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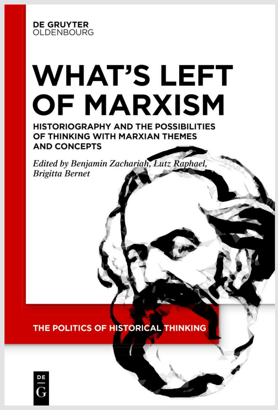
Benjamin Zachariah, Lutz Raphael, Brigitta Bernet (Eds.)

WHAT'S LEFT OF MARXISM

Historiography and the Possibilities of Thinking with Marxian Themes and Concepts



Have Marxian ideas been relevant or influential in the writing and interpretation of history? What are the Marxist legacies that are now re-emerging in present-day histories? This volume is an attempt at relearning what the "discipline" of history once knew – whether one considered oneself a Marxist, a non-Marxist or an anti-Marxist.

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The Politics of Historical Thinking

Historical thinking has a politics that shapes its ends. While at least two generations of scholars have been guided into their working lives with this axiom as central to their profession, it is somewhat of a paradox that historiography is so often nowadays seen as a matter of intellectual choices operating outside the imperatives of quotidian politics, even if the higher realms of ideological inclinations or historiographical traditions can be seen to have played a role. The politics of historical thinking, if acknowledged at all, is seen to belong to the realms of nonprofessional ways of the instrumentalisation of the past.

This series seeks to centre the politics inherent in historical thinking, professional and non-professional, promoted by states, political organisations, 'nationalities' or interest groups, and to explore the links between political (re-)education, historiography and mobilisation or (sectarian?) identity formation. We hope to bring into focus the politics inherent in historical thinking, professional, public or amateur, across the world today.

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Kavita Philip

The Science Problem in Marxism

On a loose sheet of paper, sometime between 1873 and 1882, Friedrich Engels scribbled some notes about a late-eighteenth-century shift in the meaning of scientific materialism:

> At the end of the last century, after the French materialists who were predominantly mechanical, the need became evident for an encyclopaedic comprehensive treatment of the entire natural science of the old Newton-Linnaeus school, and two men of the greatest genius undertook this, Saint Simon (uncompleted) and Hegel.[1]

In the aftermath of the Scientific Revolution of the sixteenth and seventeenth centuries, the eighteenth century Enlightenment and the Industrial Revolution, previous understandings of the natural and physical worlds had been overturned. Engels continued, referring to an ongoing late nineteenth century scientific conversation: “Today, when the new outlook on nature is complete in its basic features, the same need makes itself felt, and attempts are being made in this direction.”[2] Here Engels was identifying the still-incomplete task of integrating all of revolutionary discoveries in natural and physical sciences, and of connecting these, in turn, with social, economic, and philosophical investigations.

This ‘new outlook on nature’ was emerging in scientific contexts, which Engels avidly studied. On many other sheets of paper like this one, contemporary scientific findings were described, debated and summarised with as much detail and attention as we find in Engels’s more well-known investigations of the working classes or of political economic theory. No clear conclusion nor any integrated vision for a political economy of science emerges in these sheets, however. They were transcribed, decades later, simply labelled ‘Notes,’ and appended to other excerpts and notes on ‘Heat,’ ‘Electricity,’ ‘Natural Science and the Spirit World’ and ‘The Part Played by Labour in the Transition from Ape to Man.’ Together with an appendix containing previously unpublished ‘Notes to Anti-Dühring,’ these constituted fragmented chapters of the rather abstruse book known as *The Dialectics of Nature*.

1 Friedrich Engels, *The Dialectics of Nature* (New York: International Publishers, 1940), 178 – 179. These notes appear in a paragraph titled “The classification of sciences,” in Chapter VII, “Notes.”

2 Engels, *Dialectics of Nature*, 179.

https://doi.org/10.1515/9783110677744-007

This chapter suggests that we pay close attention to this vast, untapped vein of scientific study in the work of Karl Marx and Engels. A problem immediately arises, however, as we attempt to formulate the question of science in Marxism. Ahistorical models of science, tied to assumptions of deterministic social models of transition, and technocratic histories of technique, tied to Promethean systems of extraction and labour-control, have shaped the more deterministic and scientistic strands of Marxism. The political economic analysis of science and technology as a historical form of knowledge, however, has not been a significant part of mainstream humanist legacies in Marxism. This is the 'science problem' that this chapter sets out to address.[3]

In order to bring Marxist science back into focus, we have not only some understudied and fragmentary texts, such as *The Dialectics of Nature* and Marx's scientific notebooks, but also a rich historical record of the ways in which these fragments inspired shifts in scientific practice and planning. Marxist humanists have not considered the lab, the scientific conference, technological objects, infrastructure, or logistics as sites of Marxist theorising. But small, scattered groups of Marxist scientists have, at different periods in the twentieth century, been intrigued by Engels's radical approach to the practice of science. Although they are largely neglected in cultural and economic history, these 'red scientists' are well known in the history of science, and their work still circulates globally in science- and technology-oriented activist networks. We will draw on their history to understand both the mechanistic dead-ends and the potentially dynamic futures of radical anti-capitalist science.

The call for a new, non-mechanical materialism, rooted in a new understanding of nature, but going beyond the dialectics of Georg Wilhelm Friedrich Hegel (1770–1831) and the industrial optimism of Henri de Saint Simon (1760–1825), was critical to Marx and Engels's work from their earliest collaboration in the early 1840s. Marx's scientific excerpt notebooks, contemporaneous with his unfinished work on the second and third volumes of *Capital*, have thus far been the interest only of scholars of archival marginalia. The meaning of these notes has remained cryptic to humanist interpreters of the Marxist legacy. Today, with Marx's extensive notes on science being prepared for publication in the new MEGA editions, we have, for the first time, an archive that helps us understand the significance of science for Marxist political economy and philoso-

3 The most comprehensive treatment of Engels's legacy is Helena Sheehan, *Marxism and the Philosophy of Science: A Critical History, The First Hundred Years* (New Jersey: Humanities Press, 1985). The planned second volume (covering post-1945 developments in the dialectics of nature debate) was never completed.

phy.[4] While this archive in its entirety is not yet widely available, we must prepare ourselves to read it by revisiting the problem that science has posed for Marxists. Without a framework for understanding how and why science has been a problem in the Marxist legacy, we are likely simply to reproduce some of the anachronisms and stereotypes that have dogged this issue since its inception. And without paying attention to the details of the scientific changes of the late nineteenth century, we would miss an important aspect of the changes in Marx's models of materialism and nature. This chapter attempts to retrieve a historiographic framework to help reformulate questions about science, technology and capitalism, a century and a half after Marx and Engels began studying this conjuncture.[5]

The 'science question' for Marxists, then, is twofold: What was the role of science in Marx and Engels's formulation of philosophical critique and political

4 Begun in the 1920s in Moscow and still ongoing, the MEGA project in different forms has encountered many historical and geopolitical obstacles. Its current status can be accessed at http://mega.bbaw.de/projektbeschreibung. Accessed April 21, 2020. My comments in this chapter are thus provisional, based on a few scholars' pioneering work using the newly edited scientific and technical excerpt-notebooks, which are by no means complete or conclusive yet. The point is not to arrive hastily at a conclusive view of this newly-edited archive, but to begin, here, to put it in its proper historical context. We have a fresh chance to properly historicise these nineteenth-century writings rather than continue in the variously teleological and politically motivated readings we have inherited from a complex twentieth century.

5 It is important to note that science has a place in Marx's corpus that goes far beyond the influence of scientific work on Marx and Engels, and their uptake by scientists. I restrict this chapter to this narrow focus for reasons of space. I am in agreement with Saito's claim in his pathbreaking analysis of the notebooks, where he shows how Marx's scientific interests were key to the political economic arguments he was working on, slated to appear in *Capital,* Volumes 2 and 3. As Saito writes: "[I]t is essential to emphasize that Marx's notebooks need to be analyzed in close connection with the formation of his critique of political economy rather than as a grandiose materialist project of explaining the universe. In other words, the notebooks' meaning cannot be reduced to his search for a scientific worldview. Earlier literature often claims that through new discoveries in natural sciences Marx followed the classical tradition of the philosophy of nature by Hegel and Schelling, trying to figure out the universal laws that materialistically explain all phenomena within the totality of the world. In contrast, I inspect Marx's research on natural science independent of any totalizing worldview but examine it in close relation to his unfinished project of political economy." See Kohei Saito, *Karl Marx's Ecosocialism: Capital, Nature, and the Unfinished Critique of Political Economy* (New York: Monthly Review Press, 2017), 19. Marx's wide-ranging attention to the intersection of science, technology, and human subjectivity requires historians to expand their own analytical frames. A reconstruction of Marxist science studies would include, for example, the Frankfurt School tradition of Marxist sociology of science and its critiques of technocratic instrumentalism and fascism. Such an exploration (which awaits the publication of MEGA IV) would link the "science question," as articulated here, to the issues of political economy raised by Saito.

economic methods? And how did scientists themselves understand the significance of Marx and Engels's insights into scientific method and practice? Science after Charles Darwin was bringing about a revolution in understandings of nature, which could now be analysed as historically dynamic, proceeding through shifting material conditions, rather than created *ex nihilo* or understood via static essences. Marx and Engels were fascinated by this, and believed it held the key to their own revision of bourgeois political economy and humanist philosophy. They both made extensive notes consisting of excerpts from the world of scientific research. They corresponded with each other, and with scientists of their day, seeking to revise the mechanical, determinist analytics that spilled over from eighteenth century French and British materialism. As Eric Hobsbawm observes, Engels recognised that "diachronicity, that is, history, inevitably entered the sciences with the theory of evolution." The dialectical materialist method, in this context, addressed the task of constantly historicising both scientific and political categories of analysis. Marx and Engels's notion of dialectics, drawn from science, "was essentially historical, and its concern was with change and transformation."[6]

Retrieving the Science Question

Reading these 'excerpt notebooks' and scientific correspondence entails dipping into a history of science that has seemed positivist and technical to humanists.[7] Discussions of science have seemed abstruse and marginal to mainstream humanist interpreters of the Marxist tradition. However, this seemingly internalist history has spoken, over the years, to radical scientists who find inspiration in the kind of truth-making that science promotes, while simultaneously seeking

6 Eric Hobsbawm, "Preface", in *J.D. Bernal, Life in Science and Politics* eds. Brenda Swann and Francis Aprahamian (London: Verso, 1999), ix – xx.

