Postdigital Science and Education

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Bioinformational Philosophy and Postdigital Knowledge Ecologies

Springer

Postdigital Science and Education

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Series Editor's Preface

We dedicated *Bioinformational Philosophy and Postdigital Knowledge Ecologies* to the eternal question of human race – the interplay between biology, information, and society. In our postdigital age, and coupled with the Covid-19 pandemic, recent reconfigurations of these relationships strongly shape some of the most prominent issues of today: environmental crisis, the changing nature of work, teaching, learning… (Jandrić 2021). We focused our call to philosophy and theory of postdigital knowledge ecologies (Peters et al. 2021a), emerging configurations and practices (Peters et al. 2021b), and teaching and learning (Peters et al. 2021c). On top of exploring the book's main themes, we conducted a little experiment in academic editing (Peters et al. 2021d) – and this is where the book exemplifies today's reconfigurations of academic work.

In our age of postdigital communications and dialogues (Jandrić et al. 2019), it is an obvious choice to develop new and different knowledge ecologies. It is even more apparent that these new postdigital knowledge ecologies will be more collective than those from our analog past (Peters et al. 2021e). I will not discuss what our experiment was about and how it ended – you can read all about it in our Introduction and Postscript. For my current argument, it suffices to say that its preparation consisted of initially publishing four papers. Writing proposal forms, blurbs, abstracts, and contracts followed. Then reviewing, copy-editing, and proofing. All of this involved sending and receiving thousands of emails. However simple, our experiment required a lot of invested time, creativity, and effort. I am not complaining, because I enjoyed the process like a pig in mud. But I do want to bring this often-invisible work out in the open and briefly discuss some of its implications.

Plumbers always have dripping taps. The shoemaker always wears the worst shoes, or in a bit more old-fashioned language, the cobbler's children always go unshod. This phrase, versions of which appear in nearly all cultures and languages, has even acquired its own syndrome. The Cobbler's Children Syndrome 'manifests as tech companies that slack on their own tech, marketing and branding agencies that neglect their own marketing, and magazine editors who no longer write' (Bedford 2020). I am not sure whether the Cobbler's Children Syndrome is even a 'proper' concept, as I was unable to locate it on Wikipedia, Britannica, and other sanctuaries of low and high theory. But the Internet bursts with testimonies of people and companies who have fallen as its victims, and I find the last part of the definition, about editors who no longer write, particularly pertinent for my own context.

As my generation of academics approaches an age when we become editors, deans, principal investigators, and other wheels in production and dissemination of knowledge, I can see a clear path of decline in the quantity of our academic output. Instead of papers, we write project bids and reviews. Instead of books, we write reports. On rare occasions when we reconvene over a pint or a glass of wine, no one has ever said that they like writing these mundane texts. Yet most of us agree that there is nothing more rewarding than seeing an academic experiment arrive into being. And then, a smaller but still significant part of us agrees that it is highly rewarding to write up and publish our insights, especially if they manage to achieve some impact to scholarship.

Yet these days, we all fall victim to the Cobbler's Children Syndrome. We spend less and less time working on things that attracted us into academia, such as scholarship, and we spend more and more time working on things we don't like, such as doing all other necessary things that sit around scholarship. As academic work becomes increasingly work-intensive and poor on benefits (precarious, low paid, etc.), many of us question whether it is really worth the effort.

After years of thinking, I think that the answer is: yes, it is. There are only 24 hours in a day, and writing more reports inevitably results in writing less books and papers. But our projects and administrative duties do not just make us better writers of reports; they also teach us important lessons and connect us to wonderful people. We should mercilessly fight against commodification and neoliberalization of the academia, and the Cobbler's Children Syndrome is an important reminder that we should never give up our research and writing. Yet it would be epistemically wrong to enclose ourselves in an ivory tower, even if we somehow managed to find one. We need to make our hands dirty. It is only by experiencing and critically analysing real-life circumstances, in a never-ending cycle of collective critical praxis (Jandrić et al. 2017), that we can imagine better futures and develop practical steps towards achieving them.

Today's academia gives us some very sour lemons. Without white rum, sugar, soda water, mint, and a fridge, we cannot turn these lemons into stone-cold mojitos. But we can advertise, 'look, I've got some lemons', and then make a party (Jandrić 2017: xi). Some of our guests may bring other ingredients, others may suggest new recipes, and many will just hang around and tell a good joke. We still may not end up drinking stone-cold mojitos, but perhaps we'll come up at least with lukewarm lemonade.

As co-editor of *Bioinformational Philosophy and Postdigital Knowledge Ecologies*, I present our little experiment in academic publishing. As editor of the Postdigital Science and Education book series, I invite all prospective authors and editors to use it as a platform for experimentation. We probably won't drink stone-cold mojitos, but we can still have a great party!

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Foreword: Thinking with the Biodigital

To be in conversation with and to engage with ideas, through the publishing processes of academia, is one of its pleasures. As the authors point out, this is also a form of labour, and the collection makes visible the work of research, teaching, writing, editing, and publishing. This attention to work is an operative lens through this book, and it calls our attention, as readers, to the co-labouring work of collaboration. It also calls for the making of community through scholarship, and this invocation of writing and publishing as practices of intellectual kinship-making has very strong appeal for me. It resonates with my own projects in queer intellectual kinship-making (Dahl and Gabb 2020; O'Riordan and Reed 2021), and my own experiments with collective and collaborative, many handed writing (Basset et al. 2019).

It is a pleasure then to read this collection, engage with it, reflect on it, and write into it. The book is generous and incredibly ambitious, assembling a breadth of literatures and positions, provocations, reflections, analyses, and arguments. The concept, approach, and object of study are articulated as postdigital-biodigital convergence. This is a spectrum of lively folds and compounds, where post- and bio-digital are hinged, folded into each other, already compounded, and converge again. These linguistic compounds and others throughout the book operate as forms of composition, mixing and remixing, and this plays through the text in relation to technologies and their cultures and politics.

The authors and editors attend to different cultures, politics, positions, and objects, and the collection is polyphonic and creatively contradictory. It contests and evaluates its own framework as it builds it. However, across this breadth are a number of strong and deeply connecting scaffolds, including a close attention to the conditions of academic labour, research, education, and publishing. The collection thus enacts its own form of experimental writing about conditions which have implications for knowledge making, across the range of sites explored. The book, taken as a whole, builds a theoretical platform comprising a philosophy of the biodigital. This is a generative structure that supports an examination of an underpinning bioeconomy, which could be understood as one based on the circulation and extraction of biodata. As such, interoperable flows of bioinformation, enabled through infrastructures and shared substrates, animate the imaginaries of this bioeconomy.

I have written elsewhere about the biodigital as a generative frame for thinking about genomics, where genomes are biodigital artefacts, *bios* recontextualized as data (O'Riordan 2010). The production and circulation of genomic data, and global flows of genomic sequence data, lend themselves to thinking about an extractive bioeconomy. In this collection and more broadly, the bioeconomy is one in which an underpinning fossil fuel economy declines, and a more circular and transformative bioeconomy underpins global futures. This is dependent on interoperable flows across biological and digital forms, new forms of extraction, and the circulation of biodata. This plays out through some enabling infrastructures but is also blocked and challenged by others. While social media platforms and the convergence of health data and informatics open up flows of biodata, many interfaces block, disrupt, and prevent such flows.

An appropriate challenge for biodigital thinking is a question of whether it is too reliant on seductive rhetoric and fantasies of seamless integration, which might be materialized through attention and investment, but should rather be challenged. This opens out the other way in the proposition that challenges to biodigital thinking might have too much recourse to nostalgic and utopian models of nature and the human subject. Actor network approaches (ANT) sometimes seem to navigate these tensions, and 'Cycling in the Time of the Biodigital' (Royle 2022) is an interesting and lively provocation via ANT. Another aspect to this argument is unfolded through 'Reconceiving the Digital Network: From Selves to Cells' (Johnson et al. 2022) which makes the case that networks can be understood through cellular organization, in which connection is about boundary preservation in uncertain environments. This indicates that models of circulation in relation to differently porous boundaries might enable another route to thinking through the biodigital.

In my own work I have found this term generative and distinctive. It has been deployed in relation to registers of analysis and practices that attempt to critically engage with knowledge production around the intensification of the transactional and economic value of life itself. Other language in this register includes biovalue (Waldby and Mitchell 2006), biocapital (Sunder Rajan 2006), and Melinda Cooper's (2008) formulation of 'life as surplus'. These offer terms, registers, and languages of critical theory that are in conversation with broader framings such as biosociality, biopower, and bioeconomy. They are different attempts to get more specificity into these larger and potentially more abstract frames of reference and, thus, sharper critical tools. However, they also sometimes (re)create the same issues of potentially catch all, territorial terms that can sometimes get in the way of understanding things in the world. The postdigital-biodigital convergence of this collection connects in lively and imaginative ways to these, in challenging some of this work, offering definition and generative frameworks, and instigating new ways of thinking.

I have orientated towards the biodigital as a way of thinking because it seemed to me to help put mediation at the centre. When I think about how the world has perhaps changed, I think inevitably about the pandemic, and about scale, intensification of mediation, and centrality of ecology. For me, and rather inevitably as media scholar, mediation is central. Thinking with the biodigital seems to orientate towards the reciprocal dynamics of media infrastructures which mix up and move forms of life in and with information and media technologies. It signals both the mediation of life through infrastructures of meaning making and communication, and the exchange of biological materials and information. It facilitates thinking about how forms of living, beyond material exchange of tissues or organs, are involved in the labour of biopolitics – for example – forms of attention and sensory perception, attachments and feelings, and writing, viewing, or engagement capacities.

