives also belong to Eliot's narrator; the direction of the parable of the telescope and the microscope is again to suggest that the reader's position is in fact no different from the partial perspectives occupied by Cadwallader and Vincy. As microscopic lenses of increasing strength seem to reveal the life of Loamshire evermore sharply, the analogy that sees 'the Miss Brookes and their matrimonial prospects' (56) in terms of the microbial life in a water-drop, rather than fixing meaning, instead opens the possible associations available to the novel's web. In the same way, as a telescopic lens sweeps 'the parishes of Tipton and Freshitt', scientific inquiry is focussed not only on the marriage plot, but on the Loamshire soils where the novel's agricultural experiments are taking shape. To carry the parable to its conclusion, the processes active in these soils are like Cadwallader's movements – understood at best imperfectly. As with the aleatory realism Beaumont detects in the parable of the pier-glass, the above passage gestures towards what Griffiths calls 'networks of contingent, unpredictable, but nevertheless sociable encounter' that extend outwards, beyond the human and beyond the bounds of the novel.[120]

Eliot famously saw *Middlemarch* as investigating 'the history of man, and how that mysterious mixture behaves under the varying experiments of Time' (3); one direction the unknowable web extends is into the decades separating the novel's setting and authorship. Hence the 'pretty bit of midland landscape' surrounding Stone Court, where Fred and Rosamond Vincy are seen riding early in the novel, is imbued with meaning. The passage below captures and examines those changes that were beginning to transform the English countryside in the mid-nineteenth century, and in which the 'theoretic and practical' improvements of those such as Vincy will be instrumental:

> […] meadows and pastures, with hedgerows still allowed to grow in bushy beauty and to spread out coral fruit for the birds. Little details gave each field a particular physiognomy, dear to the eyes that have looked on them from childhood: the pool in the corner where the grasses were dank and the trees leaned whisperingly; the great oak shadowing a bare place in mid-pasture; the high bank where the ash-trees

[120] Devin Griffiths, '*Silas Marner* and the Ecology of Form', *Victorian Literature and Culture*, 48.1 (2020), pp. 299-326 (300-01).

> grew; the sudden slope of the old marl-pit making a red background for the burdock; […] (96)

Recalling those 'coral treasures' that Jane Eyre analyses in the hedgerows around Thornfield, Eliot's narrator looks fondly back with forty years of hindsight to hedges 'still allowed to grow in bushy beauty and to spread out coral fruit for the birds'.[121] Part of the 'shocking farming' that Gaskell's Mr Bullock denounces in *Mr Harrison's Confessions*, the mid-nineteenth century saw high farmers grub out and cut back such 'high hedge-banks' as larger stretches of land were enclosed and improved.[122] The 'old marl-pit', meanwhile, offers a source of lime to balance an acid soil, fertiliser that will soon be available in the form of Super-Phosphatë from Deptford, whereby such 'meadows and pastures' will become part of a global trade in nutrients captured by Dickens in *Our Mutual Friend*. In these changes, enmeshed in an unforeseeable web of contingent action, what Jesse Oak Taylor calls the 'unexpected futurity' of Eliot's writing comes to the fore in a specifically agricultural context.[123] Where Elizabeth Miller draws attention to the long presents of extraction, extending two centuries into the pasts that produced them, so 'the particular physiognomy' of each field has today long since been lost to industrial monoculture.[124]

So passes, too, a way of relating to the land, easy to idealise were it not for the terrible urban and rural poverty that these agricultural improvements were, at least in name, seeking to address. The discussion of Master Bunney's 'sixty years' experience as to soils' (737), with which my thesis opened, is placed amidst the climax to the marriage plot – a symbolic acknowledgement of a transition from one way of knowing Loamshire's soils to another. Dorothea, animated by the sudden energy of chemical decomposition, has left Ladislaw and Rosamond standing 'motionless', and will in a few hours spend the night realising she is 'part of that involuntary, palpitating life':

> She paused […] to talk to old Master Bunney who was putting in some garden-seeds, and discoursed wisely with that rural sage about the crops that would make the most return on a perch of ground, and the result of sixty years' experience as to soils – namely, that if your soil was pretty mellow it would do, but if there came wet, wet, wet to make it all of a mummy, why then – (737)

---

[121] Charlotte Brontë, *Jane Eyre*, ed. and intro. by Stevie Davies (1847; St Ives: Penguin, 2006), p. 131.
[122] Gaskell, *Mr Harrison's Confessions*, p. 30; P.J. Perry, 'High Farming in Victorian Britain: Prospect and Retrospect', *Agricultural History*, 55.2 (April 1981), pp. 156-66 (164).
[123] Jesse Oak Taylor, *The Sky of Our Manufacture: The London Fog in British Fiction from Dickens to Woolf* (Charlottesville: University of Virginia Press, 2016), p. 70.
[124] Elizabeth Carolyn Miller, 'Drill, Baby, Drill: Extraction Ecologies, Open Temporalities, and Reproductive Futurity in the Provincial Realist Novel', *Victorian Literature and Culture*, 48.1 (2020), pp. 19-56 (33).

Bunney's knowledge centres on physical structure rather than chemical composition. The passage ends abruptly as Dorothea realises that she is late for dinner with Mr Farebrother, the natural historian, Eliot's narrator explains, who is 'like another White of Selborne' (737-38). Gilbert White's *The Natural History and Antiquities of Selborne* (1789) began by explaining how 'the soils of this district are almost as various and diversified as the views and aspects', describing 'chalk', 'stiff clay', 'rank-clay', 'black malm', 'white malm', 'wet, sandy loam', and 'hungry, lean sand' soils that, one suspects, Bunney would have plenty to say about too.[125] With Dorothea acting as a chemical body in the social soil of Middlemarch, she pauses to hear Bunney's qualitative, experiential, and local knowledge of Loamshire soil. It is perhaps unsurprising that this knowledge should focus on the problems that follow when 'there came wet, wet, wet', for this is exactly what Garth's land drainage seeks to address. As such work releases fertility and paves the way for the application of chemical fertilisers by removing the pools that make 'the grasses […] dank' (96) around Stone Court, so an older knowledge of soil structure is replaced by a chemical epistemology that acts across the novel's social situations. In this way, Bunney's words on soil refract back to throw Dorothea's position within the marriage plot into sharper relief, a chemical body whose fertility is soon to be unleashed, as with Margaret Hale and Lizzie Hexam, in a suitably productive marital union.

These tensions shed further light on the wording of Vincy's 'practical and theoretic' paper on the 'Cultivation of Green Crops and the Economy of Cattle-Feeding'. Here is theory that thinks about Liebig's chemistry but also qualifies it, practice that incorporates older knowledge but also modernises it, a way of working the land that increases production while seeking to resist an extractivist model whereby soil becomes an extension of a factory economy. An ethos of improvement, then, without the counterpoint of extinction. If Vincy's farming seems to offer something approaching a sustainable system, it is also true that his agriculture is charged with balancing almost impossible forces; as Les Levidow explains, any true sense of 'sustainable agriculture' always 'concerns more than simply quantitative yields'.[126]

But in this way, Eliot seeks to distinguish Vincy's ethos of improvement from the programmes followed by his uncles. Bulstrode's 'notions of improvement' (425), focused largely on the New Fever Hospital, capture everything about the improvement ethos so

[125] Gilbert White, *The Natural History and Antiquities of Selborne* (1789; London: Penguin, 1977), pp. 7-9.
[126] Les Levidow, 'Simulating mother nature, industrializing agriculture', in *FutureNatural: Nature, Science, Culture*, ed. by Jon Bird and others (London: Routledge, 1996), pp. 55-71 (67).

destructive to the lives of others. With his 'profits made out of lost souls', the banker 'view[s] them all as implements for tilling Thy garden rescued here and there from the wilderness' (579). Bulstrode's Christianity collapses distinctions between human bodies and the wealth that might be extracted from them, whereby the yield generated by 'labourers who were loading the last shocks of corn' (390) around Stone Court becomes inseparable from the expendable lives of the rural poor. Such men see 'the earth as a putrefying nidus' (581) from which to extract wealth only with eyes for the life of the soul to come. It seems fitting, then, that Bulstrode's secretive past is revealed at a meeting held to discuss 'a cholera case in the town' (681), a nod to the zymotic pathology by which his Providence dismisses the claims of a soiled material world.

The easy distinction that Featherstone tries to establish between Bulstrode and himself is clearly untenable: 'God A'mighty sticks to the land', he tells his nephew. 'He promises land, and He gives land, and He makes chaps rich with corn and cattle. But you take the other side. You like Bulstrode and speckilation better than Featherstone and land' (103). Yet the worlds of high farming and high finance are not so easily extricated; Featherstone has 'got money out of a company' (520) and Joshua Rigg, who inherits Stone Court, converts soil into capital. The 'new hay-ricks' (489) become 'the breeding coins of all nations' as Rigg, selling the land to Bulstrode, extracts wealth to finance 'a money-changer's shop on a much-frequented quay' (488). This transaction sees Bulstrode enact the reverse movement, converting capital drawn from a 'flourishing city and west-end trade' (578) back into land. And John Raffles, who of course knows all about the dubious sources of Bulstrode's money, would see the wealth of Stone Court invested in more distant soils: 'a little capital might enable me to make a first-rate thing of the shop. The tobacco trade is growing' (388).

The temporal associations of Loamshire's soils thus also meet and extend as spatial relationships. They are part of what Mary Ellis Gibson calls the 'networked local' of the provincial novel, a world both shaped by and in incalculably diffuse ways also shaping far-reaching forces such as global capital.[127] If Loamshire's Borthrop Trumbull, 'a distinguished bachelor and auctioneer of those parts, much concerned in the sale of land and cattle' (290), is right in 'feeling that "the celebrated Peel, now Sir Robert" […] would not fail to recognise his importance' (291), then this is at least partly due to the politician's coming work in support of free trade. (Peel, as discussed in chapter 2, lifted the protectionist Corn Laws in

[127] Mary Ellis Gibson, 'Regionalism and Provincialism: Where is the Local?', in *The Routledge Companion to Victorian Literature*, ed. by Dennis Denisoff and Talia Schaffer (London: Routledge, 2019), pp. 449-61 (451).