7 MEGA Section IV ("Exzerpte, Notizen, Marginalien") contains miscellaneous notes that are in the process of being edited for wider circulation. Kohei Saito is editor of Volume 18, in process. His compelling book, *Karl Marx's Ecosocialism: Capital, Nature, and the Unfinished Critique of Political Economy* (New York: Monthly Review Press, 2017) is based on his initial readings of this archive. Some further notes on Marx and Engels's scientific writings are available in scattered contexts. See, for example, Kaan Kangal, "Engels' Intentions in Dialectics of Nature," *Science & Society* 83, no. 2 (2019): 215 – 243 and Pradip Baksi, "MEGA IV/31: Natural-Science Notes of Marx and Engels, 1877 – 1883," *Nature, Society, and Thought: A Journal of Dialectical and Historical Materialism* 14, no. 4, October 2001: 377 – 390. Baksi notes that MEGA IV, Volume 31 "provides new materials related to the hitherto little-noticed natural-science studies of Marx, and some materials related to Engels's Dialectics of Nature."

a way to put their daily modes of knowledge-making practices into political economic contexts. Exploring the science question in Marxism can prompt not only historicist revision but activist reorientations as well. The beginning of the twenty-first century has witnessed an explosion in progressive social movements calling for attention to the way scientific and technological systems were being reshaped and deployed by state and corporate forces. This proprietary corporate/imperial capture of science has seemed, to many scientists and technologists, to betray the potential of the new techno-sciences of the late twentieth century, from the human genome project to the internet. Challenging this capture, and suggesting that the potential of science and technology should be turned to the needs of the people, the creativity and resistance of progressive movements in the techno-scientific domain grew vigorously in the first two decades of the twenty-first century. However, for the most part, their ethical and social justice demands were not articulated in Marxist terms. In this context, there is a need for a broader engagement with Marx and Engels's writings on science that offer us a *longue durée* understanding of capitalist science and help us speculate about the futures of anti-capitalist science.

Marx had been interested, since his earliest political investigations, in the political significance of antagonisms between metaphysics and materialism.[8] For example, in his doctoral dissertation, *Differenz der demokritischen und epikureischen Naturphilosophie,* Marx explored the roots of contingency in the philosophies of science of Democritus and Epicurus. Under the guidance of Young Hegelian scholar Bruno Bauer, Marx argued that theology would inevitably give way to philosophy. However, a few years later, in *The Holy Family*, Marx articulated a more robust commitment to materialism, rejecting Bruno Bauer's philosophical idealism. *The Holy Family* included a key section on scientific materialism. Engels later described this section as the expression of their collaborative realisation that "the cult of abstract man, which formed the kernel of Ludwig Feuerbach's new religion, had to be replaced by the science of real men and

8 See Karl Marx, "Debates on the Law on Thefts of Wood," a series of articles first published in the Supplement to the Rheinische Zeitung Nos. 298, 300, 303, 305 and 307, October 25, 27 and 30, November 1 and 3, 1842. Translated Clemens Dutt, archived at https://www.marxists.org/archive/marx/works/download/Marx_Rheinishe_Zeitung.pdf, accessed April 21, 2020 and Karl Marx, "The Difference Between the Democritean and Epicurean Philosophy of Nature," Doctoral Thesis, March 1841, in Marx-Engels Collected Works, Volume 1 (Progress Publishers, 1902), archived at https://www.marxists.org/archive/marx/works/1841/dr-theses/index.htm, accessed April 21, 2020.

of their historical development."[9] Marx's understanding of materialism grew systematically away from the humanist idealism of Feuerbach and Bauer and towards a philosophy grounded in experimental science.[10] The notion of material exchanges, which was revolutionising the natural sciences of the late nineteenth century, would offer Marx a way to get beyond both the idealist theological models of abstract humans and the ahistorical, mechanistic models of nature that were legacies of eighteenth century philosophy.

For example, Marx' and Engels' claims about all matter being in motion grew out of their anti-theological politics. By arguing that all matter began in motion rather than in stasis, they were arguing against a theological, static first-cause position, and thus putting their weight behind a materialist chemistry-based understanding of life rather than a metaphysical, God-created notion. Returning to a well-known critique of religious teleology in *The Dialectics of Nature*, we note Engels's anti-teleological argument linking matter and mind:

> The old teleology has gone to the devil, but it is now firmly established that matter in its eternal cycle moves according to laws which at a definite stage – now here, now there – necessarily give rise to the thinking mind in organic beings.[11]

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9 Friedrich Engels (from "Ludwig Feuerbach and the End of Classical German Philosophy"), cited in the introduction (by the Institute of Marxism-Leninism), in Marx and Engels's first joint work, Karl Marx and Friedrich Engels, *The Holy family, or Critique of Critical Critique. Against Bruno Bauer and Co.* (Moscow: Foreign languages Publishing House 1956), 11.

10 Humanities theorists John Clark and Andreas Malm have found in the early Marx evidence of a technological optimism, and a "promethean" attitude towards nature. Judith Butler has recently responded to this argument, exploring Marx's model of nature in the 1844 Economic and Political Manuscripts, finding evidence of more than simple instrumentalist anthropocentric models of nature. Kohei Saito explores a longer history of shifting notions of nature in Marx. He traces the changes in Marx's model of labor and nature after the publication of *Capital* Volume I. He shows that the notion of "species being" in the 1844 manuscripts owed its origin to Feuerbach. Marx later discarded this, argues Saito, moving far beyond his early Prometheanism and developing a more complex, material, "ecological" view influenced by soil science and organic chemistry. See John P. Clark, "Marx's Inorganic Body," *Environmental Ethics* 11:3 (Fall 1989), 243–58, and Judith Butler, "The inorganic body in the early Marx: A limit-concept of anthropocentrism," *Radical Philosophy* 2, no. 6 (Winter 2019), 3–17. The "Promethean v. Ecosocialist" Marx debate was framed by Paul Burkett and John Bellamy Foster, and extended by Kohei Saito. I draw on their scholarship in the following section on *Stoffwechsel*/material exchange. See John Bellamy Foster, *Marx's Ecology: Materialism and Nature* (New York: Monthly Review Press, 2000); Paul Burkett, *Marx and Nature: A Red and Green Perspective* (Chicago: Haymarket Books, 2014); Saito, *Karl Marx's Ecosocialism.*

11 Karl Marx and Frederick Engels: *Collected Works*, Vol. 25 (London: International Publishers, 1987), 475–476.

Kohei Saito, in *Karl Marx's Ecosocialism*, demonstrates that Marx and Engels found support for this argument in post-Darwinian natural sciences and organic chemistry. Chemistry was a field that came into existence at the intersection of philosophical and theological theory, agricultural practice, capitalist agriculture and laboratory experimentation. It is only when seen in the context of the fierce nineteenth century arguments over metaphysics, nature and science that the 'matter in motion' phrase reveals its historical significance. As an abstract rule for contemporary scientists, the admonition to see all matter as being perpetually in motion is not practically useful, especially through much of the twentieth century when theology is not the main political enemy of science.

Marx, as we know, commonly produced polemics against the theories of bourgeois economists and philosophers, finding in their theories too much of the theological impulse, resistant remnants of mystical views of life and resurgent metaphysical notions of self. His own articulations of radical political economy were rooted in the processes of labour. In order to understand changes in the ways in which labour operated on nature, and production shifts in technology that rendered workers less and less able to control the terms of their labour or the products of their work, Marx studied not only the sciences of life but also the technologies of production (particularly factory machines), to understand how workers and machinery competed for power. In Chapter 15 of *Capital*, Volume I, "Machinery and Modern Industry", Marx and Engels argue: "But machinery not only acts as a competitor who gets the better of the workman, and is constantly on the point of making him superfluous. It is also a power inimical to him … It is the most powerful weapon for repressing strikes … It would be possible to write quite a history of the inventions, made since 1830, for the sole purpose of supplying capital with weapons against the revolts of the working-class."[12] In this chapter they lay out the framework for a philosophy and history of technology, issuing a challenge that few philosophers or historians have fully taken up. Marx's labour theory of value was indebted to, and inextricable from, a historiography and philosophy of science and technology.

12 Karl Marx and Frederick Engels: *Collected Works*, Vol. 35, Capital Volume I (London: Lawrence & Wishart, Digital Edition, 2010), 438–439.

Material Exchanges[13]

> "Capitalist production … disturbs the circulation of matter between man and the soil"[14]

Marx borrowed terms like 'Stoffwechsel' (or the exchange of materials) from the chemistry of metabolism. This term became central to the ways in which he understood all kinds of material exchange, from agricultural production to circulation.