The collection before the reader mediates, celebrates, and interrogates different ways of thinking with the biodigital. Sometimes it diagnoses the political economy in terms of data flows and animates this through an analysis of hopeful or dystopian futures. Some authors challenge this analysis almost entirely. In 'Maps of Medical Reason: Applying Knowledge Graphs and Artificial Intelligence in Medical Education and Practice' (Cope et al. 2022) the authors argue that the digital and the biological are so entirely and irreducibly different as to make such flows impossible, and in 'Competing Pedagogies for the Biodigital Imaginary: What Will Happen to Teachers?' Sinclair (2022) argues that dialogue is irreducible, indicating that pedagogy and the biodigital are incompatible. This very strong analysis that the biodigital is always reductive in some contexts is countered through hopeful and recuperative analyses in other parts of the collection.

For example, '*Technē* and Indigenous Exosomatic Memory: Heidegger, Stiegler, and Cutting the Gordian Knot of Modernity' (Irwin and White 2022) offers an analysis of ecological *technê* as offering a challenge to anthropocenic entropy. The overall framing by the editors, which directs the building of this platform, is also much more recuperative, and 'Biodigital Philosophy, Technological Convergence, and Postdigital Knowledge Ecologies' (Peters et al. 2022) builds up the biodigital as enabling a promising convergence of critical theory and cultural studies in dialogue with information and genomics. This same chapter centres and recuperates the critical language of technoscience, framing biodigitalism as a generative platform for putting the posthumanities, and twenty-first-century technoculture, in relation. Thus, the bioeconomy is imagined as generative, flowing into future ecologies of critical praxis, and also dystopian, enabling extraction, exploitation, and evisceration. At the same time, it is challenged as impossible, hyperbole, technological fix, and seductive spectacle, a diversion from the real.

A foreword is the product of writing words that appear before the main body of the text but are written after the production of that text. Chronologically late and formally early, it is a reflexive and contradictory writing space through which to consider thinking with and enacting forms of biodigitality: digits, digital, *bios*, and *technê*. It is also a privileged and generative position. Reading and writing of all kinds, across multiple media texts, appeal to me because of its promise to enable access to many different ways of thinking. Reading, like listening (and watching), is an active engagement. It seems to me that thinking cannot be known except though communicative media forms including writing and speaking. Thinking itself, when it can be known, is relational and communal, generated through communicative acts and practices. Academia is a powerful space of knowledge production, where thinking is a practice. Although its communicative forms are published writing, most of the work occurs in acts of reading, research, experimentation, making, discussion, seminars, and classes. This collection resonates with that power in its ambition and reach, it is generous and lively, making its own conditions of production explicit and calling out some of its hierarchies, as well as inevitably affirming them.

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Introduction: Bioinformational Philosophy and Postdigital Knowledge Ecologies

The Background to This Book

In late 2020 we launched the Call for Chapters for *Bioinformational Philosophy and Postdigital Knowledge Ecologies*. The title contains something of a platform for reflection on the nature of the form of the edited collection, especially in the area of 'bioinformational philosophy', where we want to argue that there are interesting technological convergences among the disciplines that bring to life a new configuration of the postdigital and the biodigital (Peters et al. 2021a). We try to present this theme in relation to the concept of 'knowledge ecologies' that suggests the disciplinary boundaries are no longer firm or distinct but rather fluid, converging and driven by new biodigital technologies that can change the structure, substance, and research methodologies of the fields in question. This is the Call for Chapters that we sent to our potential contributors:

> According to Freeman Dyson (2007), 'the twentieth century was the century of physics and the twenty-first century will be the century of biology'. In our pandemic age, even those who succumbed to the capitalist fallacy of 'bigger, faster, better' computers, transportation, and economy, will now agree that the twentieth century focus to machinery needs to be succeeded by a focus towards better understanding of living systems and their interactions with technology at all scales – from viruses, through human beings, to the Earth's ecosystem. This change of direction cannot be made by simple relocation of focus and/or funding from one discipline to another. In our age of the Anthropocene, (human and planetary) biology cannot be thought of without technology. Today's curious bioinformational mix of 'blurred and messy relationships between physics and biology, old and new media, humanism and posthumanism, knowledge capitalism and bio-informational capitalism' (Jandrić et al. 2018: 896) defines the postdigital condition and creates new knowledge ecologies.
>
> Postdigital knowledge ecologies are mutually constitutive with bioinformational capitalism. Coming 'after mercantile, industrial, and knowledge capitalisms' (Peters 2012: 105), bioinformational capitalism is 'based on a self-organizing and self-replicating code that harnesses both the results of the information and new biology revolutions and brings them together in a powerful alliance' (Peters 2012: 105). In the general public, bioinformational capitalism develops new media ecologies burdened by posttruth, fake news, infodemics, etc. In scholarly research, new knowledge ecologies are built upon emerging forms of scientific communication, big data deluge, opacity of algorithmic operations, etc. Many of

> these developments can be approached using the concept of viral modernity, which 'applies to viral technologies, codes and ecosystems in information, publishing, education and emerging knowledge (journal) systems' (Peters et al. 2020a, b, c; Peters and Besley 2020). Based on theories of bioinformationalism (Peters 2012), viral modernity (Peters and Besley 2020), the postdigital condition (Jandrić et al. 2018; Jandrić 2020), and others, this book asks: Which new knowledge ecologies are now emerging; which philosophies and research approaches do they require?

In accordance with this description of themes, we have highlighted the question of philosophy as a social theory of bioinformation, an account of bioinformational science, and in the vein of biopolitics and bioinformational capitalism that involves a philosophy of biodigital becoming and ties in with aspects of social and environmental epistemology. From the perspective of viral modernity (Peters et al. 2020b; Peters et al. 2020c), this asks the role and function of big data/viral data/artificial intelligence as well as the social epidemiology and viral systems of postdigital theory that focuses on the role of post-truth (lies, bullshit, fake news, etc.) and infodemic/conspiracy theories and the educational importance of being able to distinguish between disinformation and knowledge in a way that supports an infrastructure of openness, open knowledge, and knowledge socialism.

Peters, Jandrić, and Hayes have published four related papers which set the ground for *Bioinformation Philosophy and Postdigital Knowledge Ecologies*. The first paper, 'Biodigital Philosophy, Technological Convergence, and Postdigital Knowledge Ecologies', explores 'a philosophy of biodigitalism as a new paradigm closely linked to bioinformationalism' which involves 'the mutual interaction and integration of information and biology, which leads us into discussion of biodigital convergence'. This creates new knowledge ecologies and reconfigures theory and practice all the way to the notion of critical reason itself. 'This heralds a new biopolitics which brings the philosophy of race, class, gender, and intelligence, into a compelling dialog with genomics and information' (Peters et al. 2021a).

The second paper, 'Biodigital Technologies and the Bioeconomy: The Global New Green Deal?', explores the emergence of bioeconomy including policy documents by various countries and organizations such as the Organisation for Economic Co-operation and Development (OECD). It historicizes biodigital convergence and reminds us that it 'is not a completely new paradigm; it is merely the latest (and by now the widest) techno-social convergence, based on earlier convergences (such as digital-analog), which are built into its very core'. The paper projects a lot of faith into initiatives such as the Global New Green Deal, yet it warns that 'in our age of bioinformational capitalism (Peters 2012), all these changes and initiatives will be worthless without a solid material base' and calls for development of 'new understandings of bioeconomy fit for our biodigital moment in history' (Peters et al. 2021b).

The third paper, 'Postdigital-Biodigital: An Emerging Configuration', clears up some conceptual mess caused by the rapid emergence of concepts such as biodigital philosophy, postdigital knowledge ecologies, bioeconomy, viral modernity, and others. Focusing to an emerging configuration of postdigital-biodigital, it reaches deeply into various postdigital convergencies. 'The paper also reviews these developments within the familiar landscapes of posthumanism and postmodernism, raises the question of political bioeconomy and the role of postdigital education within it.' This trialogue paper, which gives each author a distinct voice, walks its talk by seeking 'a common ground between its authors' positions' while also exposing 'various cracks and tensions' (Peters et al. 2021c).

The fourth paper which set the ground for this book is 'Revisiting the Concept of the Edited Collection: *Bioinformational Philosophy and Postdigital Knowledge Ecologies*' (Peters et al. 2021d). In this paper, we introduced our ideas about the importance and value of edited collections and explored its reconfigurations in the age of the postdigital-biodigital convergence. This paper has also served as an addition to our Call for Chapters, aimed at providing additional resources, research directions, and hopefully a greater research coherence.

Based on these four papers, we asked the authors in this book to respond to the question: *Which new knowledge ecologies are now emerging; which philosophies and research approaches do they require?*

What's in the Book?

Part I: Bioinformational Philosophy and Theory

The first part of the book, 'Bioinformational Philosophy and Theory', starts with our chapter 'Biodigital Philosophy, Technological Convergence, and Postdigital Knowledge Ecologies' (Peters et al. 2021a). The next chapter is John Reader's 'Biodigital Becoming', which argues that most responses to rapid developments in the field of biotechnology so far 'depend upon traditional understanding of human reason and autonomy which assume that sound judgement and appropriate regulation and governance can prevent any potential harmful impacts of these'. According to Reader, this is clearly not the case 'so new and expanded interpretations of both are now required'. In the next chapter, 'Reconceiving the Digital Network: From Selves to Cells', Mark Johnson, Elizabeth Maitland, John Torday, and Sebastian Fiedler trace the historical development of modern conceptions of 'network' and question 'some of the assumptions made about networked digital phenomena and their relation to biological and phenomenological processes'. In contrast to the topological node-arc model of networks, they argue that 'networks arise from evolutionary biological processes which are fundamentally oriented around boundary preservation rather than "connection"'.