1846.)[128] Brooke has already introduced *The Wealth of Nations* in his debate over agricultural chemistry and economics with Chettam, an understanding of 'political economy, that never explained science' (17), as likely to lead him astray as it is to cement his points:

> It won't do, you know, breaking machines: everything must go on – trade, manufactures, commerce, interchange of staples – that kind of thing – since Adam Smith, that must go on. We must look all over the globe: - "Observation with extensive view," must look everywhere, "from China to Peru," […] That is what I have done up to a certain point – not as far as Peru; but I've not always stayed at home – I saw it wouldn't do. I've been in the Levant, where some of your Middlemarch goods go – and then, again, in the Baltic. The Baltic, now. (474)

Brooke's election speech of course descends into farce, his words parroted by an effigy and the man himself hit with an egg. But where the logic of free trade demands continual expansion into distant soils, his rambling words are peculiarly suited to the obscure processes of a liberal world economy that, to take only the staples of grains and other foodstuffs, is unknowable in the whole. 'Prices, I'll admit, are what nobody can know the merits of', says the shopkeeper Mr Mawmsey; 'the sudden falls after you've bought in currants, which are a goods that will not keep – I've never myself seen into the ins and outs there; which is a rebuke to human pride' (470-71). Political economy may function on the basis of a positivist claim to know the world, yet the networks of finance that stretch through Loamshire's soils are as unknowable as the novel's narrative web. Eliot's narrator acknowledges her failure to account for 'Joshua Rigg's destiny', for example, 'which belonged to the unmapped regions not taken under the providential government, except perhaps in an imperfect colonial way' (489).

Such imperfect colonial solutions, seen in the endings of novels such as *Jane Eyre* and *Mary Barton*, are acknowledged in *Middlemarch* via Ladislaw and Dorothea. Cadwallader and Chettam discuss having Ladislaw 'shipped off like a head of cattle' to do the work of improvement abroad 'in the suite of some Colonial Governor' (456). But Ladislaw, 'a rising young man' (273), is better suited to the work of pioneering at home. He becomes editor of the symbolically named 'Pioneer' (274), the Middlemarch broadsheet that, in supporting Brooke's election chances, falls on the side of 'Peel' and 'Liberalism' (336). These associations lend an uneasy weight to Ladislaw's earlier joke that his sketching is

[128] A similar play on this subsequent history is at work as Eliot's narrator introduces Dorothea as an 'heiress' to 'provincial families, still discussing Mr Peel's late conduct on the Catholic Question, and innocent of future gold-fields' (9). The 'Catholic Question', as David Carroll explains in his notes to the novel, refers to how Peel, 'as Home Secretary an opponent of religious and political freedom for Catholics, […] suddenly changed sides in March 1829, and supported Catholic Emancipation': Carroll, 'Explanatory Notes', in *Middlemarch*, p. 787. Peel's name is thus frequently associated with Casaubon in the novel (36, 49, 51, 269).

meant to convey 'migrations of races and clearings of forests – and America and the steam-engine' (200). This improvement, recognisable as the work of extinction, comes close to fruition in Ladislaw's 'plans of colonization' (710) – 'an intended settlement on a new plan in the Far West' (752) of America.

Dorothea's schemes also approach a destructive imperialism. She strives 'to lead a grand life here – now – in England' (27), but if this sounds like a rejection of the colonial improvement St John Rivers would argue for, similar problems beset those looking to pioneer at home: 'everything seems like going on a mission to a people whose language I don't know; – unless it were building cottages – there can be no doubt about that' (27), she explains. This suggestion of colonialism turned inward comes to the fore in one of the most troubling moments in the novel, Dorothea expressing a desire to 'take a great deal of land, and drain it, and make it a little colony, where everybody should work' (517). As she tells Garth, 'I should feel, if I lived to be old, that I had improved a great piece of land and built a great many good cottages' (518); it is of course this work that Chettam carries out on his land according to her specifications. Such projects, as they 'make the life of poverty beautiful' (29), surely frustrate efforts at more far-reaching reform – to land ownership, for example, whereby Middlemarch's wealth is concentrated in the pockets of a chosen few.

Dorothea and Ladislaw finally step back from these projects of colonial improvement, yet seemingly irreconcilable contradictions remain. Dorothea travels to Yorkshire to see 'about some land' (642) that might suit her domestic imperialism, but while this is the county to which Esther and Woodcourt escape in *Bleak House*, she and Ladislaw reject the provincial, favouring instead a life lived in the sprawling heart of the Victorian world-ecology. Together they travel from the 'rarefied social air' of Middlemarch to the work of sanitation and such causes in London, Ladislaw serving as a member of parliament 'in those times when reforms were begun with a young hopefulness of immediate good' (782). Even as they turn towards addressing the exploitation of others, however, slow violences nonetheless remain. As with Margaret Hale, Lizzie Hexam, and Bella Wilfer, marriage serves as a union that bonds Dorothea such that, as she becomes part of the material world, so her potential is both released and contained. With 'a nature struggling in the bonds of a narrow teaching' (26) at the novel's opening, *Middlemarch* ends with Dorothea 'absorbed into the life of another, […] only known in a certain circle as a wife and a mother' (783). As her son inherits the Tipton estate, female restoration once more enables and is strictly delimited by existing economic and social structures.

Yet Dorothea's narrative also points to how caring for life in the unknowable web becomes a question of acting from a limited perspective without causing harm:

> There were various subjects that Dorothea was trying to get clear upon, and she resolved to throw herself energetically into the gravest of all. She sat down in the library before her particular little heap of books on political economy and kindred matters, out of which she was trying to get light as to the best way of spending money so as not to injure one's neighbours, or – what comes to the same thing – so as to do them the most good. (756)

Qualifying what *North and South* calls 'the science of trade', Dorothea recognises the exploitative and extractive practices of rapacious mid-century capitalism and seeks to resist them.[129] If the urban reforms she and Ladislaw work at seem to be directed at helping those at home such as Esther Barton and the crossing-sweeper Jo, rather than those such as Bertha Mason abroad, then *Middlemarch* argues that distant good can come from reforms near at hand. As Ladislaw puts it, 'your cure must begin somewhere' (437).

In the unknowable web, Dorothea's ethic of care is diffused through and beyond those around her in ways that may follow the unknown pathways of capital, such as when she releases Lydgate from his debt to Bulstrode. Yet neither can her actions be reduced to such pathways, for like the biochemical relations of life, shared feeling extends in unforeseen ways through the novel's medium. By acting 'so as not to injure one's neighbours', Eliot suggests, the 'growing good of the world' is dependent on the 'incalculably diffusive' (785) actions of beings that are enmeshed in a web of contingent relation that extends beyond the human, beyond the organic, and beyond the known. In this way, Dorothea's situated knowledge of Loamshire adheres to an epistemic foundation of unknowability that foregrounds the ethical.

As the novel's ecology of scientific endeavour is influenced in important ways by agricultural chemistry, *Middlemarch* speaks back to the ecology of literature and science that binds chemistry and the realist novel in and around the soils of the mid-nineteenth century. Even Lydgate, though a failure in his own eyes, writes a 'treatise on Gout, a disease which has a good deal of wealth on its side' (781) and a paper, it might be said, to address stagnation in the upper-class social body. The novel argues for a reduced ethos of improvement, work that knows its limits and strives for good while always acknowledging the possibility of doing harm. If this argument remains unsatisfactory, then this is because *Middlemarch* strives to address arguably irreconcilable tensions, between an ideology of unceasing growth and the limits of peoples and soils from which such economics extract.

[129] Gaskell, *North and South*, p. 226.

Conclusion: Dirty Realism

Chapter XXIX of *Middlemarch* captures so many of the priorities and contradictions of the mid-nineteenth-century realist project in its proximity to soil. The chapter begins with Chettam's desire to 'act on Brooke' (363), and Dorothea is delighted to hear that her uncle is 'thinking of having the farms valued, and repairs made, and the cottages improved' (364). Brooke attempts to qualify her optimism, prompting the following speech from Dorothea:

> He only feels confident that you will do it […] because you mean to enter Parliament as a member who cares for the improvement of the people, and one of the first things to be made better is the state of the land and the labourers. Think of Kit Downes, uncle, who lives with his wife and seven children in a house with one sitting-room and one bedroom hardly larger than this table! – and those poor Dagleys, in their tumble-down farmhouse, where they live in the back-kitchen and leave the other rooms to the rats! That is one reason why I did not like the pictures here, dear uncle – which you think me stupid about. I used to come from the village with all that dirt and coarse ugliness like a pain within me, and the simpering pictures in the drawing-room seemed to me like a wicked attempt to find delight in what is false, while we don't mind how hard the truth is for the neighbours outside our walls. I think we have no right to come forward and urge wider changes for good, until we have tried to alter the evils which lie under our own hands. (365)

The improvement of the self and the improvement of the soil become inextricable, human character and soil character constituted in dynamic and intra-active relation. In the same way, to represent faithfully the soil and with it the 'coarse ugliness' of lived experience is to arrive at truthful knowledge, a felt experience of a shared reality where both landed gentry and rural labourer are immersed in 'dirt', enmeshed in material coexistence.

But even as Dorothea makes this argument, resisting the allure of 'simpering pictures' as she attempts to capture 'truth […] for the neighbours outside our walls', her words descend into falsity. The tumble-down farmhouse, the rats, the poverty of Kit Downes and his large family – all are stereotypical images of the rural poor that seem to escape her knowledge, even as she strains to make her point. She is right that Brooke's calls for reform ring hollow, but at the same time, her own qualification of 'wider changes for good' risks something akin to the realist novel's comforting movement back towards the provincial and the domestic. The farming poor, 'those poor Dagleys', risk being cast within an ideology that views them as a resource 'to be made better' – and then only in strictly limited ways, for the wealth and comfort of others depends in great part on their suffering. As Dorothea seeks to limit the exploitative economics of which her societal position is a part, she must do so within an unquestioned ideology of growth and improvement founded on externalising harm.