13 A particular idea of materialism, emerging from scientific debates of the time, underpins Marx's political economy. Marx borrowed the word *Stoffwechsel* from Justus Liebig. Friedrich Tiedeman (1830) in *Physiologie des Menschen* used it to describe the chemistry of life, although it might have been in general use before that. As early as 1796, J. C. Reil uses the term "Wechsel der Materie" (Reil, "Von der Lebenskraft," *Archiv für Physiologie*, i, Part 1 (1796), 8 – 162, cited in Bing 1971). Bing comments: "Through a veil of mysticism he seems to have seen that life consists of changes which obey the laws of chemistry." It is precisely this momentous shift from mysticism to science that was in progress while Marx was writing. Liebig used the term Stoffwechsel less often than the term Metamorphose. There were many other phrases in use to describe the exchange of materials and transformations of energy forms in living things. Bing explains that the "richness of expressions for the idea of metabolism may be related to the intellectual vigor in Germany during the middle of the nineteenth century." Bing notes that in eighteenth-century scientific texts, the term "animal economy" (*die thierische Oekonomie*) is used for "what we today would call 'metabolism' … It could have been said that [medical scholars] made studies of the economy of their bodies." F. C. Bing, "The History of the word 'metabolism,'" in *Journal of the History of Medicine and the Allied Sciences* 26, no. 2 (April 1971): 158 – 180 can see here that the familiar eighteenth- and nineteenth-century notion that metaphors could be borrowed between the spheres of science and society to elucidate, discover, and systematise theories of each, while also elucidating the term itself, in its technical meanings. After the specialisations of the nineteenth century were complete, however, terminology and theory in each field became insulated, and, when borrowings did occur, scientific terms tended to be more static, having settled more firmly into specialised disciplinary significations after the 1920s.

14 "Die kapitalistische Produktion … stört sie andrerseits den Stoffwechsel zwischen Mensch und Erde." Marx and Engels, Das Kapital, Vol. II (Hamburg: O. Meissner, 1883), 517. Marx explains this borrowing from science, and makes the link to economic exchange in the C-M-C equations. See the note in one of his last economic writings [Randglossen zu Adolph Wagners "Lehrbuch der politischen Ökonomie" (Zweite Auflage), Vol. I, 1879]: "wo der "*Wechsel in den (naturalen) Bestandteilen der Gütermasse*" {einer Wirtschaft, alias bei Wagner getauft "*Güterwechsel*" für Schäffles "*sozialen Stoffwechsel*" erklärt wird—wenigstens ein Fall desselben; ich habe das Wort aber auch beim "naturalen" Produktionsprozeß angewandt als Stoffwechsel zwischen Mensch und Natur} von mir *entlehnt* ist, wo der Stoffwechsel zuerst auftritt in Analyse von W-G-W und Interruptionen des Formwechsels". Available in German and English at https://www.marxists.org/archive/marx/works/1881/01/wagner.htm. accessed April 21, 2020.

A year after the publication of *Das Kapital, Volume I*, Karl Marx wrote to Friedrich Engels:

> I would like to know from Schorlemmer what is the latest and best book (German) on agricultural chemistry. Furthermore, what is the present state of argument between the mineral-fertilizer people and the nitrogen-fertilizer people? … For the chapter on ground rent I shall have to be aware of the latest state of the question, at least to some extent.[15]

In *Capital* Volume I, Marx had drawn on the scientific debate over the chemical origins of life, the agrarian debate over fertilisers, and the link between science and craft. But he had only drawn out a fraction of the implications of these, and was already starting to extend his reading in order to address, in future volumes, the precise ways in which he saw craft and technique, science and the state, agrarian production and soil fertility, labour and machinery, the worker and bourgeois subjectivity, as historically interconnected. Organic chemistry was at the time a new field, founded in the radically experimental context of the late eighteenth and early nineteenth centuries, when ancient theories of the natural world were being overturned by experimental findings. Engels saw the communist commitment to totality and dialectics at the core of this vast intellectual scope that synthesised history, philosophy and scientific method.

Organic chemistry had originated in 1828 when German chemist Friedrich Wöhler experimentally disproved the doctrine of vitalism. Vitalism, the belief that organic matter was endowed with an inherent, vital life force, can be traced back to antiquity, through Aristotle and Galen. Marx and Engels were engaged with the revolutions that from the sixteenth through the eighteenth century had brought a confrontation between ancient vitalist theories (seeing life in terms of spirit, force, or *telos*) and a modern mechanistic view.

Many of the chemists Marx and Engels admired were influenced by early years in craft or practice of some kind. Organic chemistry by the 1870s was a battleground for theory and praxis. This battleground was the same one in which Marx and Engels were formulating, testing and changing their theories of political economy and history. Marx's inquiries after nitrogen fertiliser were likely to have been part of his attempt to understand the intense agrarian de-

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15 Marx, letter to Engels, 3 January 1868. The letter is cited in Ian Angus, Marx Engels and The Red Chemist https://monthlyreview.org/2017/03/01/marx-and-engels-and-the-red-chemist/ and in Saito, Marx's Ecological Notebooks https://marxismocritico.com/2016/02/24/marxs-ecological-notebooks/ accessed April 21, 2020. On Marx's funeral, see *Der Sozialdemokrat* March 22 1883 https://www.marxists.org/archive/marx/works/1883/death/dersoz1.htm, accessed April 21, 2020.

bates over the practical implications of Justus Liebig's *Agricultural Chemistry*.[16] The centrality of Liebig's work to Marx's work in *Capital* Volume I has been well established.[17] For example, Marx was taken by Liebig's characterisation of modern cultivation as a *Raubbau,* or 'robbery system,' a term that resonated with Marx's notion of exploitation, linking his economic analysis with new findings in agrarian science. Thus it seemed to Marx that whether individual scientists were explicitly socialist or not did not matter; new scientific findings were proving that theory and practice were inseparable, that materialist concepts linked different specialisations to offer a unity of natural and cultural analytics, and thus that science of the time had 'unconscious' socialist tendencies. It remained to the revolutionary political economist to thread these tendencies together with historical dynamics while striving for a materialist analytic that pushed back against the resurgence of vitalism and other new forms of Romanticism, paired as they were with post-1871 German nationalism.[18]

Justus Liebig (1803–1873), a Darmstadt-born scientist, whose fascination with chemistry had begun in his father's hardware shop where pigments were compounded, is considered the founder of organic chemistry. Recent archival work suggests that Marx wanted, in Volume 3, to analyse the relationship between the "declining productivity of the soil" and the falling rate of profit.[19] Saito's reading of Marx's "ecological notebooks" reveals that Marx was, by 1868, following the critical debate in which many of Liebig's supporters had descended into Malthusianism, linking declining productivity to the need for reducing population. This Malthusianism outraged Marx – who saw capitalist exploitation to blame for reduced productivity – and altered his science-reading trajectory. He began to follow a new crop of critical botanists and agricultural physicists such

16 Justus Freiherr von Liebig and Lyon Playfair, *Organic Chemistry in Its Applications to Agriculture and Physiology* (London: Taylor and Walton, 1840). Enormously influential, the book was commonly referred to by the short title *Agricultural Chemistry.*

17 J. D. Bernal noted this link as early as 1935. See also John Bellamy Foster, *Marx's Ecology: Materialism and Nature* (New York: Monthly Review Press, 2000).

18 Irrationalism and anti-science attitudes do not, of course, entail fascism, as Anne Harrington has shown. The relationships between authoritarianism, rationalism, holism, and socialism cannot be deduced from formalisms, but must be unraveled through their historical specificity. See Anne Harrington, *Reenchanted Science: Holism in German Culture from Wilhelm II to Hitler* (Princeton: Princeton UP, 1996).

19 See Kohei Saito, "Marx's Ecological Notebooks," *Monthly Review* 67, no. 9 (2016): 25–42, and Kohei Saito, *Karl Marx's Ecosocialism.*

as Carl Fraas, whose theories of agrarian crisis and climate became interesting to him as representing an "unconscious socialist tendency."[20]

Marx and Engels critically engaged with the findings of science as they occurred, followed debates, and historicised the terms and implications in conversation with both scientists and economists. They did not simply accept scientists' opinions as theirs; rather, they evaluated scientific claims in the light of arguments from theology, metaphysics and political economy.

Saito reports that "in the final fifteen years of his life Marx filled an enormous number of notebooks with fragments and excerpts. In fact, a third of his notebooks date to this period, and almost one half of them deal with natural sciences."[21]

These notebooks show that, contrary to common assumptions about the divisions of labour between Marx and Engels, positing a humanist Marx and a scientistic Engels, both Marx and Engels were fascinated with the ways in which the new sciences were overturning ancient philosophical foundations and traditional economic assumptions about the organisation of life. As in all their work, they attempted to theorise from the ground up in their work on scientific method, building expertise by reading and engaging with scientists in every sphere. Because this was such a huge task, and because recent revolutions had occurred in almost every field of science, this was literally unending work – it never ended for Marx, and although Engels's editing and publishing of *Capital* Volume III had been expected to integrate these studies with their theories of labor, subject-formation, and knowledge, it failed to do so.