Joff P. N. Bradley's chapter, 'On the Collective Algorithmic Unconscious', uses the works of philosophers Bernard Stiegler, Pierre Lévy, and others, to explore 'whether we are becoming more autonomous or further enslaved by collective intelligence'. While the question remains unanswered, Bradley concludes that 'it is right to question the prospects of educational emancipation and subjection in the light of the pharmakon of new knowledge ecologies and hegemonies'. The final chapter for this section, Ruth Irwin's and Te Haumoana White's '*Technē* and Indigenous

Exosomatic Memory: Heidegger, Stiegler, and Cutting the Gordian Knot of Modernity', explores 'the intersectionality of all elements of the ecological milieu'. 'Accepting the indigenous orientation of exosomatic memory', their theory 'enables modernity to avoid the perils of technological enframing and its ensuing alienation of culture from nature'.

Part II: Emerging Configurations and Practices

The second part of the book, 'Emerging Configurations and Practices', starts with our chapter 'Biodigital Technologies and the Bioeconomy: The Global New Green Deal?' (Peters et al. 2021b). The next chapter, Catherine Price's 'Agriculture 4.0: Bioinformationalism and Postdigital Hybrid Assemblages', explores two interconnected questions: (1) '[H]ow can we understand new agricultural technologies from a postdigital hybrid assemblage perspective?' (2) '[C]an the concept of postdigital hybrid assemblages help us understand the impact of the biodigital in the agricultural sector'? Next, 'Maps of Medical Reason: Applying Knowledge Graphs and Artificial Intelligence in Medical Education and Practice', by Bill Cope, Mary Kalantzis, ChengXiang Zhai, Andrea Krussel, Duane Searsmith, Duncan Ferguson, Richard Tapping, and Yerko Berrocal, explores the connections between the material and the immaterial reflected in medical knowledge. It discusses two recent research and development projects and argues that 'purely algorithmic AI needs to be supplemented by human reasoning in the form of semantically-grounded data models'.

In 'Cycling in the Time of the Biodigital: Small Acts Towards a Conscious Uncoupling from Non-regenerative Digitised Economies', Karl Royle explores data creation and use within the context of a cycling group using Actor Network Theory. Based on this work, 'the chapter calls for change and an adopting, not of political class consciousness but of data consciousness, rights, and ownership'. The final chapter for this section, David Neilson and Nat Enright's 'From Dead Information to a Living Knowledge Ecology', focuses on the shift in the form of Marx's 'class struggle between "living labour" and capital's project to transform it into "dead labour"' to 'capital's project to transform "living knowledge" into "dead information"'. On that basis, they develop Peters' concept of knowledge socialism (Peters et al. 2020a) 'as the project to design, construct and manage a democratic socialist framework of global-local regulation, institutions of cosmopolitan solidarity, and a global virtual civil society'.

Part III: Teaching and Learning in Postdigital Knowledge Ecologies

The third part of the book, 'Teaching and Learning in Postdigital Knowledge Ecologies', starts with our chapter 'Postdigital-Biodigital: An Emerging Configuration' (Peters et al. 2021c). The following chapter, Steve Gennaro and Douglas Kellner's 'Digital Culture, Media, and the Challenges of Contemporary Cyborg Youth', revisits Donna Haraway's philosophical concept of the cyborg and applies it to contemporary youth's relationships to technology, pointing towards development of an 'an entangled embodiment of technologies, capitalism and selves which constitutes a hybrid of *poiesis* and *technē*'. The next chapter, 'Spreading Stupidity: Disability and Anti-imperialist Resistance to Bioinformational Capitalism' by Megha Summer Pappachen and Derek R. Ford, offers a novel form of resistance to bioinformational capitalism within the notion of stupid knowledge. 'Stupidity is able to resist primarily because it can't be quantified, articulated, or rendered transparent.'

Taylor Webb and Petra Mikulan's 'Decolonizing Racial Bioinformatics: Governing Education in Contagion and Dehiscence' proposes 'a speculative reading of bioinformatics as a particular moment of "excess contagion"'. In this reading, bioinformatics has the potentials to exceed enclosures, and an accelerated use of 'contagious bioinformatics' could be 'a way to proliferate unknown becomings for new kinds of intra-connectivity'. In the next chapter, 'Competing Pedagogies for the Biodigital Imaginary: What Will Happen to Teachers?', Christine Sinclair asks the crucial question of the role of the teacher within the biodigital imaginary. 'The chapter concludes with an argument for the necessary retention of teachers in our biodigital future, to navigate the tensions, contradictions and losses exposed in the analysis and to ensure that multiple pedagogies survive.' The last chapter in the book, Pete Bennett and Michael Jopling's 'The Global Pandemic Did Not Take Place: Cancellation, Denial and The Normal New', examines 'the existential and epistemological threats, and opportunities for change, created by the pandemic'. They conclude that our understanding of the pandemic is far from deep and that we need to resist the myths and pretences used to disguise it.

Postscript: Revisiting the Concept of the Edited Collection

In the Postscript the editors reflect on our experiment with the genre of the edited collection conducted during production of this book. The Postscript reproduces a large part of our paper 'Revisiting the Concept of the Edited Collection: *Bioinformational Philosophy and Postdigital Knowledge Ecologies*' (Peters et al. 2021d), followed by a brief analysis. We conclude that the book's contribution to knowledge is inextricably linked to the genre employed for knowledge-making and that development of new postdigital knowledge ecologies requires active experimentation with the theory and practice of academic publishing.

Acknowledgement The background to this book section reproduces a part of our invitation paper for authors in this collection, Peters, M. A., Jandrić, P., & Hayes, S. (2021). Revisiting the Concept of the 'Edited Collection': *Bioinformation Philosophy and Postdigital Knowledge Ecologies. Postdigital Science and Education, 3*(2), 283–293. https://doi.org/10.1007/s42438-021-00216-w.

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Part I
Bioinformational Philosophy and Theory

Biodigital Philosophy, Technological Convergence, and Postdigital Knowledge Ecologies

Michael A. Peters, Petar Jandrić, and Sarah Hayes

1 A Philosophy of Biodigitalism?

Anyone living through the last year of Covid-19—its first, second, and third waves—will understand pragmatically the new significance of the relationships between the biological and the technological and, specifically, two emerging paradigms. The first paradigm, 'bioinformationalism', draws a close association between viral biology on the one hand and information science on the other to critically discuss the parallel structure of epidemics and infodemics and the nature of conspiracy in a post-truth world (Peters et al. 2020a). It also investigates the political economy and the effects of bioinformational capitalism (Peters 2012). The second paradigm, 'biodigitalism', also refers to the mutual interaction and integration of information and biology. In particular, it investigates biological futures through biodigital technologies including molecular diversity, the *de novo* synthesis of DNA constructs, the engineering of biochemical pathways, and genomic construction (the synthesis of new life). The acquisition of novel biological diversity here includes DNA synthesis, 'shuffling', and bioprospecting, as well as efficient mass screening. The focus is on understanding and manipulation of

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biological systems in computational biology, in systems biology more generally, and in genomic medicine (National Research Council 2009).

The philosophical aspect is not simply bioethics, but also biopolitics (after Foucault), 'bioepistemologies' (or evolutionary theories of epistemology), and evo-ontologies (Peters and Jandrić 2019a, b). In broad terms, it focuses on the historical flash point where forces of biology and information come together to determine the paths of cultural co-evolution through the development of eco-cybernetic systems and its form of rationality in relation to Earth system governmentality. Covid-19 revealed that despite 30 years of the experience of reorganizing social life through the Internet, over 80 years since Alan Turing's 'universal machine' and some 50 years since the first UNIX operating system portable across multiple platforms, most countries—indeed, humanity as a whole—were unprepared for adopting and adapting to a digital way of life (Peters et al. 2021).

The extent of 'being digital/digital being' surprisingly demonstrated how dependent we had become on digital technologies and yet how unprepared we were for fail-safe digital systems in terms of communication, trade, education, and security. This dynamic is inherent to the 'hard to define; messy; unpredictable; digital and analog; technological and non-technological; biological and informational' postdigital condition, which is 'both a rupture in our existing theories and their continuation' (Jandrić et al. 2018: 895). Lockdown and social distancing strategies effectively shut down the 'real' economy rendering mass populations unemployed, keeping children away from schools, students from universities, families at home, and all away from cafés, bars, and restaurants. In particular, hospitality, tourism, travel and export higher education, all collapsed suddenly with no digital fallback (see Jandrić et al. 2020, 2021a, b). Media, especially around the 2020 US election, became increasing partisan and polarized (Peters et al. 2020a). The only institution that continued to function was the share market that boosted finance capital and created decoupling effects that seemingly denied the reality of ongoing massive unemployment and its social disruption.