It is to 'those poor Dagleys' that chapter XXIX then turns. Mr Dagley's son has killed a young hare belonging to Brooke, one suspects for food rather than sport. Eliot's narrator introduces their home 'under that softening picture of the fine arts which make other people's hardships picturesque' (369), a representation the novel sets up so as to dismantle. On the journey, Brooke quotes from 'Young, the poet Young' (369), *Middlemarch* offering another comment on the aesthetic elision of labour and suffering; it is of course the agricultural writer Arthur Young, not the poetry of Edward Young, that would better help Brooke understand the poverty with which he is confronted:[130]

> The mossy thatch of the cow-shed, the broken grey barn-doors, the pauper labourers in ragged breeches who had nearly finished unloading a wagon of corn into the barn ready for early threshing; the scanty dairy of cows being tethered for milking and leaving one half of the shed in brown emptiness; the very pigs and white ducks seeming to wander about the uneven neglected yard as if in low spirits from feeding on a too meagre quality of rinsings – all these objects under the quiet light of a sky marbled with high clouds would have made a sort of picture which we have all paused over as a 'charming bit', touching other sensibilities than those which are stirred by the depression of the agricultural interest and the sad lack of farming capital, as seen constantly in the newspapers of that time. But these troublesome associations were just now strongly present to Mr Brooke, and spoiled the scene for him. (370)

As the associations of Dorothea's speech 'spoil' the lens through which Brooke would see rural labour, there is something of Harold Skimpole's useful fictions in the supposedly benevolent landlord's aesthetics. The representations of fine art and poetry may obscure the suffering and poverty of both human and non-human life. Labourers and livestock alike become 'objects' under such a gaze, as easy to dismiss as they are to abuse, especially from a distance. Such perspectives also elide the wider forces that shape the soils and lives of the farm. Global capital is impacting British agriculture from far beyond the shores of the nation, even as the violence of imperialism is turned inward on the English rural poor. But the sense of distance must at some level remain for an aesthetic form, the realist novel, that is of course a representation itself; hence the plural first person address introduces an implicitly middle-class observer, distinct from the scene's labouring subject. The 'charming bit' may then be compromised, not only for Brooke, but for a readership as unfamiliar with the lived

[130] Arthur Young toured England and Ireland writing on agriculture in the 1760s and 1770s. His works included *A Six Weeks' Tour through the Southern Counties of England and Wales* (1768), *A Six Months' Tour through the North of England* (1770), *Farmers Tour through the East of England* (1771), and *Tour in Ireland* (1780), and were widely read into the nineteenth century. Elizabeth Gaskell's *My Lady Ludlow* (1859), for example, has Captain James reading 'Arthur Young's 'Tours'' to improve his agricultural knowledge. Elizabeth Gaskell, *My Lady Ludlow*, in *The Works of Mrs Gaskell, Volume 3*, ed. by Charlotte Mitchell, 10 vols (1859; London: Pickering and Chatto, 2005), pp. 143-294 (197).

experience of poverty as Dorothea. And if this is Eliot's intent, to destabilise the lens by which her reader is accustomed to view such scenes, then the novelist is nevertheless placed at such a distance herself.

Yet *Middlemarch* does try to look the suffering of rural poverty square in the face. As with the death of Jo in *Bleak House* and the account of the cellar where the Davenport family live and die in *Mary Barton*, the novel momentarily animates Mr Dagley from 'a figure in the landscape' (370) by giving him a voice of his own:

> 'Niver do you mind what he's done,' said Dagley, more fiercely, 'it's my business to speak, an' not yourn. An' I wull speak, too. I'll hev my say – supper or no. An' what I say is, as I've lived upo' your ground from my father and grandfather afore me, an' hev dropped our money into't, an' me an' my children might lie an' rot on the ground for top-dressin as we can't find the money to buy'. (372)

A life lived 'upo'' the land as a mid-nineteenth-century tenant farmer is a life of hardship, the lived experience of which Dagley describes – and within which his dialect speech is designed to situate the reader. An unforgiving circle of destitution encompasses both soil and farmer, who with no capital to improve the land, and little chance of investment from his landlord, struggles to generate the yields by which he might feed himself and his family. This is writ large on Mrs Dagley's body, 'a thin, worn woman' (371) who bears the marks of poverty. Her experience of 'clemmin'' (527) – as agricultural labourer Timothy Cooper will later describe it – is etched onto the bodies that populate mid-century realism: the girls at Lowood School in *Jane Eyre*, the Manchester poor in *Mary Barton*, the Boucher and Higgins families in *North and South*, Phil Squod and Jo in *Bleak House*, the children forced to eke an existence on the banks of the Thames in *Our Mutual Friend*, all suffer and die from abject poverty. Dagley thus captures how only extinction remains for those, like himself, deemed to be beyond improvement. Seen as irredeemable souls with 'no earthly "beyond" open to [them]' (373), disadvantaged populations become 'top-dressing' – good for little else than the earthly elements of which their bodies are composed. To take the ethos of improvement to its conclusion, then, death releases the elements of the labouring body to fertilise the soil, extinction that sustains the pockets of the wealthy.

Yet, as Brook tries to dismiss Dagley as 'drunk' (372), the farmer's words are lent a 'truth' (370) that is also safely contained. For in coming so close to soil, arriving at the terrible truth concealed within the ethos of improvement, the realist novel, as has been seen throughout my thesis, steps back from this knowledge. Dagley's first words – 'it's my business to speak, an' not yourn' – are directed at his wife rather than Brooke, and thus direct

attention away from the class and economic interests that shape his experience. Offering the antithesis of Brooke's globalised liberalism, Dagley's 'farming conservatism' suggests an organicism that, it must be said, contains its own violences every bit as harmful as the improvement ethos. But *Middlemarch* gives Dagley's implied views on free trade as another stereotype – 'his farming conservatism, which consisted in holding that whatever is, is bad, and any change is likely to be worse' (370). The farmer's perspective, as Mr Gridley finds in *Bleak House*, is all too easy to silence and dismiss.

As Chapter XXIX of *Middlemarch* attempts to navigate the contradictions of the mid-century realist novel in its relations to soil, then, it throws these contradictions into sharp relief. There is this attempt to capture the inequalities that extend through soil, so destructive to the labouring poor and so enriching to the middle and upper classes. *Middlemarch* suggests that Bulstrode and Brooke, though very different characters, both flourish at the expense of others. But if 'fine art and social improvement' (373) cannot be separated for Dagley's landlord, the former limiting the perspectives of the latter, then realist form and soil improvement are as difficult to separate in the mid-nineteenth-century novel, the logic of the latter surely constraining the possibilities of the former.

The English realist novel of the mid-nineteenth century offers, what might be called, a dirty realism; a literary realism that, as it investigates the relations between matter and mind, material and discourse, the natural and the social, is recognised by its authors as partial and imperfect in its perspectives. In dialogue with the emerging science of soils, realist novels of the period examine and often qualify the reductionist understandings of chemistry. In the same way, they expose a burgeoning laissez-faire economics that offered a conception of soil as a free-market economy as it began to assimilate a global soil, quantifiable and improvable at the molecular level, into its structures. Though offering different realist aesthetics – from Brontë's gothic eruptions to Gaskell's bodily sympathy, from Dickens's hyper-realism to Eliot's experimental construction – truth for all becomes a question of showing life in its proximity to soil. Contrary to the chemistry of agriculture, then, the realist novels of the period prioritise the organic over the inorganic. But even as they do so, they serve to naturalise an ethos of growth and improvement that extends from the soil to the human. Most damagingly of all, even as they expose the inequalities of the society they describe, their narrative solutions export harm and exploitation through economic and ecological networks that extend beyond the bounds of the novel, perpetuating the violences of extraction that they seek to resist. Viewed in this light, the realist novels of the mid-nineteenth century work alongside as well as against the chemistry of soil, furthering an extractive economy that

conceptualises humans and soils across the globe as so many natures, so many potential resources, to colonise and exploit.

The concerns of the present can be seen in Brontë's, Gaskell's, Dickens's, and Eliot's writing, refracted back in ways that reveal the tensions we inhabit today. In novels that reveal suffering even as they frustrate change, that expose but also further the exploitation of beings enmeshed in an unknowable web of contingent action, the worlds they describe form part of our long present. Realist narrative fractures along fault lines that emerge between open networks and the desire for closure, offering a novel form that is both for and of the Anthropocene. In this realisation that the closed systems of realist narrative are radically open, we have the pervasive experience of life in industrial modernity, where the smallest actions extend beyond our control as they impact others in unforeseen and unintended ways. To turn away from literary realism in a time of socioecological breakdown must then also be to ignore the tensions and violences of our own world. The mid-nineteenth century gives us a soiled and imperfect literary realism – a dirty realism, the contradictions of which show the situated nature of human experience within the crises of modernity, and the challenges of which surely help us to see our own social and ecological responsibilities all the more clearly. In their dynamic and agential worlds, realist novels point to how human flourishing, and indeed the flourishing of all beings on the Earth's surface, has always been and so remains intimately connected to soils and their health.