The Taming of Early Scientific Speculation: Specialisation, Positivism and Anti-Science Politics

Marx and Engels's research notebooks show what scholars have seen as an astonishing level of engagement between scientific research and social and humanist thinking. Historians of science show us that this kind of interchange was not unusual between the seventeenth and mid-nineteenth century. The nineteenth century saw a number of contradictory trends in science, some extensions

20 Marx to Engels in a letter dated March 25, 1868, praising Fraas's book *Climate and the Plant World Over Time*, as cited in Kohei Saito, "Marx's Ecological Notebooks." *Monthly Review* 67, no. 9 (2016): 25–42. https://marxismocritico.com/2016/02/24/marxs-ecological-notebooks/

21 Kohei Saito, "Marx's Ecological Notebooks," *Monthly Review* 67, no. 9 (2016): 25–42.

of the past two centuries, and others the beginning of new trends that would shape twentieth century academic disciplines and industrial development. By the end of the nineteenth century, institutional changes favored the specialising and narrowing tendencies that had begun to characterise scientific research since the 1850s. Specialisation was good for the progress of science in precisely delineated problem areas, in which standardised assumptions and constraints made it easier to accumulate usable insights. Powerful scientific and technological findings powered the industrial revolution. But institutional specialisation constrained the wide, sweeping sorts of scientific and humanist speculation that had characterised the revolutions in physics, chemistry, agrarian science, mathematics and biology of the seventeenth and eighteenth centuries.[22] Indeed, the very proliferation of specialised forms of knowledge, and the generalised acceptance of specialisation that followed, is what made Engel's attempt to follow multiple sciences in their own terms and using their specific notations seem abstruse to twentieth and twenty-first century readers.[23] The fading of early modern cultures of intermingled scientific and humanist speculation brought more than a philosophical loss. The everyday effects of separating religious, technical, poetic and humanist spheres would come to define, in a popular cultural sense, the disenchantment of the industrial age.

The scientific and philosophical work of Austrian physicist and philosopher Ernst Mach (1838–1936) for example illustrates both this shift in the relationship between science and the humanities and the ongoing centrality of science to Euro-American political philosophies of the late nineteenth century, as well as its confusing legacy in the twentieth century. Mach has been credited for bringing socialist, pragmatist, positivist, constructivist and even Buddhist commitments to his influential work on the epistemic implications of the seismic shifts

22 For an influential analysis of the separation of disciplines in eighteenth-century Prussia, see Immanuel Kant, trans. Mary J. Gregor, *The conflict of the faculties (Der Streit der Fakultäten*) (Lincoln: University of Nebraska Press, 2011) (1798). Thomas Kuhn in *Structure of Scientific Revolutions* argues that specialisation is part of the natural process of scientific progression. However, the question of which parts of science do progress, when, and why are also connected to politics and funding. This something Kuhn acknowledged, but never developed. These links between science and the histories of nationalism, imperial politics, and political economy were taken up by scholars of science and technology studies (STS) after the Cold War.

23 This was precisely the kind of scholarship that was expected from historians of science until recently. Until the 1990s, scholars of science and society tended to be trained in some scientific or technical field in addition to being trained in history, philosophy, or sociology. With the rise of STS, a unified methodological canon has to some extent replaced the older model of multiple disciplinary trainings.

in scientific knowledge that he lived through, and participated in.[24] Historian of science Gerald Holton suggests that Mach's anti-metaphysical arguments were crucially important for nineteenth-century experimental and theoretical work that sought to describe natural and physical systems through their observation and description rather than by recourse to transhistorical theological assumptions. This required a strong break with tradition (understood as continuous with ancient or classical knowledge). A guide for breaking with abstract, theological, received knowledge seemed to be provided by Mach's grounded science and its immanent philosophy (a mixture of atheism, socialism, empiricism and pragmatism), seen as radical "in the last third of the nineteenth century, when some German textbooks in physics still implied that the meaning of concepts was to be sought on a higher, metaphysical plane."[25] It was this radical break with abstract theory that was so new in the late nineteenth century but would soon appear antiquated in the light of the new physics and its irreducibly complex intermingling of theory and experiment, abstract concepts and measurable data.

Mach is known to the public for his scientific work on the speed of sound, but his philosophical work even was more far-reaching. He influenced almost the entire range of philosophy forged at the turn of the century, from pragmatists like William James to the 1911 Gesellschaft für positivische Philosophie (Society for Positivist Philosophy) and its successor, the 1929 Vienna Circle.[26] Philosophers from Mach to the Vienna Circle, notes historian of science Helena Sheehan, "strove to set science upon secure foundations … to subject all belief to the clear light of reason and the rigor of experiment."[27] As physicist Philipp Frank recalled: "An attempt was made by a group of young men to retain the most essential points of Mach's positivism, especially his stand against the misuse of metaphysics in science."[28]

24 See John Thomas Blackmore, *Ernst Mach: His Work, Life and Influence* (Berkeley: University of California Press, 1972); Gerald James Holton, *Science and Anti-science* (Cambridge, Massachusetts: Harvard University Press. 1997).

25 Gerald J. Holton, *Science and Anti-Science*, 4.

26 Gerald J. Holton, *Science and Anti-Science*, 12–14. Holton reproduces the 1911 "Aufruf" from the 'Gesellschaft für positivische Philosophie', which begins: "Eine umfassende Weltanschauung auf Grund des Tatsachenstoffes vorzubereiten, den die Einzelwissenschafter aufgehäuft haben, und die Ansätze dazu zunächst unter den Forschem selbst zu verbreiten, ist ein immer dringenderes Bedürfnis vor allem für die Wissenschaft geworden, dann aber auch für unsere Zeit überhaupt, die dadurch erst erwerben wird, was wir besitzen."

27 Sheehan, *Marxism and the Philosophy of Science*, 43.

28 Philipp Frank, cited by Thomas Uebel, "On the Austrian Roots of Logical Empiricism," in *Logical Empiricism – Historical and contemporary Perspectives*, ed. Paolo Parrini, Wesley C. Salmon, Merrilee H. Salmon (Pittsburgh: University of Pittsburgh Press, 2003), 76–93. Citation 70. Franck

The effort to reinforce scientific facts against idealist philosophy was linked to Mach's early understanding of the mid-nineteenth century traditionalist threat to science. Mach, as well as his followers whose work extended into the late twentieth century, failed to understand that the philosophical and political implications of scientific observation had changed by the 1920s. Yet even as his philosophical influence grew stronger, beyond the nineteenth century, Mach literally could not understand what was going on in physics by the 1920s – for example, in his correspondence with younger physicists it is clear that he did not have the required mathematical literacy to even read Einstein's papers, let alone formulate adequate philosophical frameworks for the new sciences.

The turn to description had run its course by the 1920s; twentieth-century physics as well as the century's global anti-imperial political cultures suggested that all facts are theory-laden.[29] But Mach's influence on two continents and across almost all philosophical specialisations meant that his followers – many of whom lived and worked throughout the twentieth century, like behavioral psychologist B. F. Skinner (1904–1990) – would extend a nineteenth century empiricism far beyond its expiry date. Machism's fuzzy domain suggests both the sheer productivity of this fuzzy metaphor.[30] In Otto Blüh's words, Mach wished to keep "the door between laboratory and church firmly shut" and so he "barred the door of the laboratory from within."[31] Many attempts have been made to batter down this laboratory door since then. But the effects of this positivist overreach are still with us.

was part of this group that grew into the Vienna Circle. Philipp Frank's Machism was vigorously criticised in the Soviet version of scientific dialectics.

29 The implications of this radical intermingling of theory and fact were to reverberate through the first half of the twentieth century. Initially, physicists were also philosophers (see Werner Heisenberg, *Physics & Philosophy: The Revolution in Modern Science* (New York: Harper Perennial, 2007 (1958)), and almost all physicists were conversant with the philosophical questions about representation, reality, correspondence, and models. By mid century, however, questions about observation and measurement were to be disciplinarily separated from questions about meaning and reality.

30 Historian of science Nancy Stepan has argued that metaphor is not a removable overlay over scientific observation; it is an integral part of scientific thinking. Loose metaphors are not a sign of faulty thinking; on the contrary, scientists need capacious metaphors to understand, to speculate, or to test new hypotheses. Nancy Leys Stepan, "Race and Gender: The Role of Analogy in Science," *Isis* 77, no. 2 (1986): 261–77.

31 Otto Blüh, Ernst Mach: Physicist and Philosopher (1970), 18, as cited in Sheehan, *Marxism*, 267.

Experiments in Marxist Science

The extensive twentieth-century changes in science, technology, and their roles in global capitalist production mean that it is insufficient simply to pick up Marx and Engel's late-nineteenth-century scientific observations and celebrate their prescience. Methodologically, it is their approach to the historiography of science that has been the missing element in scholarly treatments of Marxist science. When scientific practice and historiography are carried out within the same frame, they can offer radical insights into both science and history, as well as into a range of political and philosophical questions. Their methodology grew from critically weaving together three different problem areas: labour and economic change, scientific theories and technological machinery and the history of science and technology. Each of these were of course already of interest to bourgeois thinkers in the nineteenth century; but Marx and Engels differed from them in that they were historicizing their categories of analysis in all three areas.

The most prominent attempt to situate *The Dialectics of Nature* at the heart of state policy and scientific practice was in the Soviet Union. In the brief period after the revolution and before Stalin's purges, Soviet science soared. Cold War historiography has left us with the notion that Lysenkoism, the term almost synonymous with pseudoscience, resulted from the application of dialectical materialism to the everyday practice of science. Lysenkoism's disastrous results, politically and scientifically, are held to falsify dialectical materialism as a philosophy and methodology. But as historian Nikolai Krementsov notes: "We know now that the problem with genetics wasn't dialectical materialism or the relationship of Mendelian inheritance to agriculture; the problem with genetics was Stalin."[32]

Soviet science through the twentieth century was to fail on many counts; but in the 1930s a paradigmatic intertwining of Marxist science, history of science and political economic analysis might have helped fuel one of the most influential western periods of scientific engagement with Engels.