While there might be interesting shared conceptual overlaps between biology and informatics, there are few examples yet of their full integration (see Williamson 2019a, b). At the same time, biodigitalism emerges as a new episteme concerned with the living—with *bios*—and the intersections between genetic and digital codes that continues to furnish the 'new biology'. These intersections start with technologies for the creation of synthetic life after the discovery of DNA in the 1950s and now culminate in modern biopolitics with its conceptual tools and technologies for the management of populations. Philosophers and political theorists following Foucault and Deleuze and Guattari inquired into the general problematic of exploring the complex set of relations between the dialectic of the *bios* and the *technē*. These inquiries are based on two main disciplinary trajectories: the rise of systematic biology with Carl Linnaeus at Uppsala in the late eighteenth century, and the concept of a digital programmable computer with Charles Babbage at Cambridge in the early nineteenth century. As Pasquinelli (2011: 51–52) puts it: 'What are the consequences of a computer-based understanding of cellular reproduction for the sphere of ecology and biodiversity?'

2 The Great Convergence

These questions intimate the evolving coevolution of two overlapping systems (*bios* and *technē*) that have accelerated interactions over the last couple of decades giving new meaning to 'the coming biology revolution' where new biology approaches 'depend on greater integration within biology, and closer collaboration with physical, computational, and earth scientists, mathematicians and engineers' (National Research Council 2009). It is exactly at this point that the notion of 'technological convergence' has a strong application with the development of nanotechnology that implies a new technoscientific synthesis at the nanolevel (Bainbridge and Roco 2016; Peters 2020a, b). In *The Age of Living Machines: How Biology Will Build the Next Technology Revolution* Susan Hockfield (2019) mentions Convergence 1.0, which is the convergence between physics and engineering that drove much of the innovation of the twentieth century including new technologies that are still evolving: radios, telephones, televisions, aircrafts, radar, nuclear power, computers, and the Internet. Convergence 2.0, which is the new convergence between biology and engineering that is occurring now, includes virus-built batteries, protein-based water filters, cancer-detecting nanoparticles, mind-reading bionic limbs, and computer-engineered crops.

The new convergences 2.0 and beyond are of a different order, suggesting a megaconvergence of genomic and information science at the level of code, leading to the 'Nano-Bio-Info-Cogno Paradigm' which has been one of the new bases of the US National Science Foundation in the last decade (Peters 2020a). In this context, we need a postdigital critical philosophy that examines the nature of these convergences and especially the convergence of information and genomic science at the nanolevel, linking it to techno-science, techno-politics, and techno-nationalism (Peters and Besley 2019). A central point of critique in the critical philosophy of convergence is the political economy of 'post-biological technocracy' and its tendency to 'numb' the biological self and creates a kind of digital obedience where Big Tech 'platform ontologies' know us better than we know ourselves (Peters 2020b; Peters and Jandrić 2019b).

Reports increasingly recognize the 'emergence of biodigitalism' as the coming horizon and examine a societal and economic future based on the merging of biology and digital technologies. A recent report in Policy Horizons Canada entitled Exploring Biodigital Convergence (2020) 'uses foresight to help the federal government build stronger policies and programs in the face of an uncertain future' and investigates the question—What happens when biology and digital technology merge?—from an economic perspective. The report addresses why biodigital convergence is occurring now and the characteristics and new capabilities arising from the biodigital systems. Kristel Van der Elst, Director General of Policy Horizons Canada, puts it this way:

> In the coming years, biodigital technologies could be woven into our lives in the way that digital technologies are now. Biological and digital systems are converging, and could change the way we work, live, and even evolve as a species. More than a technological

> change, this biodigital convergence may transform the way we understand ourselves and cause us to redefine what we consider human or natural. … Digital technologies and biological systems are beginning to combine and merge in ways that could be profoundly disruptive to our assumptions about society, the economy, and our bodies. We call this the biodigital convergence. (Van der Elst in Policy Horizons Canada 2020: 5)

Both 'biodigital technologies' and 'biodigital convergence' are useful concepts and related to the 'Nano-Bio-Info-Cogno Paradigm'. The US National Science Foundation (NSF) have published reports exploring the convergence of the 'NBIC technologies' ('nano-bio-info-cogno') suggesting there that there is a new scientific 'unity at the nanoscale' (Bainbridge and Roco 2006: 49). The notion of 'convergent technologies'—*the great convergence*—has guided NSF for over a decade, has been recognized and adopted also in Europe and China (Peters et al. 2021), and attracts much commentary from scholars around the world. However, the concept of 'the biodigital convergence' is used seemingly without prior knowledge of its use or its kindred concepts like 'bioinformation'. With this in mind, we move on to explore the very foundations of the bioinformational convergence.

3 The Technologization of Bioinformation

For thousands of years, (natural) scientists have employed various analytical methods[1] to make sense of reality. The analytical method can be roughly divided into three stages. The first stage consists of problem posing and gathering of relevant information. The second stage is problem abstracting, which ends with an abstract 'law of nature' such as the Second Newton's Law. In the third stage, abstract laws and principles are applied and tested, leading to their confirmation or falsification. There are various interpretations of this process (for instance, Popper vs. Kuhn), but this general structure of the analytic method has remained firmly in place for many centuries.

In the second part of the twentieth century computers have gained enough power to enable a numerical approach to scientific inquiry. The first stage still consists of problem posing and gathering of relevant information; these days, this translates into the creation of huge datasets often called Big Data. In the second stage, Big Data is manipulated using various numerical processes, often supported by artificial intelligences, leading again to abstract laws and principles. But now, artificial intelligences do not just process data towards a pre-determined problem. They also surface connections and relationships within data and identify new problems,

[1] Here, the term 'analytical method' refers to the mathematical distinction between analytical and numerical methods and should not be confused with other uses of the term analysis (such as analytic philosophy). 'In mathematics, some problems can be solved analytically and numerically. An analytical solution involves framing the problem in a well-understood form and calculating the exact solution. A numerical solution means making guesses at the solution and testing whether the problem is solved well enough to stop.' (Brownlee 2018)

previously unseen by human beings. In the third stage, abstract laws and principles are applied and tested, more often than not, using more Big Data and more artificial intelligences. This brings about a fundamental difference between analytical and numerical research. Since human beings are unable to process Big Data, algorithms have a lot of agency in all stages of research. This leads to a widely debated symmetry between human and nonhuman researchers (Jones 2018; Fuller and Jandrić 2019) and brings about the posthumanist shift from *using* computers to *collaborating with* computers.

In one direction, a strong reliance on numerical methods represents the digitalization of biology; in the opposite, equally important direction, it represents the biologization of information. On the 70th anniversary of Erwin Schrödinger's famous lecture 'What is life', Craig Venter gave a presentation 'What Is Life? A 21st Century Perspective' at Trinity College Dublin where he vividly outlined practical consequences of this bidirectionality:

> We can digitize life, and we generate life from the digital world. Just as the ribosome can convert the analogue message in mRNA into a protein robot, it's becoming standard now in the world of science to convert digital code into protein viruses and cells. Scientists send digital code to each other instead of sending genes or proteins. There are several companies around the world that make their living by synthesizing genes for scientific labs. It's faster and cheaper to synthesize a gene than it is to clone it, or even get it by Federal Express. (Venter 2012)

This marriage between analytical and numerical methods builds the basis of the bioinformational convergence and has important philosophical implications. Bioinformatics has not arrived from a sudden or artificial blend of the 'soft' or 'moist' *bios* and the 'hard' or 'cold' *technē*; instead, the *technē* is an inherent feature of the *bios*. To various extents, biology is digital information and digital information is biology; one cannot be divorced from the other. Humanity's newly acquired technological ability to deal with this dialectic now builds the basis of biodigitalism and biodigital technologies that represent a new revolutionary way forward where technology leads science.The ability to turn biology into digital code, and then to return digital code back into biology, offers much more than new theoretical insights. Just as importantly, it offers extended and up to recently unimaginable opportunities for tinkering with and actively transforming living organisms. This leads to numerous ethical dilemmas in bioinformational research (see Peters and Jandrić 2019a) such as the popular question of germline gene therapy 'which would allow the inserted gene to be passed to future generations'. This practice is deeply controversial. 'While it could spare future generations in a family from having a particular genetic disorder, it might affect the development of a fetus in unexpected ways or have long-term side effects that are not yet known.' Consequently, the US Government does not support research on human germline gene therapy (US National Library of Medicine 2018). These unintended consequences are not at all fictional. For instance, the first cloned mammal, Dolly the sheep, has lived a short life burdened with multiple diseases, and researchers are unsure whether her health problems are associated with cloning (Shiels et al. 1999).

Such technologization of biology, with its numerous practical capabilities, is the reason why biodigitalism is a wider concept than bioinformation. Furthermore, these practical capabilities cannot be thought of without a wide array of theoretical questions such as whether artificial intelligences can be understood as a form of life (see Fuller and Jandrić 2019; Savin-Baden 2021) and how should we treat the possible arrival of 'Hawking-inspired postdigital human beings created through self-designed evolution quicker than non-tampered (natural) evolution of human intelligence' (Peters and Jandrić 2019a; see Hawking 1996; Peters et al. 2020b). They also open up various long-term scenarios, such as Ray Kurzweil's (2005) vision of singularity in which humans and computers will form a sort of shared planetary intelligence. Summarizing these and other issues, Gillings et al. ask a crucial question:

> It seems inevitable that digital and biological information will become more integrated in the future. This scenario raises the question of how such an organic–digital fusion might become a symbiosis that coevolves through natural and artificial selection. In all symbioses, there is potential for exploitation and cheating [75], and this possibility has to be examined for the biological–technological fusion. (Gillings et al. 2016: 8)

These and related questions sit within new biodigital knowledge ecologies based on new relationships between biology and informatics. They include new understandings of life, including development of algorithmic non-carbon-based 'living' systems and human-machine self-evolution quicker than non-tampered (natural) evolution (Peters and Jandrić 2019a; see Hawking 1996; Peters 2020c). They require active engagement with continuous reconfigurations of relationships between biodigitalism and society. Biodigitalism is inherently Anthropogenic, so this engagement does not stop at human beings but extends towards all life forms—as can be seen from the recent example of the Covid-19 pandemic, our dietary practices are dialectically intertwined with humankind's collective health and well-being (O'Sullivan 2020). New knowledge ecologies are a 'part of the wider innovation of technocapitalism and can only really be understood in postdigital terms of posthumanism though biodigitalism—specifically how these two forces between them shape the future of human ontologies of what we can become' (Peters and Jandrić 2019b). Situated within bioinformational capitalism (Peters 2012), and co-developed by humans and machines as we write this chapter, the new knowledge ecologies further bring about perhaps the most fundamental shift in the typology of traditional scientific disciplines and their economy in the history of science.