Bibliography

Alaimo, Stacy, 'Trans-Corporeal Feminisms and the Ethical Space of Nature', in *Material Feminisms*, ed. by Stacy Alaimo and Susan Hekman (Bloomington, Indianapolis: Indiana University Press, 2008), pp. 237-64

---, *Undomesticated Ground: Recasting Nature as Feminist Space* (Ithaca, NY: Cornell University Press, 2000)

Alexander, Christine, and Jane Sellars, eds., *The Art of the Brontës* (Cambridge: Cambridge University Press, 1995)

Alexander, Sarah C., 'The Residuum, Victorian Naturalism, and the Entropic Narrative', *Nineteenth-Century Contexts*, 35.2 (2013), 99-120

Allen, Michelle, *Cleansing the City: Sanitary Geographies in Victorian London* (Athens, OH: Ohio University Press, 2008)

Anon., 'Artificial Fertility', *All the Year Round*, 11 March 1865, pp. 157-64

Anon., 'British Association for the Advancement of Science', *Literary Gazette*, 30 June 1832, pp. 408-09

Anon., 'The British Association for the Advancement of Science', *Manchester Guardian*, 25 June 1842, p. 5

Anon., 'The British Association for the Advancement of Science', *Manchester Guardian*, 29 June 1842, p. 5

Anon., 'Chemical Cleanliness', *Chambers's Journal of Popular Literature, Science and Arts*, 14 November 1868, pp. 735-36

Anon., 'Commission and Omission', *Household Words*, 18 November 1854, pp. 319-24

Anon., 'Conversazione at the Royal Institution', *Manchester Guardian*, 5 April 1843, p. 6

Anon., 'Dirty Cleanliness', *Household Words*, 24 July 1858, pp. 121-23

Anon., 'Dr Playfair's Lectures on the Chemistry of Vegetation', *Manchester Guardian*, 5 February 1845, p. 6

Anon., 'Dr Playfair's Lectures on the Chemistry of Vegetation', *Manchester Guardian*, 12 February 1845, p. 2

Anon., 'Dr Playfair's Lectures on the Chemistry of Vegetation', *Manchester Guardian*, 19 February 1845, p. 8

Anon., 'Dr Playfair's Lectures on the Chemistry of Vegetation', *Manchester Guardian*, 26 February 1845, p. 6

Anon., ‘Dr Lyon Playfair’s Lectures on the Progress of Chemistry’, *Manchester Guardian*, 10 July 1844, p. 6

Anon., ‘The Economy of Sewage’, *Manchester Guardian*, 10 October 1846, p. 4

Anon., ‘Exhaustion of Soils’, *London Review*, 2 November 1861, pp. 567-68

Anon., ‘The Exhaustion of Our Soil’, *London Review*, 23 July 1864, pp. 89-90

Anon., ‘Familiar Letters on Chemistry. First Article’, *Chambers’s Edinburgh Journal*, 16 December 1843, pp. 378-79

Anon., ‘Familiar Letters on Chemistry. Second Article’, *Chambers’s Edinburgh Journal*, 23 December 1843, pp. 386-87

Anon., ‘Friday’, *Manchester Guardian*, 25 June 1842, p. 3

Anon., ‘The Golden Vale’, *Household Words*, 1 January 1853, pp. 377-81

Anon., ‘The Great Bustard’, *Leisure Hour*, 15 Apr. 1871, pp. 232-34

Anon., ‘The Great Coffee Question’, *Household Words*, 12 April 1851, pp. 49-53

Anon., ‘High Farming’, *Tate’s Edinburgh Magazine*, January 1850, pp. 44-49

Anon., ‘Illustrations of Cheapness’, *Household Words*, 8 June 1850, pp. 253-56

Anon., ‘Johnston’s *Notes on North America*’, *Blackwood’s Edinburgh Magazine*, December 1851, pp. 699-718

Anon., ‘Lecture on the Insalubrity of Towns’, *Manchester Guardian*, 28 May 1845, pp. 6-7

Anon., ‘Liebig’s Animal Chemistry’, *Chambers’s Edinburgh Journal*, 27 August 1842, pp. 253-54

Anon., ‘Liebig’s Organic Chemistry’, *Chambers’s Edinburgh Journal*, 15 May 1841, pp. 131-32

Anon., ‘Liebig When A Boy’, *Chambers’s Edinburgh Journal*, 15 March 1845, p. 176

Anon., ‘Local and Provincial Intelligence’, *Manchester Guardian*, 15 March 1843, p. 4

Anon., ‘Local and Provincial Intelligence’, *Manchester Guardian*, 12 April 1843, p. 4

Anon., ‘Local and Provincial Intelligence’, *Manchester Guardian*, 2 August 1843, p. 4

Anon., ‘Manchester Agricultural Society’, *Manchester Guardian*, 27 September 1843, p. 4

Anon., ‘The Martyrs of Chancery’, *Household Words*, 7 December 1850, pp. 250-52

Anon., ‘Minerals that we eat. In Two Chapters. Chapter the First’, *Household Words*, 24 May 1856, pp. 437-42

Anon., ‘The Night-Soil Nuisance’, *Manchester Guardian*, 8 April 1854, p. 8

Anon., ‘Nothing Lost’, *Chambers’s Journal of Popular Literature, Science and Arts*, 20 August 1859, pp. 116-19

Anon., ‘Nuisance’, *Manchester Guardian*, 4 October 1854, p. 7

Anon., ‘Removal of Night Soil’, *Manchester Guardian,* 3 March 1847, p. 7

Anon., ‘Report on the Sanatory Condition of The Large Towns of Lancashire, by Dr, Lyon Playfair’, *Manchester Guardian*, 2 April 1845, p. 4

Anon., ‘The Restoration of Our Soil, part I’, *Once a Week*, 28 February 1863, pp. 258-60

Anon., ‘The Restoration of Our Soil, part II’, *Once a Week*, 14 March 1863, pp. 316-18

Anon., ‘Sewage of Towns’, *London Review*, 10 September 1864, pp. 286-87

Anon., ‘Tenth Meeting of the British Association for the Advancement of Science’, *Athenaeum*, 3 October 1840, pp. 767-81

Anon., ‘The True Tom Tiddler’s Ground’, *Household Words*, 27 December 1851, pp. 329-32

Anon., ‘A Way to Clean Rivers’, *Household Words*, 10 July 1858, pp. 79-82

Anon., ‘Why are Towns Unhealthy?’ *Manchester Guardian*, 24 January 1846, p. 6

Anon., ‘Wigan’, *Manchester Guardian*, 10 May 1845, p. 6

Anon., ‘The Work of the World’, *Household Words*, 13 September 1851, pp. 589-92

Anon., [‘A Kentish Farmer’], ‘Works on Agriculture’, *Manchester Guardian*, 22 November 1843, p. 5.

Anon., ‘Yorkshire Agricultural Society: Meeting at Hull’, *Hull Packet*, 6 August 1841, pp. 4-5

Archer, Jayne Elisabeth, Richard Marggraf Turley and Howard Thomas, ‘“Moving Accidents by Flood and Field”: The Arable and Tidal Worlds of George Eliot’s *The Mill on the Floss*’, *ELH*, 82.2 (Summer 2015), 701-28

Armstrong, Nancy, *Desire and Domestic Fiction: A Political History of the Novel* (Oxford: Oxford University Press, 1987)

---, ‘A Gothic History of the British Novel’, in *New Directions in the History of the Novel*, ed. by Patrick Parrinder, Andrew Nash and Nicola Wilson (New York: St Martin’s Press, 2014), pp. 103-20

Ashton, Rosemary, *G.H. Lewes: A Life* (Oxford: Clarendon Press, 1991)

Athmanathan, Divya, ‘“You might pioneer a little at home”: Hybrid Spaces, Identities, and Homes in Elizabeth Gaskell’s *North and South*’, in *Place and Progress in the Works of Elizabeth Gaskell*, ed. by Lesa Scholl and Emily Morris (London: Routledge, 2015), pp. 37-52

Banerjee, Sukanya, ‘Ecologies of cotton’, *Nineteenth-Century Contexts*, 42.5 (2020), 493-507

Barad, Karen, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Durham, NC: Duke University Press, 2007)

Barthes, Roland, 'The Reality Effect', in *The Rustle of Language*, trans. by Richard Howard (1984; Berkeley, CA: University of California Press, 1989), pp. 141-48

Bate, Jonathan, *The Song of the Earth* (London: Picador, 2000)

Beer, Gillian, *Darwin's Plots: Evolutionary Narrative in Darwin, George Eliot and Nineteenth-Century Fiction* (1983; Cambridge: Cambridge University Press, 2009)

Beaumont, Matthew, 'Aleatory Realism: Reflections on the Parable of the Pier-Glass', *Synthesis: an Anglophone Journal of Comparative Literary Studies*, 0.3 (2011), 9-17

Beesley, George, *A Report on the State of Agriculture in Lancashire* (Preston: Dobson and Son, 1849)

Bewell, Alan, *Romanticism and Colonial Disease* (Baltimore: Johns Hopkins University Press, 1999)

Blair, Kirstie, 'Contagious Sympathies: George Eliot and Rudolf Virchow', in *Unmapped Countries: Biological Visions in Nineteenth Century Literature and Culture*, ed. by Anne-Julia Zwierlein (London: Anthem Press, 2005), pp. 145-54

Blount, Trevor, 'Dickens and Mr. Krook's Spontaneous Combustion', *Dickens Studies Annual*, 1 (1970), 183-211, 291-92

Bodenheimer, Rosemarie, '*North and South*: A Permanent State of Change', *Nineteenth-Century Fiction*, 34.3 (1979), 281-301

Brantlinger, Patrick, *Dark Vanishings: Discourse on the Extinction of Primitive Races, 1800-1930* (Ithaca, NY: Cornell University Press, 2003)

Brassley, Paul, 'Agricultural Science and Education', in *The Agrarian History of England and Wales, vol. 7, 1850-1914*, ed. by E. J. T. Collins, 8 vols (Cambridge: Cambridge University Press, 2000), pp. 594-649

Briggs, Asa, *The Age of Improvement, 1783-1867* (1959; London: Routledge, 2014)

Brill, Barbara, and Alan Shelston, 'Manchester: "A Behindhand Place for Books": The Gaskells and The Portico Library, *Gaskell Society Journal*, 5 (1991), 27-36

Brock, William H., *Justus von Liebig: The Chemical Gatekeeper* (Cambridge: Cambridge University Press, 1997)

Brock, William H., and Susanne Stark, 'Liebig, Gregory and the British Association, 1837-1842', *Ambix*, 37 (1990), 137-47

Brontë, Charlotte, *Jane Eyre*, ed. and intro. by Stevie Davies (1847; St Ives: Penguin, 2006)

---, *Shirley*, intro. and notes by Sally Minogue (1849; Ware: Wordsworth, 1993)

---, *The Letters of Charlotte Brontë*, ed. by Margaret Smith, 3 vols (Oxford: Clarendon Press, 1995-2000)

Buckland, Adelene, *Novel Science: Fiction and the Invention of Nineteenth-Century Geology* (Chicago: University of Chicago Press, 2013)

---, '"The Poetry of Science": Charles Dickens, Geology, and Visual and Material Culture in Victorian London', *Victorian Literature and Culture*, 35 (2007), 679-94

Bud, Robert, 'Applied Science in Nineteenth-Century Britain: Public Discourse and the Creation of Meaning, 1817-1876', *History and Technology*, 30.1 (2014), 3-36

Burton, Anna, 'Remarks on Forest Scenery: *North and South* and the Picturesque', *Gaskell Society Journal*, 32 (2018), 37-54

Cammack, Susanne S., '"You Have Made Him What He Is": Irish Laborers and the Preston Strike in Elizabeth Gaskell's *North and South*', *New Hibernia Review*, 20.4 (Winter 2016), 113-27