In 1931, a delegation of scientists and historians of science led by Bukharin attended the Second International Congress of the History of Science and Tech-

32 Nikolai Krementsov, *Stalinist Science* (Princeton, NJ: Princeton University Press, 1997), 25. I do not touch here on the considerable Soviet achievements in rocketry and computer science; see Asif A. Siddiqi, *The Red Rockets' Glare: Spaceflight and the Soviet Imagination, 1857–1957* (Cambridge University Press, 2013); Benjamin Peters, *How Not to Network a Nation: The Uneasy History of the Soviet Internet* (Cambridge, MA: MIT Press, 2017).

nology in London. Gary Werskey, a Marxist involved in the British post-1968 radical science movement, wrote a 1971 introduction to the re-issue of the papers presented by the 1931 Soviet delegation. Looking back from 1971, he wrote: "What they wished to communicate above all else was the intellectual vitality, self-awareness, social usefulness and sheer prosperity of science in a socialist society."[33] As Joseph Needham (one of the only surviving attendees of the 1931 meeting) noted in the same volume, most of the Soviet scholars he had admired in 1931 had since then perished in the Stalinist purges or been banished from mainstream Soviet science. He had been one of a small group of British Marxist scientists who were taken with the 1931 Soviet delegation's scholarship.[34] Most profoundly, they were attracted by the ways in which science and the history of science were intertwined in the Soviet model. Many of them had already moved towards socialism, but this was their first encounter with the way historiography of science, embedded in contexts of scientific practice, and could offer a new perspective on the current forms of science, society, and state interactions. Werskey notes that "Unlike most of the historians, philosophers and scientists whom they were eventually to confront in London, the Russians offered their scholarship as a contribution to a programme of socialist reconstruction which relied heavily on the work of natural scientists."

The Soviet scholars, particularly Boris Hessen, who presented a paper on the socio-economic history of Newton, set out "a sustained Marxist treatment of social and economic factors as elements in scientific and technological development."[35] In this framework, historiography and scientific practice were inextricable from each other, and both were linked to State planning. Socialist planning depended on both science and history. Sheehan reports that Antonio Gramsci read the Russian conference paper collection in prison, and that it influenced Marxist physicist Christopher Caudwell's work on science and society.[36] Although Hessen, Bukharin, and most of the delegation were soon to fall out of fa-

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33 Gary Werskey, "The Marxist Critique of Capitalist Science: A History in Three Movements?" *Science as Culture* 16, no. 4 (2007): 397–461.

34 On Needham as an unknown classic in modern historical scholarship see: Hans Ulrich Vogel, "Joseph Needham (1900–1995)," in *Klassiker der Geschichtswissenschaft, Vol. 2*, ed. Lutz Raphael, (München, Beck, 2006) 27–44.

35 "Editors Note", in *Science at the Cross Roads: Papers Presented to the International Congress of the History of Science and Technology Held in London from June 29th to July 3rd, 1931*, ed. by the Delegates of the USSR, with a new Foreword by Dr Joseph Needham and a new Introduction by P. G. Werskey. (London: Frank Cass & Co, 1971), v.

36 Delegates of the USSR, ed., *Science at the Cross Roads: Papers Presented to the International Congress of the History of Science and Technology Held in London from June 29th to July 3rd, 1931* (London: Kniga Ltd, 1931).

vour with the Stalinist regime, the 1931 conference is believed to mark the origin of Marxist science studies in Britain. The British 'red scientists' active in the 1930s included Conrad Waddington, J. D. Bernal, J. B. S. Haldane, Lancelot Hogben, Hyman Levy, Joseph Needham, Christopher Caudwell and others. The story of Marxist science in the twentieth century inextricably links Soviet, US and European histories, and a truly global history is yet to be written.[37] In retrospect, the founding of British Marxist science studies in the 1930s was both an unprecedented opportunity to develop Engels's ideas in a different political context as well as a tragic failure to do so.

In the same decade, John Desmond Bernal would elevate Francis Bacon as the ideal philosopher-scientist while Adorno and Horkheimer would lay much of the blame for an instrumentalised, imperialist, mathematical imagination at Bacon's feet. Each group took up vital elements of Marx and Engels's legacy, but the half-century since Marx's death, and the political and philosophical impacts of science, war, and empire brought into question the very categories of their analysis – reason, observation, subjectivity, ethics. Marxist scholars of science and society diverged from Marxist scholars of culture and philosophy. The two Marxist worlds of science studies and critical theory separated in the 1930s, and would not agree on the role of reason in the world for the next century.

The British 'red scientists' spent the 1930s and 1940s attempting to do three things together: practice cutting edge science, publish historical analyses of science and society and work within the State to bring scientific planning to center stage. They succeeded in the first, had mixed results with the second, and succeeded so well with the third that they would rethink some of their convictions about the inherent progressiveness of science. Through the 1930s and 1940s, many of the British leftist scientists were to become Fellows of the Royal Society and win accolades for their fundamental contributions to physics, biology, chemistry and mathematics. The red scientists of the 1930s were pioneers in their scientific disciplines as well as public intellectuals who, following Engels and inspired by the Soviet 1920s model of dialectical materialist historiography of science, laid the western foundations for the integrated study of science, technology and society.

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37 Sheehan's *Marxism and the Philosophy of Science* is the best Marxist treatment of dialectics and science from Engels through Lukacs. Loren Graham, Elena Aronova and Audra Wolfe have written extensively on Cold War science. An oral history of 1930s red science is Gary Werskey, *The Visible College: A Collective Biography of British Scientists and Socialists of the 1930s* (London: Free Association, 1988). There is a need for more global history that can take into account not only Russia and the US but put them in the context of post-colonial scientific and historiographic debates after 1945.

In pre-World War II Cambridge, scientists formed the second largest academic group (after historians) on the Left.[38] Because of their influence, the study of the 'social relations of science' grew into a separate division by 1938 in the British Association for the advancement of Science. There were French and Dutch leftist science movements as well, and the European scientists' leftism influenced the US Marxist journal *Science and Society.*[39] It seemed as if Engels's approach had found its moment. J. D. Bernal wrote in *The Labour Monthly*: "After half a century of neglect, the methods of Engels and Marx are at last coming into their own in the scientific field."[40]

J. B. S. Haldane's *The Marxist Philosophy and the Sciences* explicated Marx and Engels's dialectical principles, arguing that Marxism was an open-ended philosophy of science, not an economic-determinist toolbox. The following year he completed his introduction to the first English edition of Engels's *Dialectics of Nature*. Soon after the Suez crisis of 1956, he departed for India with Helen Spurway, leaving angry denunciations of British imperialism and looking forward to joining a diverse postcolonial scientific context. J. D. Bernal, deeply influenced by conversations with Bukharin and Hessen in 1931, would go on to strongly advocate for the role of planning in science. His 1939 book, *The Social*

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38 Gary Werskey, "The Marxist Critique of Capitalist Science: A History in Three Movements?" Science as Culture. 16, no. 4 (2007): 397–461, 407

39 Gary Werskey, "The Marxist Critique of Capitalist Science," 408; David Caute, *Communism and the French Intellectuals, 1914–1960* (London 1964); Mary Jo Nye, "Science and Socialism: The Case of Jean Perrin in the Third Republic," *French Historical Studies* 9, no. 1 (1975): 141–69.

40 John D. Bernal, "Engels and Science," *Labour Monthly Pamphlets,* No. 6 (1935) https://www.marxists.org/archive/bernal/works/1930s/engels.htm, accessed April 21, 2020. For a sample of the extensive social and cultural analyses of science produced by scientists, see, e.g., P. M. S. Blackett, *The Military and Political Consequences of Atomic Energy* (London: Turnstil Press, 1948), P. M. S. Blackett, *Studies of War: Nuclear and Conventional* (Edinburgh: Oliver & Boyd, 1962), M. Prenant, *Biologie et Marxisme* (Paris: Editions Société Internationale, 1935); H. Levy, *The University of Science* (London: Watts, 1932); H. Levy, *A Philosophy for Modern Man* (London: Watts, 1938); J. B. S. Haldane, *The Marxist Philosophy and the Sciences* (London: Allen and Unwin, 1938); C. H. Waddington, *The Scientific Attitude* (West Drayton, Middlesex: Penguin Books, 1948), Jean Baptiste Perrin, *Pour la Libération* (New York 1942). Their scientific findings were often far ahead of their time. For example, Waddington introduced the term "epigenetics" into biology, indicating the role of historical development that a narrow, deterministic focus on genetics had obscured. For an analysis of the once-obscure, now newly important importance of history in biological development, see Jessica Riskin, "The Naturalist and the Emperor, a Tragedy in Three Acts; Or, How History Fell Out of Favor As a Way of Knowing Nature," *Know: A Journal on the Formation of Knowledge* 2, no. 1 (2018): 85–110. For a contemporary science studies perspective on the importance of epigenetics, see Hannah Landecker, "Food As Exposure: Nutritional Epigenetics and the New Metabolism," *Biosocieties* 6, no. 2 (2011): 167–194.

Function of Science, set out the red scientists' dream of a progressive, vanguardist, science-driven nation whose policies and education were structured around research and the improvement of everyday life through science. Much of this vision did in fact become central to the post-war capitalist landscape, due partly to the effects of the work of scientists as public intellectuals and immediately after the war, as advisors to governmental agencies.