4 Scientific Crises and Social Implications

In the background to biodigital reconfigurations of traditional scientific disciplines, there has been a growing concern that 'quality control has failed to keep pace with the growth of science' (Ravetz 2016). While biodigitalism, as a mutual interaction of information and biology, is bringing far reaching changes to these paths of cultural coevolution, there are issues of scientific credibility that 'are older than most junior faculty members' (Bishop 2019: 435). From concerns over reproducibility (Open Science Collaboration 2015), through to the abuse of metrics (Wilsdon 2016), to problems of peer review in publishing (Peters et al. 2016; Jandrić 2020a), an ongoing disquiet in these and other areas of integrity cannot be overlooked. This is a stream of infiltration to knowledge ecologies over time, where a pervasive lack of reproducibility has effects on what we can 'know'. Yet this situation has also become more complex as human beings have ceased to be able to process Big Data. Now that algorithms have so much agency in all stages of research, there are questions of reproducibility to be levelled at both human and non-human researchers together, given their close collaboration.

New knowledge ecologies therefore include a posthumanist angle which allows reflection on an ongoing credibility and culture crisis in research and academic scholarship. This crisis has spanned predigital and postdigital times, with a combination of factors including how our political economy has placed systems of control and rewards that have produced positivist incentives for researchers (Jandrić 2020b). Then there is the 'industrialized' nature of science and the global division of labour with its accompanying inequalities (Jandrić and Hayes 2019). Short-term contracts afforded to researchers and teachers, where renewal rests in the hands of principal investigators, also means that maintaining 'ideals of independence and integrity becomes increasingly difficult' (Ravetz 2016). We now face the enormous proliferation of scientific writing which remains unread in its original form (Jandrić and Hayes 2019), and a blurring of lines between politics, journalism, and science that has been particularly apparent during the Covid-19 crisis (Rose 2020; MacKenzie et al. 2021). Pressures on the use of science for policymaking have been enormous bringing the convergence of relationships across scientific disciplines and mutual interactions between information, biology, politics, and the economy to the attention of a global audience.

Sutton (2020) argues that the 'frantic pace of the 24-hour news cycle and competition from social media mean the bandwidth through which complex ideas must be relayed to the public is very narrow'. Additionally, when parliament is composed largely of graduates of the humanities and social sciences, 'quantitative methods of physical science have always been something of an afterthought'. Added to this are incentives for broadcasters to gain 'a catastrophising 10-second soundbite' rather than 'a level-headed exposition' concerning the 'challenges of various competing strategies' (Sutton 2020). Therefore, we should not excuse any government's scientific advisers 'funded by the public purse and bearing considerable social responsibility, from providing cynical interpretations of data, of questionable validity, and drawn from a weak evidence base, all in order to justify further restrictions' (Sutton 2020). Innovative ideas quickly become old news and a prioritization of novelty over replication has developed. While 'under these harsh conditions quality becomes instrumentalised' because 'impact' is the name of the game, even more concerning is the issue that perhaps those who engage in 'shoddy' or 'sleazy' science do not know what is in fact, sub-standard (Ravetz 2016).

Picking up on these issues, Bishop (2019: 435) reflects on the last four decades of her scientific career to observe that threats to reproducibility have been recognized but have remained unaddressed. Furthermore, 'many researchers persist in working in a way that is guaranteed not to deliver meaningful results'. Enormous social implications therefore now include some concepts that need to be unlearned and some skills that must be relearned in order to restore the legitimacy and integrity of science (Benessia et al. 2016). Given that biodigital convergence is surfacing new knowledge ecologies, this brings to the forefront questions concerning what our image of science is, or should be, in relation to posthumanist theory. Historical ideals concerned science in opposition with organized religion, with a turning point as recent as the 1960s in debates between Popper and Kuhn (Fuller and Jandrić 2019). The questions of quality and credibility however have only recently become dominant, given that 'during the "science wars", sociological critics attacked the epistemological foundations of science, but not the imperfections in its practice' (Ravetz 2016).

Now the biodigital convergence needs to be explored across all of the emerging ecologies of knowledge with questions and implications of scientific credibility considered alongside characteristics of the biodigital systems, such as democratization, decentralization, geographic diffusion, scalability, customization, and reliance on data (Policy Horizons Canada 2020). Bishop (2019: 435) argues that 'new forces' such as the field of metascience, documentation, and awareness of the issues may finally help to address irreproducibility, as 'we can no longer dismiss [these] concerns as purely theoretical'. These days 'social media enables criticisms to be raised and explored soon after publication'. In scientific publishing, 'more journals are adopting the registered report format, in which editors evaluate the experimental question and study design before results are collected'. Finally, those who fund research have introduced requirements 'that data and scripts be made open and methods be described fully' (Bishop 2019: 435). James Ball (2020: 219) makes another important point that many of the scientists, technologists, and entrepreneurs behind the Internet and major systems and scientific advances under discussion, are still alive. This in itself has implications for new philosophies of science that are inclusive of the pioneers who brought them into being.

5 Biodigital Knowledge Ecologies

New technological ability is leading postdigital science where biology as digital information, and digital information as biology, are dialectically interconnected. This bioinformational convergence simultaneously leads to convergence and divergence of research activities. Convergence: this unified ecosystem allows us to answer questions, resolve problems and build things that isolated disciplinary capabilities cannot. Divergence: this creates new pathways, opportunities, competencies, knowledge, technologies and applications. Policy Horizons Canada (2020) outlines three main ways that biodigital convergence is emerging.

Firstly, *a full physical integration of biological and digital entities* means that digital technology can be embedded into organisms, and biological components can exist as parts of digital technologies. This merging of 'the biological and digital are creating new hybrid forms of life and technology, each functioning in the tangible world, often with heightened capabilities' (Policy Horizons Canada 2020: 9). Secondly, *a coevolution of biological and digital technologies* emerges when advances in one domain generate major advances in the other, to enable progress that would be impossible otherwise. This could potentially lead to biological and digital technologies that are developed as integrated or complementary systems now that so many complex living systems 'are increasingly subject to examination and understanding by digital tools and applications such as machine learning' (Policy Horizons Canada 2020: 9). Thirdly, *a conceptual convergence of biological and digital systems* is a form of biodigital convergence that could reshape our framing and approach to biological and digital realms, facilitating the blending of the two (Policy Horizons Canada 2020: 10).

5.1 A Full Physical Integration of Biological and Digital Entities

Some implications of a full physical integration of biological and digital entities could include robots with biological brains and biological bodies with digital brains (Policy Horizons Canada 2020). Kevin Warwick (2010) looks at culturing neural tissue and embodying it in a mobile robot platform to essentially give a robot a biological brain. He suggests that for a long time the topic of Artificial Intelligence was concerned with getting machines to copy humans, which restricted both technical and philosophical development, while building machine brains that are far more powerful than human brains was left aside. Yet this potential future would mean that possibly conscious beings could outthink humans at every turn, posing extreme dangers to the future of humankind. Rather than claim that such a brain is definitely conscious, he instead raises questions about what consciousness really is (Warwick 2010: 233). Similar questions and speculations emerge across a range of contexts (see Peters and Jandrić 2019a, b). For instance, in *Postdigital Humans: Transitions, Transformations and Transcendence*, Maggi Savin-Baden (2021) explores a wider notion of 'what it means to be a human subject, and the extent to which the idea of the human subject is still useful'.

Whether such questions, in the light of scientific changes in the twenty-first century, now need different philosophical ideas from those upon which we have built our society thus far, are important considerations (Harari 2017; Peters 2020c, d; Savin-Baden 2021). These configurations of relationships between biology and informatics include new understandings of debates concerning identity and communication that are raised in the notion of 'biodigital bodies'. O'Riordan (2011: 308) points out that a shift can now be traced from biodigital fictions to biodigital practices, but this has arrived rather quietly, along with the rhetoric of convergence. Picking up on the implications of the circulation of personal genomes, she argues that:

> In the biodigital elites that are assembled around genome scanning and sequencing, the attempts to establish the circulation of individual genomic information as socially normative … involves the extraction of free labor in the service of biomedicine, the empowerment of consumers in accessing their genomic information, and the creation of technocultural capital to enhance the power of an individual's career value. However, it also creates a milieu in which biological dimensions of life become subject to norms of digital sociality. (O'Riordan 2011: 308)

O'Riordan's argument brings philosophical considerations to whether such a convergence affects fundamental changes to how meaning is made through communication: 'A constitutive dimension of media is a power to change the sites of production and consumption. Media, where bodies are represented and meanings are made about them, have an inscriptive power upon actual bodies.' (2011: 309) This leaves us with questions of what existing or new social issues, injustices or inequalities may be aggravated, or alternatively what positive visions are developing and how these might be improved.