Caneva, Kenneth L., *Robert Mayer and the Conservation of Energy* (Princeton: Princeton University Press, 1993)

Çellikol, Ayşe, *Romances of Free Trade: British Literature, Laissez-Faire, and the Global Nineteenth Century* (Oxford: Oxford University Press, 2011) <doi:10.1093/acprof:oso/9780199769001.001.0001>

'Chafe, *v.*', in *The Oxford English Dictionary* [online], < https://www.oed.com/view/Entry/30151> [Accessed 11 May 2021]

'Chaff, *n.*[1]', in *The Oxford English Dictionary* [online], < https://www.oed.com/view/Entry/30161> [Accessed 11 May 2021]

Chang, Elizabeth Hope, *Novel Cultivations: Plants in British Literature of the Global Nineteenth Century* (Charlottesville: University of Virginia Press, 2019)

Chappell, Patrick, 'Paper Routes: *Bleak House*, Rubbish Theory, and the Character Economy of Realism', *ELH*, 80.3 (Fall 2013), 783-810

Choi, Tina Young, 'Forms of Closure: The First Law of Thermodynamics and Victorian Narrative', *ELH*, 74.2 (Summer 2007), 301-22

---, 'Writing the Victorian City: Discourses of Risk, Connection, and Inevitability', *Victorian Studies*, 43.4 (2001), 562-89

Colvin, Sidney, 'Critical Notices: *Middlemarch. A Study of Provincial Life*. By George Eliot. Blackwood and Sons.', *Fortnightly Review*, January 1873, pp. 142-47

Coriale, Danielle, 'Gaskell's Naturalist', *Nineteenth-Century Literature*, 63.3 (2008), 346-75

Corley, Liam, 'The Imperial Addiction of *Mary Barton*', *Gaskell Society Journal*, 17 (2003), 1-11

Cotsell, Michael, *The Companion to Our Mutual Friend* (London: Allen and Unwin, 1986)

Crossland, Rachel, 'Sharing the Moment's Discourse: Virginia Woolf, D. H. Lawrence and Albert Einstein in the Early Twentieth Century' (unpublished doctoral thesis, University of Oxford, 2010)

Daston, Lorraine, and Peter Galison, *Objectivity* (New York: Zone, 2007)

Davis, Mike, *Late Victorian Holocausts: El Nino Famines and the Making of the Third World* (London: Verso, 2001)

Davy, Humphry, *Elements of Agricultural Chemistry, in a course of Lectures for the Board of Agriculture* (London: Longman, 1813)

'Deodorize', in *The Oxford English Dictionary* [online], < https://www.oed.com/view/Entry/50149> [Accessed 11 May 2021]

Dickens, Charles, *Bleak House*, ed. and intro. by Nicola Bradbury, preface by Terry Eagleton (1852-53; London: Penguin, 1996)

---, *Our Mutual Friend*, ed. and intro. by Michael Cotsell (1864-65; Oxford: Oxford University Press, 2008)

---, 'Letter to Dr Sheridan Muspratt, 24 August 1851', in *The Letters of Charles Dickens, Vol. 6: 1850-1852*, ed. by Graham Storey, Kathleen Mary Tillotson and Nina Burgis, 12 vols (1988; Oxford: Oxford University Press, 2016), Oxford Scholarly Editions Online. <https://www.oxfordscholarlyeditions.com/view/10.1093/actrade/9780198126171.book.1/actrade-9780198126171-book-1> [accessed 9 May 2021]

---, 'Letter to George Henry Lewes, 25 February 1853', in Gordon S. Haight, 'Dickens and Lewes on Spontaneous Combustion', *Nineteenth-Century Fiction*, 10.1 (June 1955), 53-63 (58-60)

---, 'The Poor Man and His Beer', *All the Year Round*, 30 April 1859, pp. 13-16

Dickens, Charles, and W. H. Wills, 'The Heart of Mid-London', *Household Words*, 4 May 1850, pp. 121-25

Ding, Chinnie, '"Myriad-Headed, Myriad-Handed": Labor in *Middlemarch*', *Studies in English Literature, 1500-1900*, 52.4 (Autumn 2012), 917-36

Douglas, Mary, *Purity and Danger: An Analysis of the Concepts of Pollution and Taboo* (1966; London: Routledge, 2001)

Duncan, Colin A. M., *The Centrality of Agriculture: Between Humankind and The Rest of Nature* (Montreal: McGill University Press, 1996)

Eagleton, Terry, *The English Novel: An Introduction* (2005; Oxford: Blackwell, 2013)

Eliot, George, *Adam Bede*, intro. and notes by Doreen Roberts (1859; Ware: Wordsworth Classics, 1997)

---, *Middlemarch*, ed. and notes by David Carroll, intro. by Felicia Bonaparte (1871-72; Oxford: Oxford University Press, 2008)

---, 'The Natural History of German Life', *The Westminster Review*, July 1856, pp. 51-79

---, 'Letter to Sara Hennell, 10-13 May 1858', in *Selections from George Eliot's Letters*, ed. by Gordon S. Haight (New Haven: Yale University Press, 1985), pp. 189-91

Ermarth, Elizabeth, *Realism and Consensus in the English Novel* (Princeton: Princeton University Press, 1983)

Eyler, John M., 'The Conversion of Angus Smith: The Changing Role of Chemistry and Biology in Sanitary Science, 1850-1880', *Bulletin of the History of Medicine*, 54.2 (Summer 1980), 216-34

Federici, Silvia, *Caliban and the Witch: Women, the Body, and Primitive Accumulation* (1998; New York: Autonomedia, 2017)

'Ferment, *v.*', in *The Oxford English Dictionary* [online], <https://www.oed.com/view/Entry/69362> [accessed 11 May 2021]

Fitzwilliam, Marie, '*Mr Harrison's Confessions*: A Study of the General Practitioner's Social and Professional Dis-ease', *Gaskell Society Journal*, 12 (1998), 28-36

Fisher, Mark, *Capitalist Realism: Is There No Alternative?* (Ropley, Hants: O Books, 2009)

'Fix, *v.*', in *The Oxford English Dictionary* [online], < https://www.oed.com/view/Entry/70815> [Accessed 11 May 2021]

Foster, Shirley, '"We sit and read and dream our time away": Elizabeth Gaskell and the Portico Library', *Gaskell Society Journal*, 14 (2000), 14-23

Freedgood, Elaine, *The Ideas in Things: Fugitive Meaning in the Victorian Novel* (Chicago: University of Chicago Press, 2006)

---, 'The Novelist and Her Poor', *Novel: A Forum on Fiction*, 47.2 (2014), 210-23

Freeland, Natalka, 'The Politics of Dirt in *Mary Barton* and *Ruth*', *Studies in English Literature 1500-1900*, 42.4 (2002), 799-818

Furneaux, Holly, 'Charles Dickens's Families of Choice: Elective Affinities, Sibling Substitution, and Homoerotic Desire', *Nineteenth-Century Literature*, 62.2 (2007), 153-92

Gallagher, Catherine, *The Body Economic: Life, Death, and Sensation in Political Economy and the Victorian Novel* (Princeton: Princeton University Press, 2006)

---, 'George Eliot: Immanent Victorian', *Proceedings of the British Academy*, 94 (1997), 157-72

---, *The Industrial Reformation of English Fiction: Social Discourse and Narrative Form, 1832-1867* (Chicago: University of Chicago Press, 1985)

Garnett, William James, 'Farming of Lancashire', *Journal of the Royal Agricultural Society of England*, 10 (1849), 1-51

Garratt, Peter, *Victorian Empiricism: Self, Knowledge, and Reality in Ruskin, Bain, Lewes, Spencer and George Eliot* (Madison: Fairleigh Dickinson University Press, 2010)

Gaskell, Elizabeth, 'Letter to Eliza Fox, 26 April 1850', in *The Letters of Mrs Gaskell*, ed. by J.A.V. Chappell and Arthur Pollard (Manchester: Manchester University Press, 1997), pp. 110-13

--- 'Letter to Lady Kay-Shuttleworth, October 1850', in *The Letters of Mrs Gaskell*, ed. by J.A.V. Chappell and Arthur Pollard (Manchester: Manchester University Press, 1997), pp. 133-36

---, 'Letter to Mary Howitt, [undated]', in *The Letters of Mrs Gaskell*, ed. by J.A.V. Chappell and Arthur Pollard (Manchester: Manchester University Press, 1997), p. 798

---, *Mary Barton*, ed. and intro. by Shirley Foster (1848; Oxford: Oxford University Press, 2006)

---, *Mr Harrison's Confessions* (1851; London: Hesperus Press, 2014)

---, 'Morton Hall', in *The Works of Elizabeth Gaskell, Volume 3*, ed. by Charlotte Mitchell, 10 vols (1853; London: Pickering and Chatto, 2005), pp. 21-52

---, 'My French Master', in *The Works of Elizabeth Gaskell, Volume 3*, ed. by Charlotte Mitchell, 10 vols (1853; London: Pickering and Chatto, 2005), pp. 53-72

---, *My Lady Ludlow*, in *The Works of Mrs Gaskell, Volume 3*, ed. by Charlotte Mitchell, 10 vols (1859; London: Pickering and Chatto, 2005), pp. 143-294

---, *North and South*, ed. by Angus Easson, intro. by Sally Shuttleworth (1854-55; Oxford: Oxford University Press, 1998)

---, *Sylvia's Lovers*, in *The Works of Elizabeth Gaskell, Volume 9*, ed. by Marion Shaw, 10 vols (1863; London: Pickering and Chatto, 2005)

---, *Wives and Daughters*, in *The Works of Mrs Gaskell, Volume 10*, ed. by Josie Billington, 10 vols (1864-66; London: Pickering and Chatto, 2005)

George, Sam, *Botany, Sexuality and Women's Writing: From Modest Shoot to Forward Plant* (Manchester: Manchester University Press, 2007)

Geric, Michelle, *Tennyson and Geology: Poetry and Poetics* (London: Palgrave, 2017)

Ghosh, Amitav, *The Great Derangement: Climate Change and the Unthinkable* (Chicago: University of Chicago Press, 2016)