During the war years, many red scientists served the British military, seeing the fight against fascism as their generation's duty. But their public influence dwindled as a Cold War anti-communism took hold,[41] and their theories of science as a progressive force seemed oddly misguided as scientific and technological changes defined newer, more powerful, profitable, and penetrative modes of capitalism. The marginalisation of socialist scientists in the 1950s, and the growth of a US-State Department-funded narrative of science being the harbinger of free markets in the developing world, resoundingly defeated the red scientists' discourse of scientific socialism. Although Bernal's *Social Function of Science* was lauded as his magnum opus and re-issued in 1964, by then it had largely antiquarian interest, much as Engels's *Dialectics of Nature* had seemed quaint to Einstein in 1920. One again, three decades had brought a dramatic change in the framework of understanding science, technology, and society.

The Cold War facilitated a conservative wave in historiography of science. Conservative scholars took back their institutional privilege by a variety of means, including press campaigns against the Marxist scientists. They succeeded in marginalizing what they saw as a vulgar Marxist 'externalist' method, returning to internalist readings of science that rejected the notion that politics and economics shaped scientific fact. Yet, in his 1964 update on *The Social Function of Science,* Bernal reiterated his confidence that a technological future led by the principles of science would necessarily be socialist: "The scientific and com-

41 Werskey describes the red scientists' "swift and hard fall from political grace and influence after 1948." Bernal and Blackett would later be denied entry into the US as dangerous subversives. Eric Hobsbawm estimated that between 1948 and 1958, "no known communists were appointed to university posts … nor, if already in teaching posts, were they promoted." (Eric Hobsbawm, *Interesting Times,* 182, as cited in Werskey, *The Marxist Critique of Capitalist Science,* p 455, footnote 101). There were disciplinary shifts as well: Blackett abandoned nuclear physics for geophysics, Needham switched from biochemistry to the history of Chinese science. Haldane and his wife Helen Spurway left for India, which was to be a grand experiment in supporting postcolonial science, but ended with little more than Haldane's clever adaptation of an upper-caste Brahmin scientific imagination. See Gordon Mcouat, "J. B. S. Haldane's Passage to India: Reconfiguring Science," *Journal of Genetics* 96, no. 5 (2017): 845 – 852.

puter age is necessarily a Socialist one," he boldly announced.[42] He was spectacularly wrong. The computer age was to usher in a new age of exploitation and profits, and the corporatisation of the state in the interest of technological advancement.

Why did the red science view fail so spectacularly, twice in less than a century? Shortly after Marx and Engels' lifetimes, the troubled histories of nationalism coupled with the paradigm shifts that overturned Newtonian science made their notes on science age poorly, and they fell into the overlooked marginalia of Marxist archives. The well-funded agendas of anti-communism had, of course, much to do with the second marginalisation of red science, in the 1950s. But additionally, there was an inadequate set of skills on the left to simultaneously historicise and politicise scientific theory and practice. Bernal, Haldane and other red scientists worked outside their day jobs, reading histories of science and carrying out social analyses of science while doing full-time, cutting edge laboratory and theoretical science. Given the lack of institutional support for this combination of disciplinary activities, their achievements were remarkable. However, their skills were inadequate to the triple task that Marx and Engels had outlined: the task of braiding together scientific practice, political economic analysis and historiography of science. They combined the daily practice of science with the study of the relations between science and society; they were highly trained in science; and they had no training at all in analysing the social. Although they had a deep understanding of the dynamism of scientific processes in their own specific areas of expertise, they had no historical skills by which to locate primary sources, assess historiographic arguments, and synthesise social scientific and philosophical debates. Instead of historicising their categories of analysis, they transposed their own social habits in scientific communities largely composed of educated, liberal humanist white men onto their model of scientific progress:

> "In science men have learned consciously to subordinate themselves to a common purpose … In science men collaborate not because they are forced to by superior authority or because they blindly follow some chosen leader, but because they realise that only in this willing collaboration can each man find his goal. Not orders, but advice determines action. Each man knows that only by advice, honestly and disinterestedly given, can his work succeed, because such advice expresses as near as may be the inexorable logic of the material

42 J. D. Bernal's essay, "After Twenty-five Years" was included in the reissue of *The Social Function of Science* (Cambridge, MA: MIT Press, 1967), xvii – xxxvi. It was originally published in *The Science of Science*, eds. Maurice Goldsmith and Alan McKay, (London: Souvenir Press, 1964).

> world, stubborn … These are things that have been learned painfully and incompletely in the pursuit of science. Only in the wider tasks of humanity will their full use be found."[43]

The figure of selflessly collaborating men was rarely understood as an outcome of a long history of male privilege in science.[44] Theirs was an inspiring but deeply limited understanding of the power of science to improve humanity. The processes of collaboration and mutual advice were assumed to simply mirror the 'inexorable logic' of nature; thus, for example, the labour of secretaries or the politics of the State seemed merely background work that followed dutifully in the heroic footsteps of Nature and Scientific Man.

The red scientists excelled in scientific practice but lacked training in historiography. They did manage to learn an impressive array of skills by attending conferences and reading widely. But they were tripped up by the assumption that their scientific day-jobs could simply be combined with self-taught historiographic skills. Both science and history, as disciplines, had evolved beyond the amateur contexts of Enlightenment gentlemen's pursuits. The red scientists produced remarkable texts in the historical and social analysis of science given that they were amateurs in the field. Even their Soviet-inspired socio-economic skills had aged poorly, in the light of the nuanced archival and historiographic developments that had resulted, in part, from the very specialisation and disciplinary focus that had grown in Anglo-American humanities institutions. As Needham recalled in 1971, Soviet historian Boris Hessen had stunned the red scientists with his "trumpet-blast" of an essay on Isaac Newton's bourgeois scientific production. Hessen's "externalist" model of studying science in the context of social and economic activity was threatening to the influential Oxbridge school and its "internalist," Great Men of Science model. But Hessen also made "mistakes of detail on the way," and his work suffered, Needham recalled, from an "unsophisticated bluntness."[45]

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43 Bernal, *The Social Function of Science,* xxxv – xxxvi.

44 There are reports that Rosalind Franklin found Bernal's laboratory at Birkbeck College a refuge from the sexism she experienced from male DNA-researchers who appropriated her work in X-ray crystallography. Their individual heroism, however, seemed to substitute for social and historical critique. The story of the women who supported and enabled the lives of the red scientists has yet to be told – see Hilary Rose and Steven Rose, "Red Scientist: Two Strands from a Life in Three Colours," in Swann and Aprahamian, eds., *J.D. Bernal: A Life in Science and Politics*, 132–159.

45 Joseph Needham, "Foreword", in *Science at the Cross Roads* ed. by the Delegates of the U.S.S.R., viii.

There was much to appreciate in the ad-hoc historiography that the red scientists adapted to their ends. But by the 1960s, it was also clear that they had insufficiently complex understandings of the constitutive role of science and technology in new forms of capitalism. Nor could they understand the ways in which Cold War funding had facilitated a fresh rhetoric about 'neutrality' of science, deployed in the developing world as an anti-Communist strategy. In 1953, Michael Polanyi, invited by the physicist Alexander Weissberg to chair the Committee on Science and Freedom for the Congress for Cultural Freedom, would begin a movement to end ideology and ground the future in data management.[46] The 'end of ideology' was a phrase coined by Daniel Bell. Polanyi and Edward Shils (founder-editor of the 1945 *Bulletin of Atomic Scientists*) would make it the slogan of the Congress for Cultural Freedom (CCF) from the mid-1950s, using science in opposition to ideology in a plan to "secure a post-Marxian basis for liberalism throughout the world."[47] The CCF's Committee on Scientific Freedom as well as the Committee for Economic Development sought to turn the social study of science into a key driver of anti-Communism. Several post-World War II CCF Study Groups were created to discuss "the dramatic changes in the role of technology and science."[48] The CCF aimed to frame data as the foundation of international policy advice. Data and scientific detachment were held up in opposition to political struggle and ideological debate.

The notion of data-driven social policy foreshadowed the future rise of data and algorithms as a substitute for the messiness of democratic public participation in the agendas of development. If science studies was inaugurated with Bernal's 1939 *The Social Function of Science* as a Marxist return to Engels, it was transformed in less than two decades to a CIA-sponsored discourse about anti-Communist global development. This was an even more dramatic shift than the 1920s' conversion of an anti-metaphysical nineteenth-century empiricism into logical positivism.

46 See Elena Aronova, "The Congress for Cultural Freedom, Minerva, and the Quest for Instituting 'Science Studies' in the Age of Cold War," *Minerva* 50, no. 3 (2012): 307–337. Hilary Rose and Steven Rose mark Bernal's *Social Function of Science* as the founding intellectual moment of the study of Science Technology and Society. "Even today, one of the most prestigious awards of the US Society for the Social Studies of Science is an annual Bernal prize; that all too many of its recipients have been the narrow professionals of whom his life as a public intellectual stands in contempt is just one of life's ironies." Rose and Rose, in Swann and Aprahamian eds., *J. D. Bernal: A Life in Science and Politics*, 136.