5.2 A Coevolution of Biological and Digital Technologies

Deeper understandings and manipulations of biology are being enabled through digital technologies that were not possible only a few years ago; vice versa, biology is also informing new approaches in computing. Additionally, there is a 'blurring between what is considered natural or organic and what is digital, engineered, or synthetic' (Policy Horizons Canada 2020: 10). Digitalisation and the bio-based industries that are starting to make impacts in the chemicals and materials sectors provide examples. James Philp from the Directorate for Science, Technology and Innovation explains that: 'Engineering biology needs digitalisation and vice versa. The bioeconomy is wider than biotechnology, however. There are many other ways that converging technologies and digitalisation can be applicable to the bioeconomy.' (OECD 2020).

The bioeconomy concerns using renewable feedstocks to produce everyday goods and services but now encompasses a wide range of sectors and activities including chemicals, food, agriculture, dairy, forestry, pulp and paper, waste management and others. Therefore, the bioeconomy is now seen as a new means of production that will gradually replace fossil-based production and be consistent with the concept of a circular economy (Philp and Winickoff 2018). The combination of digital and biological transformation therefore has significant implications for companies as it changes the design and handling of production processes and their products. Working with the physical world as digital means that many companies now need to become technology businesses if they are to survive.

5.3 *A Conceptual Convergence of Biological and Digital Systems*

A conceptual convergence of biological and digital systems has far reaching implications in that it could see a shift away from vitalism: the belief that living and non-living organisms are fundamentally different because they are thought to be governed by different principles (Policy Horizons Canada 2020: 10). Biodigital convergence thus involves a rethinking of biology as providing both the raw materials and a mechanism for developing innovative processes to create new products, services, and ways of being (Policy Horizons Canada 2020: 14).

In a sense, biodigital convergence is altering humans into 'the next critical infrastructure sector' (Toffler Associates 2016). It is argued that the 'rate of growth implies a growing comfort with networked, wearable, and implanted devices—and our connectivity with them'. Currently available implantable Internet of Things (IoT) devices (pacemakers, defibrillators, and insulin pumps, etc.) are external electronic devices that supplement human lives. In progressing towards an Internet of Humans (IoH), we gain greater insight into who we are to help us to know what is happening beneath our skin and inside our minds. This deeper integration with technology could connect us even more firmly within a prospective biodigital network where artificial organs could be monitored and controlled remotely, brain wave technologies may allow people to control their devices simply by thinking about them, high tech e-skin (artificial skin) would allow users to project and control their smartphone on their body, and so on (Toffler Associates 2016; see also Williamson 2019b).

Then there are the aforementioned questions of scientific quality and whether advances in IoT might contribute to the challenge of reproducibility. For example, as synthetic biology develops as an engineering discipline, it faces new challenges with standardization and inconsistencies and aims for new forms of consistency compete with the arrival of new parts, methods, and experimental practices. McCarty (2019) points towards a pivot where, rather than expect research laboratories to conform (when they each do things their own way), 'a better solution may be to instead enhance the ways that data is collected and analyzed' by connecting Internet-enabled sensors to almost any piece of equipment:

> In synthetic biology, this means that lab equipment can be monitored to ensure that experimental parameters between runs are consistent. The digital data can also be readily accessed by members of the lab or shared with external collaborators. By seamlessly connecting laboratory equipment and pooling data in a single, online database, users can always go back after an experiment and pore through the data to determine sources of inconsistency in measurements. (McCarty 2019)

Such augmentation of existing equipment with IoT-enabled sensors may be difficult though, with huge amounts of generated data challenging to process and analyse (McCarty 2019).Questions are beginning to emerge from other disciplines too. Tal Bar (2020) asks: can we think of biodigital architecture as a *site of promise* for social change? The barriers perceived here are not so much technological though as ontological, this leading us towards more philosophical considerations. Currently biodigital architecture is perceived to burden itself with a 'calculated means of encasing bodies in efficient buildings when instead, could it use the endless processing and collecting capacities to ask questions from a different order'? Drawing on the work of Rosi Braidotti (2019a) on nomadic thinking and subjectivity, Bar reflects on the architect as a digital artisan, a scrap collector, a storyteller of bodies as data. Bar's reflection reaches beyond the universal skeletal data that furnishes the tables and charts of biodigital practice, redefining the collective. The biodigital challenge 'is an opportunity to connect us to the otherness already within and surrounding us, to rethink the boundaries between individual and collective already transcending the humanist binaries to reshape our habits, our habitats, our relationalities'. Therefore, Bar asks: 'What architectural models could we see emerging?' (Bar 2020). Taking a longer look back at the shifts that have emerged in relation to science and technology, as linked activities that co-evolve, helps develop an overview of this broader landscape of technoscience, biodigitalism, and bioeconomy.

5.4 Technoscience, Biodigitalism, and Bioeconomy

In the late twentieth and early twenty-first centuries, national research funding patters have changed from 'big science' physics projects to projects in biotechnology and the so-called 'new biology' (Dyson 2007). Following early success in the post-war period that played a crucial role with the development of the Internet, twenty-first century US federal research funding now focuses on public and private sector investment in areas such as microelectronics, robotics, biotechnology, and the investigation of the human genome. These areas are now increasingly seen as the underpinnings of the new economy. An early expression of this was given by Moore, Spencer, and Wessner in their joint preface to *Capitalizing on New Needs and New Opportunities: Government-Industry Partnerships in Biotechnology and Information Technologies*:

> As we begin the twenty-first century, many believe that we are also witnessing the start of a new era—one where humankind will increasingly expand its understanding of the building blocks of life, and one which will rely on advanced information technologies to process, analyze, and share the results of such research. This era may well rest on what some call the new economy – that is, an economy where higher sustained growth rates are fed by productivity improvements made possible by the application of new knowledge and new technologies. This state of affairs depends on continued public and private sector investment in productivity-enhancing technologies. It also requires substantial and expanded investment in basic research. Increased allocations of public resources to research, though, are not sufficient; continued progress also depends on government participation in the maintenance of a policy framework that supports the development of new technologies. (Moore et al. 2001: 3)

The development of a public-private partnership where national research funds are used to provide an underpinning for the developing new economy has been a feature of US funding. In a philosophical sense, the paradigm shift from physics and the physical sciences to genomic science and the life sciences, combined with a twin emphasis on Internet and related digital technologies, indicates a number of aspects:

1. The shape and direction of the development and formation of the sciences (and knowledges) are to a large extent determined by public funding of research priorities.
2. Research priorities that influence the larger pattern of public and private sector partnerships reflect economic imperatives and the future direction of the economy.
3. The emphasis on biotechnology and information technology indicates the prominence of a technology-driven agenda or a technology-led science.
4. This new formation we refer to as the relatively new constellation of 'technoscience'.

'Technoscience', a term coined by the Belgium philosopher Gilbert Hottois in 1978 and adopted and used by Lyotard, Latour, Stiegler, Ihde, and others, approaches science and technology as linked activities that co-evolve. Hottois traces technoscience to Martin Heidegger and to Gaston Bachelard's materialism in the 1950s and places it in a tradition that significantly includes Donna Haraway and Karen Barad. In *The Question Concerning Technology* Heidegger (1977) reverses the traditional modern relation between science and technology and emphasizes *technē*. In the original Greek usage, *technē* is a concept that refers to arts, skills, and handicraft and also an assemblage of interacting techniques that demonstrate strategic knowledges in relation to economic and political goals. Vincent and Loeve (2018) mention the origin and development of the term:

> The term 'technoscience' gained philosophical significance in the 1970s but it aroused ambivalent views. On the one hand, several scholars have used it to shed light on specific features of recent scientific research, especially with regard to emerging technologies that blur boundaries (such as natural/artificial, machine/living being, knowing/making and so on); on the other hand, as a matter of fact 'technoscience' did not prompt great interest among philosophers. In the French area, a depreciative meaning prevails: 'technoscience' means the contamination of science by management and capitalism. Some even argue that 'technoscience' is not a concept at all, just a buzzword. In this chapter, on the contrary, we make the case for the constitution of a philosophical concept of technoscience based on the characterization of its objects in order to scrutinize their epistemological, ontological, political and ethical dimensions. (Vincent and Loeve 2018)

The significance of a semiological understanding of technology as a language based on a deep code that brings informatics in line with synthetic biology speaks to the transformation of science on public power and civil institutions. The outlines of this 'theory' of a technology-led science reunified at the nano-level and applicable to the human body and brain in the new neurocognitive sciences have gained traction. One of the most compelling accounts is offered by Braidotti. In *Posthuman Knowledge* she raises the issue that when we visit websites and seek to subscribe, we are routinely required to verify that we are in fact a human. This requirement 'assumes as the central point of reference the algorithmic culture of computational networks—not the human'. As such, 'the human has become a question mark' (Braidotti 2019b: 1). She argues that the complexities of 'posthuman times, and the posthuman subjects of knowledge constituted within them, are producing new fields of transdisciplinary knowledge' which she discusses under a theoretical framework of the critical posthumanities (Braidotti 2019a: 31). This includes exploration of the 'parameters that define a posthuman knowing subject, her scientific credibility and ethical accountability' (Braidotti 2019a: 31). This shifts the focus from not just a quantitative growth of areas of study and quantified non-human 'objects' of research, but towards a qualitative shift to provide new possible 'human' formations and results in patterns that frame 'missing peoples' whose 'minor' or nomadic knowledge is the breeding ground for possible futures (Braidotti 2019a: 53).