Gibson, A., and W. V. Farrar, 'Robert Angus Smith, F.R.S., and "Sanitary Science"', *Notes and Records of the Royal Society of London*, 28.2 (April 1974), 241-62

Gibson, Mary Ellis, 'Regionalism and Provincialism: Where is the Local?', in *The Routledge Companion to Victorian Literature*, ed. by Dennis Denisoff and Talia Schaffer (London: Routledge, 2019), pp. 449-61

Gilbert, Sandra, and Susan Gubar, *The Madwoman in the Attic: The Woman Writer and the Nineteenth-Century Literary Imagination* (New Haven: Yale University Press, 1984)

Gill, Josie, 'Decolonizing Literature and Science', *Configurations*, 26.3 (2018), 283-88

Goddard, Nicholas, '"A Mine of wealth"? The Victorians and the Agricultural Value of Sewage', *Journal of Historical Geography*, 22.3 (1996), 274-90

Gold, Barri J., *ThermoPoetics: Energy in Victorian Literature and Science* (Cambridge, MA: MIT Press, 2010)

Gorham, Eville, 'Robert Angus Smith, F.R.S., and "Chemical Climatology"', *Notes and Records of the Royal Society of London*, 36.2 (April 1982), 267-72

Gossin, Pamela, *Thomas Hardy's Novel Universe: Astronomy, Cosmology and Gender in the Post-Darwinian World* (Aldershot: Ashgate, 2007)

Grener, Adam, 'Mapping the "Invisible Region, Far Away" in *Dombey and Son*', in *Ecological Form: System and Aesthetics in the Age of Empire*, ed. by Nathan K. Hensley and Philip Steer (New York: Fordham University Press, 2019), pp. 121-35

Griffiths, Devin, *The Age of Analogy: Science and Literature Between the Darwins* (Baltimore: Johns Hopkins University Press, 2016)

---, '*Silas Marner* and the Ecology of Form', *Victorian Literature and Culture*, 48.1 (2020), 299-326

Griffiths, Devin, and Deanna K. Kreisel, 'Introduction: Open Ecologies', *Victorian Literature and Culture*, 48.1 (2020), 1-28

Grove, Richard, *Green Imperialism: Colonial Expansion, Tropical Island Edens, and the Origins of Environmentalism, 1600-1860* (Cambridge: Cambridge University Press, 1995)

Hack, Daniel, '"Sublimation Strange": Allegory and Authority in *Bleak House*', *ELH*, 66.1 (Spring 1999), 129-56

Hacking, Ian, *Representing and Intervening* (Cambridge: Cambridge University Press, 1983)

Haight, Gordon S., 'Dickens and Lewes on Spontaneous Combustion', *Nineteenth-Century Fiction*, 10.1 (June 1955), 53-63

Hall, Vance M. D., 'The Role of Force or Power in Liebig's Physiological Chemistry', *Medical History*, 24 (1980), 20-59

Hamlin, Christopher, 'Providence and Putrefaction: Victorian Sanitarians and the Natural Theology of Health and Disease', *Victorian Studies*, 28.3 (Spring 1985), 381-411

---, *A Science of Impurity: Water Analysis in Nineteenth Century Britain* (Bristol: Adam Hilger, 1990)

Haraway, Donna J., 'Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin', *Environmental Humanities*, 6 (2015), 156-65

---, 'Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective', *Feminist Studies*, 14.3 (1988), 575-99

Harrison, Robert Pogue, *The Dominion of the Dead* (Chicago: University of Chicago Press, 2003)

Harvey, Graham, *Grass-Fed Nation: Getting Back the Food we Deserve* (London: Icon Books, 2016)

Henchman, Anna, 'Hardy's Stargazers and the Astronomy of Other Minds', *Victorian Studies*, 51.1 (2008), 37-64

Hensley, Nathan K., and Philip Steer, eds., *Ecological Form: System and Aesthetics in the Age of Empire* (New York: Fordham University Press, 2018)

---, 'Signatures of the Carboniferous: The Literary Forms of Coal', in *Ecological Form: System and Aesthetics in the Age of Empire*, ed. by Nathan K. Hensley and Philip Steer (New York: Fordham University Press, 2019), 63-82

Henson, Louise, 'The "Condition-of-England" debate and the "Natural History of Man": an important scientific context for the social-problem fiction of Elizabeth Gaskell', *Gaskell Society Journal*, 16 (2002), 30-47

---, '"Phantoms Arising from the Scenes of Our Too-Long Neglect": Charles Dickens, Victorian Chemistry, and the Folklore of the Ghost', *Victorian Review*, 26.1 (2000), 6-23

Herbert, Christopher, 'The Occult in Bleak House', *Novel: A Forum in Fiction*, 17.2 (Winter 1994), 101-15

Hewitt, Martin, *Making Social Knowledge in the Victorian City* (London: Routledge, 2019)

Hildebrand, Jayne, '*Middlemarch*'s Medium: Description, Sympathy, and Realism's Ambient Worlds', *ELH*, 85.4 (Winter 2018), 999-1023

'Humility', in *The Oxford English Dictionary* [online], < https://www.oed.com/view/Entry/89375> [Accessed 11 May 2021]

Ingleby, Matthew, ‘Chemistry versus Biology: Dickens, Malthus, and the Familiarized Doppelgänger’, *Victorian Review*, 39.2 (Fall 2013), 97-113

Ingold, Tim, *Lines: A Brief History* (2007; London: Routledge, 2016)

Jameson, Frederic, *The Antinomies of Realism* (London: Verso, 2013)

Johnston, James Finlay Weir, *Catechism of Agricultural Chemistry and Geology* (London and Edinburgh: William Blackwood, 1844)

---, *The Economy of a Coal-Field: an exposition of the objects of the Geological and Polytechnic Society of the West Riding of Yorkshire* (Durham: Andrews, 1838)

---, *Elements of Agricultural Chemistry and Geology* (London and Edinburgh: William Blackwood, 1842)

---, *Lectures on Agricultural Chemistry and Geology* (London and Edinburgh: William Blackwood, 1843)

---, ‘Practical Agriculture’, *Blackwood’s Edinburgh Magazine*, March 1845, pp. 298-314

---, ‘The Practice of Agriculture’, *Blackwood’s Edinburgh Magazine*, April 1843, pp. 414-32

---, ‘The Present State of Agriculture in its Relations to Chemistry and Geology. A Lecture delivered before the Society at the Meeting in York’, *Journal of the Royal Agricultural Society of England*, 9 (1848), 200-36

---, ‘Science and Agriculture’, *Blackwood’s Edinburgh Magazine*, June 1842, pp. 738-55

---, ‘Things of the Day: English Agriculture’, *Blackwood’s Edinburgh Magazine*, March 1842, pp. 406-14

---, ‘Things of the Day: The Corn Laws’, *Blackwood’s Edinburgh Magazine*, March 1842, pp. 414-16

Joule, James, ‘On the Utilization of the Sewage of London and other large towns’, *Memoirs of the Literary and Philosophical Society of Manchester*, 15 (1860), 146-60

Kargon, Robert H., *Science in Victorian Manchester: Enterprise and Expertise* (Manchester: Manchester University Press, 1997)

Kay, James, *The Moral and Physical Condition of the Working Classes Employed in the Cotton Manufacture in Manchester* (London: James Ridgeway, 1832)

Kelley, Theresa M., *Clandestine Marriage: Botany and Romantic Culture* (Baltimore: Johns Hopkins University Press, 2012)

King, Amy M., *Bloom: The Botanical Vernacular in the English Novel* (Oxford: Oxford University Press, 2003)

---, ‘Reorienting the Scientific Frontier: Victorian Tide Pools and Literary Realism’, *Victorian Studies*, 47.2, Papers from the Second Annual Conference of the North American Victorian Studies Association (Winter 2005), 153-63

---, Taxonomical Cures: The Politics of Natural History and Herbalist Medicine in Elizabeth Gaskell’s *Mary Barton*’, in *Romantic Science: The Literary Forms of Natural History*, ed. by Noah Heringman (Albany: State University of New York Press, 2003), pp. 255-70

Kingsley, Lesley, ‘Guano and British Victorians: An Environmental History of a Commodity of Nature’ (unpublished doctoral thesis, University of Bristol, 2020)

---, ‘Guano, science and Victorian high farming: An agro-ecological perspective’, in *Victorian Sustainability in Literature and Culture*, ed. by Wendy Parkins (London: Routledge, 2018), pp. 126-45

Kluwick, Ursula, ‘The cultural sustainability of Victorian waste’, in *Cultural Sustainability: Perspectives from the Humanities and Social Sciences*, ed. by Torsten Meireis and Gabriele Rippl (London: Routledge, 2019), pp. 183-92

Knight, Charles, ‘The Laboratory in the Chest’, *Household Words,* 7 September 1850, pp. 565-69

Knight, David, ‘Agriculture and Chemistry in Britain around 1800’, *Annals of Science*, 33.2 (1976), 187-96

Krohn, Wolfgang, and Wolf Schäfer, ‘The origins and structure of agricultural chemistry’, in *Perspectives on the Emergence of Scientific Disciplines*, ed. by Gerard Lemaine and others (The Hague: Mouton & Co., 1976), pp. 27-52

Kromm, Jane, ‘Visual Culture and Scopic Custom in *Jane Eyre* and *Villette*’, *Victorian Literature and Culture*, 26.2 (1998), 369-94.