47 Aronova, "The Congress for Cultural Freedom," 312.

48 Aronova, "The Congress for Cultural Freedom," 314.

There would be one last western attempt before the end of the twentieth century to reconfigure the discussion of Marxist science and historiography. A group of largely American and British science students involved in the campus protests of the 1960s and inspired by the anti-imperialist solidarities of the 1970s, began radical science collectives in the early 1970s (see Fig. 1 below, *Science for the People* magazine) This group had a more precise understanding of the ways in which the nature and practices of science and tech were shaped by their political economic context. They did not believe that science embodied only collaborative and progressive values, shored up by the stubbornness of facts and reality. They entered into partnerships and coalitions with activists, and challenged the State rather than working along with it to increase the status of science. Unlike the 1930s red scientists, their careers did not lead to Fellow of the Royal Society or State science advisor roles. They took an internationalist perspective further than the anti-fascist generation had been able to.

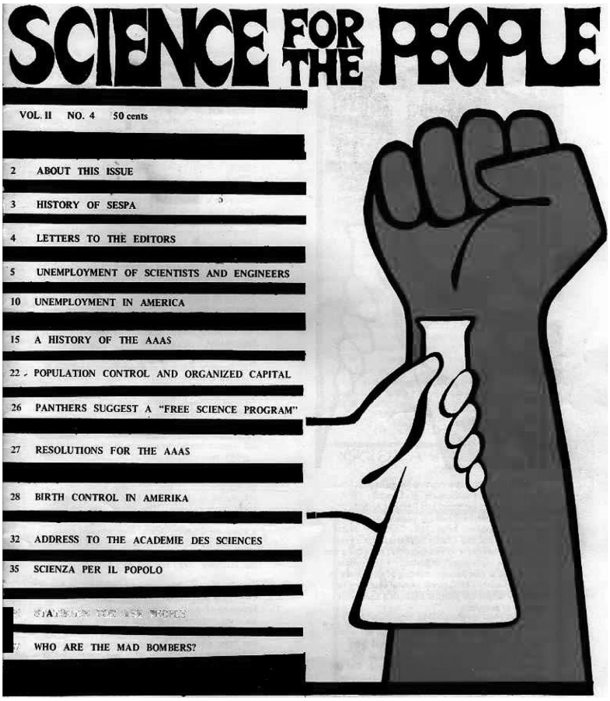

Fig. 1: "Science for the People" Magazine Cover, December 1970. Published by Scientists and Engineers for Social and Political Action (SESPA). Artwork by Elizabeth Fox-Wolfe. Reproduced with thanks to Herb Fox and the Artwork Working Group of Science for the People.

The American-born Robert Young, co-founder of the *Radical Science Journal*, emerged as a Bernal-like figure of the 1970s.[49] He abandoned a prestigious career in the history of science at Cambridge, becoming a full-time science activist and later entirely changing fields to retrain as a psychotherapist. Les Levidow, after receiving a US Master's degree in Biology, became part of the British collective in the mid-1970s, and the founding editor of the journal *Science as Culture* in 1987. The participants in this movement were quite different from 1930s red scientists, in that they spurned eminent science positions and mainstream recognition, instead supporting social movements against nuclear power, the rise of genetics, corporate agriculture and new sociobiological racisms, while articulating feminist approaches to reproductive rights and anti-imperialist critiques of population control, in the two decades following the 1968 student uprisings. They pushed for curriculum reform and democratic participation in science. They raised more feminist concerns than the 1930s red scientists did, and engaged with manifestos of groups like the Black Panthers, attempting to call attention to structural racism in science and technology. They were more engaged with grassroots struggles, much more likely to reject the mantle of vanguardist expert, and less convinced that science was inherently a model for progressive practice. Werskey recalls that "In some respects, the 'events' of 1968 more closely resemble the revolutions of 1848 than the Popular Front politics of the 1930s."[50] These activist-scientists were more influenced by the Frankfurt School's critique of science than by red scientism, closer to Gramsci than to Mach, and took their lead from counter-cultures rather than from nation-states. These popular movements would run aground on the neo-liberal defunding of public education, but they laid the foundations for future critiques of populist authoritarianism in a different era.[51]

By the 1970s there were vigorous science-oriented movements in the postcolonial world. Yet there were few interactions between western and non-western science movements in this period. In India, for example, the Peoples' Science Movement (PSM), officially inaugurated in 1978, included among its subcontinent-wide chapters a movement dating back to the 1960s whose slogan was "science for social revolution," explicitly connected to the election of a Marxist state

49 Werskey, "The Marxist Critique of Capitalist Science," 433.
50 Werskey, "The Marxist Critique of Capitalist," 429.
51 In 2014, Science for the People (SftP) in the US was re-launched, in response to the rise of anti-science and right-wing nationalist movements in the 2010s.

government in Kerala.[52] The Indian PSMs rejected hierarchies between indigenous and expert knowledge, and mobilised education, health and other campaigns to address the problems of development that confronted a young postcolonial nation. Movements across the former colonial world were raising issues of land, food, resources and survival, but these were separated from Anglo-American 'science and society' studies by invisible assumptions about identity and knowledge formations. Western studies of science were considered to be complex second-order engagements with theory, history, and knowledge-production, while developing world studies were considered to be first-order questions of poverty, survival or tribal identity.[53]

When there was a recognition of the existence of Third World Science movements, there was rarely western acknowledgement of their role as theorising or originating a new conversation about Marxist science, or as bringing the challenge of decolonisation to the fore for the first time, despite assertions of anti-imperialist sentiments since Marx and Engels's original writing. Science was still taken for granted, in all the Euro-American twentieth century movements, as a western form of thought. Even progressive scholars contested mainly its diffusion and application in the peripheries, rather than its very origin story. The his-

52 The KSSP (Kerala Shastra Sahitya Parishad), founded in 1957 or 1962 according to different reports. See Shiju Sam Varughese, *Contested Knowledge: Science, Media, and Democracy in Kerala* (New Delhi: Oxford University Press, 2017) and Anwar Jaffry, Mahesh Rangarajan, B. Ekbal and K. P. Kannan "Towards a People's Science Movement", *Economic and Political Weekly* 18, no. 11 (Mar. 12, 1983), 372–376. See also Roopali Phadke, "Reclaiming the Technological Imagination: Water, Power, and Place in India," in *Knowing Nature: Conversations at the Intersection of Political Ecology and Science Studies*, eds. Mara Goldman, Paul Nadasdy, and Matt Turner (Chicago: University of Chicago Press, 2011), 244–263.

53 While the historiography of science was largely a Eurocentric diffusion story in the 1970s, the growth of development studies and political ecology produced a vigorous scholarly/activist discourse on nature and culture, albeit in fields that rarely intersected with history of science. See, e.g. Susan George, *How the Other Half Dies: The Real Reasons for World Hunger* (New York: Dover, 1991); Michael Goldman, *Imperial Nature: The World Bank and Struggles for Social Justice in the Age of Globalization.* (New Haven, Conn: Yale University Press, 2006); Judith A. Carney and Richard N. Rosomoff, *In the Shadow of Slavery: Africa's Botanical Legacy in the Atlantic World* (Berkeley, Calif: University of California Press, 2011). The histories of science, technology, and the philosophy of dialectical materialism in China and the Soviet Union are also extensive, and specific to their shifting political contexts. See Lu Gao, "From Dialectics of Nature to STS: The Historical Evolution of Science Studies in China," in *Science Studies during the Cold War and Beyond*, ed. E. Aronova and S. Turchetti (New York: Palgrave Macmillan, 2016), 267–88; Loren R. Graham, *Science, Philosophy, and Human Behavior in the Soviet Union* (New York: Columbia University Press, 1987).

toriography of global science in the 1970s remained largely a story of western knowledge diffusion.

Both the 1930s and the 1970s saw a surge in interest among scientists to take up the questions Marx and Engels had begun to pose about science and technology, and the creation of activist-academic experiments in turning science to the cause of liberation. Both efforts lasted a decade or so before being pushed to the margins by new geopolitical forces: Cold War anti-communism marginalised red scientists in the 1950s, and neo-liberalism in the 1980s undermined the power of most post-1968 science-activism experiments.

Why Revisit the Science Problem in Marxism?

Biologists Richard Lewontin and Richard Levins argue: "The history of our science must include also its philosophical orientation, which is usually only implicit in the practice of scientists and wears the disguise of common sense of scientific method."[54] These biologists, influenced by post-1968 social movements, spent their careers devising ways to combine their everyday scientific practice with the historicist task of setting ideas in their social context as well as the critical philosophical task of studying truth alongside power. Many systematisations of Engels miss this historicising move.

Today, reading Engels's notes along with Marx's scientific notes and correspondence is both fascinating (in terms of offering accounts of contemporary discoveries) and frustrating (in terms of the absence of a complete, convincing philosophical argument).[55] On the other hand, we read other kinds of fragments: Gramsci's Prison notebooks or Michel Foucault's 1973 lectures on The Punitive

54 Richard Levins and Richard C. Lewontin, *The Dialectical Biologist* (Cambridge, Mass: Harvard University Press, 1985), 286.

55 Helena Sheehan has written a memoir in which she chronicles her attempt to unravel the mysterious forgetting of this legacy. She recalls her time in the 1970s at Trinity College Dublin, while traveling to London and later to Moscow for research: "Living as if in some parallel universe much of the time, parts of academe proceeded as if the only story in philosophy of science was the one proceeding from the Vienna Circle through Popper, Lakatos, and Kuhn … The work of Engels, Bukharin, Hessen, Bernal, Haldane, Langevin, Hörz, and many others was never mentioned. I found adjusting to the philosophy department of Trinity strange every time I returned from Moscow or Berlin or Dubrovnik or even London." (Helena Sheehan, "Marxism and Science Studies: A Sweep through the Decades," *International Studies in the Philosophy of Science* 21, no. 2 (July 2007): 197–210. https://doi.org/10.1080/02698590701498126, p 202) accessed April 21, 2020. See also Helena Sheehan, *Navigating the Zeitgeist: a Story of the Cold War, the New Left, Irish Republicanism, and International Communism* (New York: Monthly Review Press, 2019).