Braidotti (2019a: 37) argues from the point of view of the humanities for both 'royal science' formations and for multiple assemblages of 'minor science', and especially for the new critical posthumanities defined at the moment between 'ceasing to be and what we are in the process of becoming'. She makes the strong argument that 'with cognitive capitalism being tuned into bio-genetics and informational codes—there is nothing left for critical thinkers to do other than to pursue the posthuman' (Braidotti 2019a: 53). We agree with this orientation but think that 'critical reason' in this context itself needs a biodigital interpretation and is not consumed by the posthumanities. Our point is that posthumanism is but one form of biodigitalism that mediates both biohumanities and the digital humanities where is it not preoccupied with the tradition of the subject (the political subject, the economic subject) and subjectivity studies. Biodigitalism is also much more oriented to ecosystems and coordinated Earth systems (climate, food, energy) in the name of sustainability. While we accept that 'the critical posthumanities provide a diversified array of the changing perceptions and formations of the "human" in the posthuman era' (Braidotti 2019a: 53), we also want to see posthumanism as an emerging feature of biopolitics (immune-state), biosecurity, immunology, and bioterrorism. Braidotti suggests that the complex re-composition of minor science in the critical posthumanities is giving us a measure of what we are in the process of becoming. In addition, we want to put the posthumanities in a critical relationship to epistemological and historical shifts in science and to the emergence of technoscience as comprised of twin forces of new biology and the digital technologies, both of which determine cultural evolution.

Technoscience in the twenty-first century is very different from science in modernity. The shift from industrial science to digital technoscience comprises the rise of the new digital platform technologies (AI, deep learning, robotics, and quantum computing), the commercialization of research, the relationship to the neoliberal 'knowledge economy', the logic of performativity, the shift from Big Science to Big Data and finally to Big Tech (Lyotard 1984; Peters 1989, 2020a), and related shifts in a wide array of connected areas. This is a story of that emerges from the immediate aftermath of the Second World War, the conferences of the Macy Cybernetics Group, and the military investment in the beginnings of the Internet. 'Technoscience' has also created a discourse of 'technopolitics' as a critical reception and assessment of these technical tendencies (Peters 2020d, e).

In terms of a tentative simple typology we can entertain the hypothesis of a number of major epistemological shifts in the post-war period emphasizing new knowledge ecologies, technologies, and research fields, that reflect a set of technological convergences that integrate, multiply, expand, broaden, and synthesize existing fields in genomic and information science. These can be envisioned as a series of compressed historical overlays which in large measure result from strategic national political and economic imperatives defined through patterns of public-private research and funding arrangements. Such a view would also encompass China's emergence as a techno-state and its investments in a range of 5G and 6G technologies including deep learning, AI, quantum computing and so on. One possible take on this typology is as follows:

1. Industrial science to postmodern technoscience.
2. Posthumanism and new materialism.
3. Postdigital science and education.
4. Bioinformational capitalism.
5. Biodigital technologies and the bioeconomy.

'Biodigital technologies' help to initiate and to articulate an emergent form of bioeconomy that is self-renewing in the sense that it can change and renew the material basis for life and economy as well as re-evaluate and alter the code to program itself. There are accordingly two major forms in the political economy of bioeconomy—capitalist and socialist. Both are transformed in a data-intensive 'circular' bioeconomy that can create a new combinatorial synthetic material base of genetically enhanced plants, animals, insects, and microorganisms in controlled and experimental artificial and augmented environments. Both systems are theoretically able to this with a much-reduced labour force so that labour is no longer a determining formal factor of production. The shift to algorithmic agricultural systems can also utilize forms of augmented intelligence, and thus come to depend more and more on highly specialized forms of scientific labour. The novel and critical aspect of long-term prospects for bioeconomy developed through biodigital technologies is to engineer environmental self-renewal that becomes the basis of long-term sustainability.

6 Conclusion

The great convergence between biology and information creates complex, interconnected reconfigurations at all levels of theory and practice. Starting from biodigital philosophy and bioepistemology, and passing through biodigital technoscience and the bioeconomy, this chapter has arrived to strategic national, political, and economic imperatives and patterns of public-private research and funding arrangements—to conclude with the ways that the biopolitics and bioeconomy are shaping biodigital philosophy and bioepistemology. To break this full circle into more manageable units of analysis, we used Policy Horizons Canada's (2020) classification of biodigital convergence into sub-areas such as a full physical integration of biological and digital entities, a coevolution of biological and digital technologies, and a conceptual convergence of biological and digital systems. We classified the main trends in the paradigm shift from physics to the life sciences, and we also summed up some major epistemological shifts towards new biodigital technoscience.

While these classifications have indeed been helpful in our analyses, biodigital phenomena stubbornly escape our attempts at categorization—speaking of one element (e.g., bioepistemology) always implies speaking about all others (technoscience, biopolitics, bioeconomy…). Biodigital knowledge ecologies are theoretical and practical (praxis); scientific and technical (technoscience); analog and digital (postdigital); biological and informational (bioinformational); and political and economic (bioinformational capitalism). Biodigital knowledge ecologies are much more than listed elements, and they also contain various combinations of listed and unlisted elements (e.g., biodigital technoscience). Looking at scale, biodigital knowledge ecologies scale from nanolevel (1 nm is one billionth of a meter or 0.000000001 m) to planetary level (Earth diameter is 12,742 km). Thus, biodigital knowledge ecologies involve various units of analysis from DNA and viruses, though the individual (post)human subject, to the Earth's ecosystem. Biodigital knowledge ecologies are individual and collective (biopolitics) and therefore normative (bioethics).

Such scalability, interconnectedness, and complexity make biodigital knowledge ecologies difficult to understand and work with. Yet their messiness, often accompanied by unpredictability, is inherent to our postdigital condition (Jandrić et al. 2018: 895) and invites ecological thinking. According to Fawns et al. (2020), 'ecologies have no clear beginning or end'. Therefore, biodigital knowledge ecologies should not be understood as snapshots into our reality but as sets of overlapping continua including animate-inanimate matter; past-present-future; epistemology-politics-economy; and many others. An important continuum is individual-collective responsibility. According to Lorraine Code, ecological thinking implies that 'people singly and collectively—indeed, *singly* because collectively—are *responsible* for what and how they know, on an understanding of responsibility that is as epistemological as it is ethical and political' (Code 2006: ix) (emphasis from the original). Developing this chapter is our responsibility as authors, reflecting on this chapter is the responsibility of its reader, and further development of biodigital knowledge ecologies is a responsibility shared among us.

Our current understanding of biodigital knowledge ecologies shows the uneven development of disciplinary formations. The fields grow at different rates and in different directions in connection with the full economy of disciplinary fields, applying, adopting and adapting technical developments from related subject areas, to produce new constellations and new knowledge ecologies. The new knowledge ecologies of the twenty-first century offer biodigitalism as a new evolutionary constellation that changes our understanding of causation, explanation, and history while also defining a new biopolitics of identity where the philosophy of race, class, gender, and intelligence meets genomics and information.

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Biodigital Becoming

John Reader

1 Introduction

> Becoming is the unstable and risky place in which the present looks out over itself, exposing itself to a potentiality that has never been actualized and therefore, in this sense, is unactualized. It is from here that its differentiating relationship with the present arises. While the present is that which is, and therefore immediately afterwards is no more., becoming is that which the present is about to be. (Esposito 2019: 207)

Assuming that Esposito is correct, then we are always on the brink of another future, and while in the midst of this becoming, we have a brief opportunity to interpret and even critique the present in order to more appropriately shape that which will be. Before it is already too late, there is a chance of seeing things differently and responding according to different values and beliefs. Another trajectory is still possible. In terms of what is known as the biodigital, that moment would seem to be now, as both the technologies and their implementations are progressing so swiftly that it will soon be too late. What is it that prevents us from grasping this moment and allows what some would see as inevitable to occur?

Part of the answer of course is always going to be political and linked to existing power structures and economic interests. Yet behind this also rests a very particular understanding of human autonomy which presents a view of how humans function as one of sound and reasoned judgement which approaches such issues in a calm and measured fashion and can be trusted to yield appropriate ethical positions. What, however, if this is only a partial and misleading interpretation of what happens in practice?

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In this case we lay ourselves open to a status quo that disguises those very political and economic interests as the norm and prohibits more radical examinations of the development of these technologies. A different becoming needs to be revealed, one which is based on a broader understanding of how humans function. The sources for this are to be found in contemporary continental philosophy and require introducing to the public debate.

In order to illustrate the contribution of a new conceptuality emerging from continental philosophy this chapter will present three current examples of how issues of bioinformational convergence are addressed from within both the biological and digital fields. It is clear that biological information is becoming increasingly digital and that the digital is also becoming more biological, hence the term convergence to describe this process (Jandrić 2021; Peters et al. 2021). This new context requires ideas and insights into reason and human autonomy, hence examples of this will be offered in contrast to the more traditional interpretations. It becomes clear that reason as embodied and affect, human autonomy as an aspect of distributed agency, and the need to understand both as always already embedded in human non-human assemblages, point towards new criteria for assessing current ethical approaches to the challenges of bioinformational capitalism.