Langford, Thomas A., ‘Prophetic Imagination and the Unity of *Jane Eyre*’, *Studies in the Novel*, 6.2 (Summer 1974), 228-35

Latour, Bruno, *Reassembling the Social: An Introduction to Actor-Network-Theory* (Oxford: Oxford University Press, 2005)

Law, Jules, *The Social Life of Fluids: Blood, Milk & Water in The Victorian Novel* (Ithaca, NY: Cornell University Press, 2010)

Lawes, John Bennet, ‘On the Sewage of London’, *Journal of the Society of Arts*, 3 (1855), 263-84

Levidow, Les, 'Simulating mother nature, industrializing agriculture, in *FutureNatural: Nature, Science, Culture*, ed. by Jon Bird and others (London: Routledge, 1996), pp. 55-71

Levine, Caroline, *Forms: Whole, Rhythm, Hierarchy, Network* (Princeton: Princeton University Press, 2015)

Levine, George, *Darwin and the Novelists: Patterns of Science in Victorian Fiction* (Cambridge, MA: Harvard University Press, 1988)

---, *Dying to Know: Scientific Epistemology and Narrative in Victorian England* (Chicago: University of Chicago Press, 2002)

---, 'George Eliot's Hypothesis of Reality', *Nineteenth-Century Fiction*, 35.1 (June 1980), 1-28

---, *The Realistic Imagination: English Fiction from Frankenstein to Lady Chatterley* (Chicago: U of Chicago P, 1981)

George Levine, ed., *One Culture: Essays in Science and Literature* (Madison: University of Wisconsin Press, 1987)

Lewes, George Henry, 'Journal X, 1856 July 24 – 1859 March 31', Yale University, Beinecke Rare Book and Manuscript Library, George Eliot and George Henry Lewes Collection, GEN MSS 963, Box: 37

---, 'Letter to John Bennet Lawes, 10 January 1861', Harpenden, Rothamsted Archives, Papers of Sir Henry Gilbert 1817-1901 (GIL), GIL3

---, 'Literature', *Leader*, 11 December 1852, p. 1189

---, 'Literature', *Leader*, 15 January 1853, p. 64

---, 'Notebook, 1857 Feb', Yale University, Beinecke Rare Book and Manuscript Library, George Eliot and George Henry Lewes Collection, GEN MSS 963, Box: 49

---, 'Realism in Art: Recent German Fiction', *The Westminster Review*, October 1858, pp. 488-518

---, *The Physiology of Common Life* (Edinburgh and London: William Blackwood & Sons, 1859)

---, 'Spontaneous Combustion. Two Letters to Charles Dickens. No. I.', *Leader*, 5 February 1853, pp. 137-38

---, 'Spontaneous Combustion. Two Letters to Charles Dickens. No. II.', *Leader*, 12 February 1853, pp. 161-63

---, 'Theories of Food: A Letter to the Editor', *Blackwood's Edinburgh Magazine*, December 1860, pp. 676-87

Liebig, Justus von, *Animal Chemistry or Organic Chemistry in its Applications to Physiology and Pathology* (London: Taylor and Walton, 1842)

---, 'Baron Liebig and Alderman Mechi', *The Times*, 23 December 1859, p. 6.

---, *Familiar Letters on Chemistry, in its relations to Physiology, Dietetics, Agriculture, Commerce and Political Economy*, trans. by William Gregory, 3rd edn (London: Taylor, Walton, and Maberly, 1851)

---, *Familiar Letters on Chemistry, in its relations to Physiology, Dietetics, Agriculture, Commerce and Political Economy*, trans. by William Gregory, ed. by John Blyth, 4th edn (London: Walton and Maberly, 1859)

---, 'Justus von Liebig: An Autobiographical Sketch', *The Popular Science Monthly*, 40 (1891-1892), 655-66

---, 'Induction and Deduction', *Cornhill Magazine*, September 1865, pp. 296-305

---, 'Lord Bacon as Natural Philosopher', *Macmillan's Magazine*, July and August 1863, pp. 237-49, 257-67

---, 'On Poisons, Contagions, and Miasms', read by Lyon Playfair, in *Notices and Abstracts of Communications to the British Association for the Advancement of Science at the Glasgow Meeting, August 1840* (London: John Murray, 1840), pp. 72-73

---, 'On some points in Agricultural Chemistry', *Journal of the Royal Agricultural Society of England*, 17 (1856), 284-326

---, *Organic Chemistry in its Application to Agriculture and Physiology*, trans. by Lyon Playfair (London: Taylor and Walton, 1840)

---, 'Organic Chemistry in its Applications to Farming and Physiology, 25 August 1840', trans. by Pat Munday, in 'Sturm und Dung: Justus von Liebig and the Chemistry of Agriculture' (unpublished doctoral thesis, Cornell University, 1990), pp. 178-80

---, 'Utilisation of Sewage', *Journal of the Society of Arts*, 11 (1863), 655-57

---, 'Was Lord Bacon an imposter?', *Fraser's Magazine*, April 1867, pp. 482-95

Lipman, Timothy O., 'Vitalism and reductionism in Liebig's physiological thought', *Isis*, 58 (1967), 167-85

Litvack, Leon, 'Outpost of Empire: Scientific Discovery and Colonial Displacement in Gaskell's *Wives and Daughters*', *The Review of English Studies*, 55.2 (2004), 727-58

Livingstone, Catriona, 'Experimental Identities: Quantum Physics in Popular Science Writing and Virginia Woolf's *The Waves*', *Journal of Literature and Science*, 11.1 (2018), 66-81

Lyell, Charles, *Principles of Geology* (London: John Murray, 1830)

Lynall, Gregory, *Imagining Solar Energy: The Power of the Sun in Literature, Science and Culture* (London: Bloomsbury, 2020)

Lynch, Deidre Shauna, '"Young Ladies are Delicate Plants": Jane Austen and Greenhouse Romanticism', *ELH*, 77.3 (Fall 2010), 689-729

MacDuffie, Allen, *Victorian Literature, Energy, and The Ecological Imagination* (Cambridge: Cambridge University Press, 2014)

Maclure, Jennifer, 'Diagnosing Capitalism: Vital Economics and the Structure of Sympathy in Gaskell's Industrial Novels', *Nineteenth-Century Contexts*, 38.5 (2016), 343-52

Mangham, Andrew, *The Science of Starving in Victorian Literature, Medicine, and Political Economy* (Oxford: Oxford University Press, 2020)

Mann, Nancy D., 'Intelligence and Self-Awareness in *North and South*: A Matter of Sex and Class', *Rocky Mountain Review of Language and Literature*, 29.1 (Spring 1975), 24-38

Martin, Carol A., 'Gaskell, Darwin and *North and South*', *Studies in the Novel*, 15.2 (1983), 91-107

Matus, Jill, '*Mary Barton* and *North and South*', in *The Cambridge Companion to Elizabeth Gaskell*, ed. by Jill Matus (Cambridge: Cambridge University Press, 2007), pp. 27-45

McKee, Patricia, 'Racial Strategies in *Jane Eyre*', *Victorian Literature and Culture*, 37.1 (2009), 67-83

McKinnon, Andrew M., 'Elective Affinities of the Protestant Ethic: Weber and the Chemistry of Capitalism', *Sociological Theory*, 28.1 (2010), 108-26

Metropolitan Sanitary Commission: Second Report of the Commissioners Appointed to Inquire whether any and what special means may be requisite for the improvement of the Health of the Metropolis, with Minutes of Evidence (London: William Clowes & Sons, 1848)

Metz, Nancy, 'The Artistic Reclamation of Waste in *Our Mutual Friend*', *Nineteenth-Century Contexts*, 34.1 (June 1979), 59-72.

Miller, Elizabeth Carolyn, 'Drill, Baby, Drill: Extraction Ecologies, Open Temporalities, and Reproductive Futurity in the Provincial Realist Novel', *Victorian Literature and Culture*, 48.1 (2020), 19-56

Miller, J. Hillis, 'Optic and Semiotic in *Middlemarch*', in *The Worlds of Victorian Fiction*, ed. by Jerome H. Buckley (Cambridge, MA: Harvard University Press, 1975), pp. 125-45

---, *Victorian Subjects* (Durham, NC: Duke University Press, 1990)

Miller, John MacNeill, 'The Ecological Plot: A Brief History of Multispecies Storytelling, from Malthus to *Middlemarch*', *Victorian Literature and Culture*, 48.1 (2020), 155-85

Mintz, Alan, *George Eliot and the Novel of Vocation* (Cambridge, MA: Harvard University Press, 1978)

Moore, Ben, 'Invisible Architecture and Social Space in North and South', *Gaskell Society Journal*, 32 (2018), 17-36

Moore, Jason W., *Capitalism and the Web of Life: Ecology and the Accumulation of Capital* (London: Verso, 2015)

Morris, Pam, *Realism* (London: Routledge, 2003)

'Mortification', in *The Oxford English Dictionary* [online], < https://www.oed.com/view/Entry/122481> [Accessed 11 May 2021]

Munday, Pat, 'Sturm und Dung: Justus von Liebig and the Chemistry of Agriculture' (unpublished doctoral thesis, Cornell University, 1990)

---, 'Sturm und Dung. Liebig's metamorphosis from Organic Chemistry to the chemistry of agriculture', *Ambix*, 38 (1991), 135-54

Nishime, Leilani, and Kim D. Hester Williams, eds., *Racial Ecologies* (Seattle: University of Washington Press, 2018)

Nixon, Rob, *Slow Violence and the Environmentalism of the Poor* (Cambridge, MA: Harvard University Press, 2013)

O'Connor, Ralph, 'The Meanings of "Literature" and the Place of Modern Scientific Nonfiction in Literature and Science', *Journal of Literature and Science*, 10.2 (2017), 37-45

O'Gorman, Francis, *The Victorian Novel* (Oxford: Blackwell, 2002)

Orange, A. D., 'The Origins of the British Association for the Advancement of Science', *British Journal for the History of Science*, 6 (1972), 152-76

Parham, John, 'Biggish data: Fredrich Engels, Material Ecology, and Victorian data', *European Journal of Culture and Political Sociology*, 6.3 (2019), 344-64

---, 'Bleak intra-actions: Dickens, Turbulence, Material Ecology', in *Victorian Writers and the Environment: Ecocritical Perspectives*, ed. by Laurence W. Mazzeno and Ronald D. Morrison (London: Routledge, 2017), pp. 114-29

---, 'Dickens and the City: Science, Technology, Ecology in the Novels of Charles Dickens', *19: Interdisciplinary Studies in the Long Nineteenth Century*, 10 (2010), 1-23

---, '"For you, pollution". The Victorian Novel and Human Ecology: Benjamin Disraeli's *Sybil* and Elizabeth Gaskell's *Mary Barton*', *Green Letters*, 14.1 (2011), 23-38

Palin, William, 'The Farming of Cheshire', *Journal of the Royal Agricultural Society of England*, 5 (1845), 57-111

Parkins, Wendy, 'Women, Mobility and Modernity in Elizabeth Gaskell's *North and South*', *Women's Studies International Forum*, 27 (2004), 507-19