Society are examples of notes that were never fully revised into a manuscript by the author.[56] As MEGA IV is prepared for publication and this neglected archive reaches a wider global readership, is it possible to return to Marx and Engels's scientific fragments with a new open-mindedness, and to re-purpose these fragments into a new interdisciplinarity?

In his 1940 Preface to Engels's *Dialectics of Nature,* J. B. S. Haldane noted that its content "refers to the science of sixty years ago. Hence it is often hard to follow if one does not know the history of the scientific practice and theory of that time."[57] This descriptive statement holds a clue to the seeming unreadability of *Dialectics of Nature*. I have suggested that Saito's and other archival findings in MEGA (IV) help us put *The Dialectics of Nature* in its proper scientific context. But apart from the unfinished nature of the textual fragments in both Marx's notebooks and Engels's *Dialectics of Nature,* there is a disciplinary problem that poses challenges for our next steps in this urgent yet recondite debate. Marx and Engels's scientific notes seem unreadable because their requisite reader has not existed for most of the hundred and fifty years since their creation. In order to critically read and engage with these notes on science, method and history, readers would need simultaneously to draw on scientific training, methodologies from the historiography of science and a Marxist political perspective. In addition, they should have some experience in the overlapping zones of scientific research and anti-capitalist activism – this would allow the integration of non-western experiences of colonialism in the same frame as Euro-American accounts of knowledge production. But today, even Marxist studies follow scholarly models of disciplinarity that package Marx and Engels's economic theories and humanist philosophies cleanly separated from the nineteenth-century historiographies of science and rationality in whose context they had originally emerged.

Thus far, the most common systematisations of Engels's project formulate 'rules' for carrying out dialectical materialist science. So, for instance, we are encouraged to understand nature in terms of transformations from quantity to quality (illustrated by a famous passage describing the boiling of water), or to

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56 Gramsci's thirty unsystematic notebooks, smuggled out of prison in the 1930s, were edited and published more than a decade after his death. Foucault's 1973 *Punitive Society* lectures were recorded and then erased, because the tapes were re-used for a subsequent lecture. The transcript later retrieved and used for publication was an early version, done privately for Foucault's own use and heavily annotated by him, and were the only extant copy after his death.
57 J. B. S. Haldane, "Preface," in Frederick Engels, *The Dialectics of Nature*, ed. and transl. Clemens Dutt, with a preface and notes by J.B.S. Haldane (New York: International Publishers, 1940), ix.

see the centrifugal and centripetal forces in planetary motion in terms of inherent contradiction. As Marxist scientists have found, however, there is no rule-based method that one can systematise from *The Dialectics of Nature* that makes sense to use in everyday scientific practice. For example, the law of transformation of quantity into quality does not help us to discover the temperature at which water boils. While it is true that Marx and Engels's notes on science do contain many passages advocating a rule-based understanding of dialectical scientific method, these are not the most usable insights in this corpus.

Activist scientists, again, are our best guide to this issue. In a chapter on dialectics, Lewontin and Levins, reflecting on a lifetime of doing science and politics dialectically, reject "the illusion that dialectics are rules derived simply from nature."[58] They study nature through its historicity, heterogeneity and contingency, rejecting Cartesianism's errors of reductionism, reification and alienation. They do see quantity, quality, contradiction and motion in the terms that Marx and Engels explicated, but they do not use these ideas as a priori laws: "Formalizations of the dialectic have a way of seeming rigid and dogmatic in a way that contradicts the fluidity and historicity of the Marxist world view. This is especially the case when it is set out as 'laws', by analogy with the laws of natural science."[59] They historicise *The Dialectics of Nature*: "Engels's understanding of the physical world was, of course, a nineteenth-century understanding, and much of what he wrote about it seems quaint."[60] Stephen Jay Gould, who did not identify himself as a Marxist (but did acknowledge Marxist influence from his father) sees Engels's laws of dialectics as "guidelines for a philosophy of change" rather than "dogmatic precepts true by fiat."[61]

Levins lists the dialectical scientific worldview: "(1) the truth lies in the whole; (2) parts are conditioned and even created by their wholes; (3) things are richly connected; (4) each level is relatively autonomous but is also linked to other levels; (5) things are the way they are because they got that way; (6) things are snapshots of processes; (7) the dichotomies into which we split

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58 Levins and Lewontin, *The Dialectical Biologist*, 268.
59 Levins and Lewontin, *The Dialectical Biologist*, 267.
60 Levins and Lewontin, *The Dialectical Biologist*, 279.
61 Stephen Jay Gould, *An Urchin in the Storm: Essays about Books and Ideas* (New York: Norton, 1988), 154, as cited in Poe Yu-ze Wan, "Dialectics, Complexity, and the Systemic Approach: Toward a Critical Reconciliation," *Philosophy of the Social Sciences* 43, no. 4 (2013), 411–452, 438. See also Stefano B. Longo, "Book Review: The Science and Humanism of Stephen Jay Gould," *Human Ecology Review* 18, no. 1 (2011): 88–89.

the world are ultimately misleading."[62] Ernst Mayr, "a great non-Marxist biologist," claimed to share "at least six beliefs with dialectical materialists."[63] Paul Feyerabend sums up the problem for scientists with the simple borrowing of a historicist explication of dialectical materialist laws:

> It is not easy to judge the concrete work of a scientist according to the standards of dialectical materialism. The reason is that the philosophy of dialectical materialism has until now failed to develop a methodology that might guide scientists in their research. Of course, one frequently hears that good scientists have proceeded in accordance with dialectical principles, but just what these principles are and how a person who has not yet achieved greatness is supposed to proceed - this is left undetermined.[64]

There is a great deal of literature critiquing the transposition of natural laws into the humanities, and the resulting scientistic wrong turns in humanist and social scientific theorising. But we have not explored the significance of scientific practice for historiography, nor forged a nuanced Marxist historiography for the study of the social relations of science and technology.[65]

Scientists, philosophers of science and cultural historians commonly make post-hoc judgements of good or bad science, real or pseudoscience. But the historiography of science teaches us that such judgements are more complicated if one attempts to define scientific truth in its own historical context rather than by the consensus that emerges a century later. This is not to let 'bad science' off the hook. Rather, it is to insist that we more deeply historicise science, asking more questions about the social effects of truth-making practices, for example, than transhistorical ethical questions about 'pseudo' or 'real' science. Without a method by which to understand scientific practice within its political contexts, we have no way of seeing science and technology – as historically-specific practices, not as a set of axioms assumed to be transhistorically true – as part and parcel of human practices in social, cultural and political spheres. Contemporaneous arguments about the political implications of scientific experiments in their own

62 As cited in Wan, *Dialectics, Complexity, and the Systemic Approach,* 427–428.

63 Wan, *Dialectics, Complexity, and the Systemic Approach,* 428.

64 Paul K. Feyerabend, "Dialectical Materialism and the Quantum Theory," *Slavic Review* 25, no. 3 (1966): 414–417, 415.

65 The western humanist critical tradition stemming from Lukacs is summarised in Sheehan, *Marxism and the Philosophy of Science*. The other humanist tradition, stemming from the Frankfurt School, and its relationship with mathematics has recently received an original treatment in Matthew Handelman, *The Mathematical Imagination: On the Origins and Promise of Critical Theory* (New York: Fordham University Press, 2019). See also Andrew Feenberg, *Critical Theory of Technology* (New York: Oxford University Press, 1991).

time can offer valuable lessons in interdisciplinary analysis. This is what Marx and Engels's notes on science, however fragmentary, offer us. The fragments illustrate how we might build such a conversation today, bringing the everyday findings and practices of science out of their ivory tower and into the public sphere for discussion and debate.

To begin with, these fragments and notes might be read more robustly along with Marx and Engels's extensive work on labour, technology and the making of the family and the working class. Secondly, the claims relating to 'human nature' and to ecologies must be historicised: it is pointless to ask whether Marx and Engels were ecologists or interdisciplinarians in a twentieth century academic sense; we must understand them as living contemporaneously with nineteenth-century advances in physics and chemistry, rather than criticise them for not adhering to the norms of Cold War philosophers of science. Third, we might take up anew the insight of science and technology's global and cultural embeddedness (a central insight of non-Marxist twentieth century science and technology studies) while returning to Marx and Engels's insights that science and technology are neither transhistorical abstractions floating above political practice nor brute instrumentalisms undergirding the protean complexity of human politics.

When Marx and Engels's writing on science is read as a rule-book for scientists across historical periods, it fails to inspire either scientists or political philosophers. When, on the other hand, it is read as part of a historical, philosophical and activist project that historicises modes of rationality in relation to systems of production and labour relations, it illuminates interdisciplinary insights that modern disciplinary structures have obscured. It is the latter reading that constitutes an under-theorised yet newly relevant part of the Marxist legacy today.

Marx and Engels leave us with a model of scientific knowledge production that is inseparable from global analyses of capitalism. New archival explorations have begun to investigate these approaches. New social movements against the technological accelerations of capital have, several times in the last century and a half, attempted to articulate what a 'science for the people' might look like. Despite the many wrong turns and obfuscations, the science question in Marxism must be revisited, yet again, as there is no field that exemplifies the production of power and inequality more vividly than technoscience in the twenty-first century.