Paskins, Mat, 'Fragile Chemical Forms in Literature and Ethnography', conference paper given at 'Environments of Literature and Science', British Society for Literature and Science Winter Symposium, Cardiff University, 24 November 2018

Pelling, Margaret, *Cholera, Fever and English Medicine: 1825-1865* (Oxford: Oxford University Press, 1978)

Perry, P. J., 'High Farming in Victorian Britain: Prospect and Retrospect', *Agricultural History,* 55.2 (April 1981), 156-66

Pizzo, Justine, 'Atmospheric Exceptionalism in Jane Eyre: Charlotte Brontë's Weather Wisdom', *PMLA*, 131.1 (2016), 84-100

Playfair, Lyon, 'Abstract of Professor Liebig's Report on "Organic Chemistry applied to Physiology and Pathology"', in *Report of the Twelfth Meeting of the British Association for the Advancement for Science, held at Manchester in June 1842* (London: John Murray, 1843), pp. 42-54

---, 'Report on the State of Large Towns in Lancashire', in *Second Report of the Commissioners for inquiring into the State of Large Towns and Populous Districts* (London: William Clowes and Sons, 1845), pp. 345-486

Plumwood, Val, *Feminism and the Mastery of Nature* (London: Routledge, 1993)

Poovey, Mary, *Making a Social Body: British Cultural Formation, 1830-1864* (Chicago: University of Chicago Press, 1994)

'Proof, *v.*', in *The Oxford English Dictionary* [online], < https://www.oed.com/view/Entry/152580> [Accessed 11 May 2021]

Puig de la Bellacasa, Maria, 'Making time for soil: Technoscientific futurity and the pace of care', *Social Studies of Science*, 45.5 (2015), 691-716

Report of the Seventh Meeting of the British Association for the Advancement of Science, held at Liverpool in September 1837 (London: John Murray, 1838)

Rothwell, William, *Report of the Agriculture of the County of Lancaster* (London: Groombridge and Sons, 1850)

Russell, E. John, *A History of Agricultural Science in Great Britain* (London: George Allen & Unwin, 1966)

Said, Edward W., *Orientalism* (London: Penguin, 1995)

Saito, Kohei, *Karl Marx's Ecosocialism: Capital, Nature, and the Unfinished Critique of Political Economy* (New York: New York University Press, 2017)

Schling-Brodersen, Uschi, 'Liebig's role in the establishment of agricultural chemistry', *Ambix*, 39 (1992), 21-31

Scholl, Lesa, 'Moving Between *North and South*: Cultural Signs and the Progress of Modernity in Elizabeth Gaskell's Novel', in *Place and Progress in the Works of Elizabeth Gaskell*, ed. by Lesa Scholl and Emily Morris (London: Routledge, 2015), pp. 95-105

Scown, Jim, '*Our Mutual Friend* and the Chemistry of Sewage, Soils, and Circulation', *Journal of Literature and Science*, 13.1 (2020), 1-17

Schülting, Sabine, *Dirt in Victorian Literature and Culture: Writing Materiality* (London: Routledge, 2016)

Secord, Anne, 'Elizabeth Gaskell's Social Vision: The Natural Histories of *Mary Barton*', in *Uncommon Contexts: Encounters Between Literature and Science, 1800-1914*, ed. by Ben Marsden, Hazel Hutchinson and Ralph O'Connor (London: Routledge, 2013), pp. 125-44

Shaikh, Fariha, 'Temporally out of Sync: Migration as Fiction and Philanthropy in Gaskell's Life and Work', in *Place and Progress in the Works of Elizabeth Gaskell*, ed. by Lesa Scholl and Emily Morris (London: Routledge, 2015), pp. 83-93

Shannon, Mary L., 'The country in the city: Dickens and the idyllic river', in *Victorian Sustainability in Literature and Culture*, ed. by Wendy Parkins (London: Routledge, 2018), pp. 105-25

Sheail, John, 'Town wastes, agricultural sustainability and Victorian sewage', *Urban History*, 23, pt. 2 (August 1996), 189-210

Shuttleworth, Sally, *Charlotte Brontë and Victorian Psychology* (Cambridge: Cambridge University Press, 1996)

---, *George Eliot and Nineteenth-Century Science: The Make-Believe of a Beginning* (Cambridge: Cambridge University Press, 1984)

Smajić, Srdjan, 'Supernatural Realism', *Novel: A Forum on Fiction*, 42.1 (Spring 2009), 1-22

Smiles, Samuel, *Self-Help; with illustration of character and conduct* (London: John Murray, 1859)

Smith, Robert Angus, 'On the Air and Water of Towns', in *Report of the Eighteenth Meeting of the British Association for the Advancement for Science, held at Swansea in August 1848* (London: John Murray, 1849), pp. 16-31

---, ‘On the Air and Water of Towns. Action of Porous Strata, Water and Organic Matter’, in *Report of the Twenty-First Meeting of the British Association for the Advancement for Science, held at Ipswich in July 1851* (London: John Murray, 1852), pp. 66-77

---, ‘On Sewage and Sewage Rivers’, *Memoirs of the Literary and Philosophical Society of Manchester*, ser. 2, 12 (1855), pp. 155-75

---, ‘The Air of Towns’, *Manchester Guardian*, 8 August 1849, p. 2

---, ‘The Water of Towns’, *Manchester Guardian*, 11 August 1849, p. 9

Starr, Elizabeth, ‘“A Great Engine for Good”: The Industry of Fiction in Elizabeth Gaskell’s *Mary Barton* and *North and South*’, *Studies in the Novel*, 34.4 (Winter 2002), 385-402

Steig, Michael, ‘Dickens’ Excremental Vision’, *Victorian Studies*, 13.3 (March 1970), 339-54

Stevenson, William, *General View of the Agriculture of the country of Surrey. Drawn Up for the Board of Agriculture and Internal Improvement* (London: Phillips, 1809)

Stolte, Tyson, ‘“Putrefaction Generally”: *Bleak House*, Victorian Psychology and the Question of Bodily Matter’, *Novel: A Forum on Fiction*, 44.3 (Fall 2011), 402-23

Sucksmith, Peter, ‘The Dust-Heaps in *Our Mutual Friend*’, *Essays in Criticism*, 23.2 (April 1973), 206-12

Sun-Joo Lee, Julia, *The American Slave Narrative and the Victorian Novel* (Oxford: Oxford University Press, 2010)

Sutherland, John, ‘What is Jo Sweeping?’, in *Is Heathcliff a Murderer? Great Puzzles in Nineteenth-century Fiction* (Oxford: Oxford University Press, 1998), pp. 90-98

Taylor, Brooke D., ‘Spontaneous Combustion: When “Fact” Confirms Feeling in *Bleak House*’, *Dickens Quarterly*, 27.3 (September 2010), 171-84

Taylor, Jesse Oak, *The Sky of Our Manufacture: The London Fog in British Fiction from Dickens to Woolf* (Charlottesville: University of Virginia Press, 2016)

Tennyson, Alfred, *The Princess* (London: Edward Moxon, 1847)

Thomson, William, ‘On the Dynamical Theory of Heat, with numerical results deduced from Mr. Joule’s equivalent of a Thermal Unit, and M. Regnaults Observations on Steam’, *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* (July 1852), 8-21

---, ‘On a Universal Tendency in Nature to the Dissipation of Mechanical Energy’, *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science*, 47 (1852), 304-06

Toker, Leona, 'Decadence and Renewal in Dickens's *Our Mutual Friend*', *Connotations*, 16.1-3 (2006/2007), 48-59

Tree, Isabella, *Wilding: The Return of Nature to a British Farm* (London: Picador, 2018)

Tsing, Anna, *Friction: An Ethnology of Global Connection* (Princeton: Princeton University Press, 2005)

---, *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins* (Princeton: Princeton University Press, 2015)

Uglow, Jenny, *Elizabeth Gaskell: A Habit of Stories* (London: Faber & Faber, 1993)

Waples, Emily, 'Breathing Free: Environmental Violence and the Plantation Ecology in Hannah Craft's *The Bondswoman's Narrative*', *Victorian Literature and Culture*, 48.1 (2020), 91-126

Warwick Research Collective (WReC), *Combined and Uneven Development: Towards a New Theory of World-Literature (Postcolonialism Across the Disciplines)* (Liverpool: Liverpool University Press, 2015)

White, Gilbert, *The Natural History and Antiquities of Selborne* (1789; London: Penguin, 1977)

Wilkinson, Ann Y., '*Bleak House*: From Faraday to Judgement Day', *ELH*, 34 (1967), 225-47

Williams, Raymond, *The Country and the City* (1973; London: Vintage, 2016)

---, 'Culture', in *Keywords: A Vocabulary of Culture and Society* (1976; Oxford: Oxford University Press, 2015), pp. 62-66

Willis, Martin, *Vision, Science and Literature, 1870-1920: Ocular Horizons* (London: Pickering and Chatto, 2011)

Winter, James, *Secure from Rash Assault: Sustaining the Victorian Environment* (Berkeley, CA: University of California Press, 1999)

Worster, Donald, *Nature's Economy: The Roots of Ecology* (San Francisco: Sierra Club Books, 1977)

Wright, Erika, *Reading for Health: Medical Narratives and the Nineteenth-Century Novel* (Athens, OH: Ohio University Press, 2016)

Yeazel, Ruth Bernard, 'More True Than Real: Jane Eyre's "Mysterious Summons"', *Nineteenth-Century Fiction*, 29.2 (September 1974), 127-43

Yeo, Eileen Janes, *The Contest for Social Science* (London: Rivers Oram Press, 1996)

Young, Paul, 'The Land that England Lost: W. H. Hudson's *The Purple Land*, Liebig's Extract of Meat Company, and the romance of the outlands', in *Victorian*

Sustainability in Literature and Culture, edited by Wendy Parkins (London: Routledge, 2018), pp. 180-203.

---, 'Dickens's World-System: Globalized Modernity as Combined and Uneven Development', in *The Oxford Handbook to Charles Dickens*, ed. by J.O. Jordan, R. Patten and C. Waters (Oxford: Oxford University Press, 2018), pp. 703-21

Yusoff, Kathryn, *A Billion Black Anthropocenes or None* (Minneapolis: University of Minneapolis Press, 2018)