2 Developments of the Biodigital

To gain a deeper view of this it will be helpful to glance at a recent article written by Natasha Bajema (2018). She is a National Security expert in the US specialising in the area of emerging technologies. The article carries the disclaimer that it does not reflect the official policy or position of the National Defense University or of the US Government. One can assume therefore that she is at least a reputable source of information on these subjects.

The digitization of biological information is leading to biology becoming a branch of information technology. This dates back to the Human Genome Project[1] when the A's, C's, G's and T's of the human genome were transformed into the ones and zeros that computers can understand. This initiated the process of gene sequencing in which genes are converted from living organisms into digital information that can be read, processed, and analysed by computers. There is a reverse process, gene synthesis, whereby digitized genetic material in binary computer code can be translated into DNA sequences that can be produced and used to create living organisms in a laboratory environment. The fact that this has not received much public attention is because this has been focussed instead on the CRISPR[2] gene editing techniques, dating from 2012, through which the genome of living organisms can be

[1] See https://www.genome.gov/human-genome-project. Accessed 19 March 2021.

[2] CRISPR, or clustered regularly interspaced short palindromic repeats, are DNA sequences found in prokaryotic organisms.

modified. This technique has the potential to transform the field of synthetic biology, accelerating the prevention and treatment of disease, and developing new products to improve human life. There is a concern that as this becomes cheaper and more readily available these techniques could lead to new pathways for the development of biological weapons.

While that may be disturbing enough, what should be of even greater concern is the digitization of biology itself. The volume of digitized genomic data is increasing and this is now being stored in online databases and available for analysis. Scientists from around the world can access this data enabling them to construct new genes and DNA sequences of interest, and potentially create living organisms from scratch. In 2010 a team became the first scientists to create a living organism from computer data. One impact of this is on national security concerns as more and more biological information is moving backwards and forwards between the physical and biological worlds. The availability of this data while taken for granted by the scientists, disguises the risks involved such as the unintended release of information, unauthorized access to it, let alone hacking, theft, human error, or sabotage.

The chapter then goes on to address the security and governance issues raised by this new context, working on the assumption that great benefits can also result from this digitization and arguing that regulatory approaches that might hinder such technological innovation are to be avoided. Cybersecurity is clearly of importance, plus a raising of awareness of the risks in the community of scientists, researchers, and bio-industrial companies. New standards of practice should be introduced to better protect all types of digitized genomic data from being used for harm. The final proposal is for the strengthening of public-private partnerships to address the emerging governance issues as while the private sector moves on rapidly governments tend to lag behind and struggle to keep up with the speed of technological advancement.

It is important to note these recommendations as they are clearly based on the assumption that those engaged with these issues are clear-minded, rational individuals and collectives, operating from within the sphere of human autonomy and responding appropriately to the challenges involved. We would all hope that is indeed the case, but this is surely a minimum requirement. The problem is that those who would gain from subverting these processes may well not be operating according to the same code of behaviour or motives. One notes that it has recently been revealed that a major security hack of the US has been taking place over a period of time and that the implications of this are only just being calculated. How much data has been accessed and what is the potential impact of this? Simply being reasonable human beings seems inadequate as a response to what is happening, but then what is the alternative? Clearly much of this stems back to the concept of reason itself and how this has taken hold since the Enlightenment and the question of whether or not reason itself undergoes a process of evolution.

3 Reason Past, Present and Future

In a recent book, Will Davies (2018) raises some intriguing and perplexing questions about how to proceed if it is the case that reason no longer appears to be so significant in guiding peoples' judgements and actions. If it is correct that feelings are indeed the major drivers once both the digital technology and the swift responses called for by the weaponizing of aspects of normal life come into play, then are there any dimensions of reason that can still operate in our political and social life?

Having worked with these questions from a largely philosophical perspective over a long period of time it is difficult to provide a quick and accessible summary, but it is worth noting that even the original Enlightenment concept of reason was by no means unified or comprehensive. Even Kant, supposedly the key figure in the early stages of this debate, experimented with a range of understandings and roles for reason. In his last work which was not published until 170 years after his death, he talks about theoretical-speculative reason; technical-practical reason and moral-practical reason (Kant 1993: 41). The argument is that one strand of this has achieved dominance – that of technical-practical reason – through its applicability in the fields of science, technology, and also the business world.

In a much later configuration identified by thinkers such as Habermas (1984, 1987), this becomes what is called instrumental reason, thought applied in order to reason through problems in a linear fashion in order to achieve specific objectives. Those objectives are not themselves to be judged according to any ethical criterion so reasoning is simply a means to an end, hence instrumental. Habermas presents in great detail what he develops as communicative reason based upon the ways in which language operates in order to show that reason can indeed function at other levels. Without going into the complexity of this one can see that even though these philosophical speculations may have no impact whatsoever upon either politicians or the general public, the concept of reason is much more differentiated and complex once one begins to scratch the surface.

Of great interest in this context is the work of Malabou (2016) who argues that employing the idea of epigenesis (which she takes from Kant and then develops in conversation with developments in neuroscience), one can see that reason itself is always subject to a process of evolution. Rather than searching for an original meaning against which one can evaluate current interpretations, it is more appropriate to examine and propose alternative versions which emerge as a result of encounters with contemporary issues and ideas. In which case, the question becomes that of what such versions might be and whether they can be usefully employed in the spheres of politics and also science and technology. Is there nothing more than instrumental or technical-practical reason at work? Is there any scope for a form of moral-practical reason, for instance?

One particular paragraph from Malabou's book is worth further development. She says that in the first edition of *Critique of Pure Reason*, Kant suggests that the imagination plays the role of a middle term between the understanding and intuition (Malabou 2016: 114). Indeed it produces 'the pure look' that makes any objective encounter possible a priori. Thinking and objectivity agree with each other in the start from this scene. Imagination opens the horizon prior to the encounter so this becomes a matter of understanding that time itself is at stake in this discussion. In other words, there is what I called in *Blurred Encounters* (Reader 2005) a pre-autonomous moment or encounter which precedes what then develops into deeper relationship or analysis of a particular situation. Reason can only begin once that encounter has taken place, and that is something which is neither planned nor controlled – the very first glance or moment of eye contact between two people which then sparks off a relationship, for instance.

Derrida, whose work can also figure in this, talks about reason as 'acquiescing to the testimony of the other' (2002: 70) and also as hospitality, both of which suggest that there has to be a willingness and openness to receive the other as they are before any further encounter can take place or develop. I find these ideas powerful and suggestive and in contrast to the mechanical and controlled interpretations of reason that dominate current thinking. But, is it the case that digital technology now pre-empts that moment of encounter, or the exercise of the imagination as Kant and Malabou would describe it? There is indeed such a suggestion. To put this in its simplest terms, digital technology operates on the basis of logic, so instead of imagination playing the role of mediating or presenting that initial moment or look, this is now going to be communicated via a system where a more means-end instrumental process is in play. Does this mean that the more human dimension which relies upon our individual capacity to perceive, interpret and then respond is no longer part of the equation? Stiegler (2015) argues that the speed at which digital technology functions can pre-empt the process of critical thought and questioning, so this would be an equivalent concern when it comes to those initial pre-autonomous encounters from which what we then more commonly call reason will flow. Is the very action of hospitality, welcoming or being open to the other itself now determined by a more mechanical or logic-driven process?

I don't think there is yet enough evidence to be able to answer this with any conviction, but one can recognise that there are concerns – shared by Davies (2018) when he talks about the impact of the technology in terms of demanding swift and immediate responses – that imagination, intuition, and perhaps the more subjective dimensions of what we might call reason or rationality are compromised when encounters are mediated solely through that technology. We know that the use of algorithms in marketing presents us with predictions about our wants and desires based on past actions. The future comes at us in the present based on calculations of what we have done in the past, and this might indeed pre-empt any effort we would be inclined to make to consider different options. Time itself is being reconfigured by these mechanisms.

This is now uncharted territory ethically and philosophically and raises again the question of how reason might be evolving in the light of contemporary technological developments. I have mentioned elsewhere (Reader 2017) that religious traditions appear to offer a different experience of time in that they operate on the basis of repetition through liturgy and the encounter with buildings. They also provide opportunities for time for reflection, meditation, and that general slowing down of time which could allow for critical thought. Yet it is less clear whether they offer anything in the field of the imagination in the initial encounter. Traditional explanations of moments of conversion or epiphanies might be candidates for this, but they seem somewhat remote from encounters mediated by the digital. Is it possible that the digital can be more than simply an operation of logic but could also present those looks or moments that convey an experience which is associated with welcoming the other as hospitality?

This needs to be an area for further research and examination before we reach any conclusions. In which case perhaps Davies (2018) is a little too pessimistic in his overall conclusion that feelings in some narrow sense have taken over completely from reason in its wider senses which in any case must take account of a more blurred, entangled and complex relationship between what we call the objective and subjective, mind and body in his own terminology. The danger of his position is that it can lead to a form of determinism unless one can see that other options can open up, although I am sure that is not his intention. If reason in its various forms can continue to evolve then the future may hold possibilities that we are yet to envisage.

4 Privacy Is Power

In order to develop this argument further I examine a recent book on the issue of data privacy (Veliz 2020). Once again the issue is that of how much of the critique she presents rests upon a limited understanding of both reason and autonomy. Veliz's main concern is to raise awareness of the extent to which our personal data is harvested and deployed by a range of tech companies and to suggest ways in which this might be countered. Although we may have been vaguely aware of this issue, what emerges is the scope and extent of how our data is being appropriated and for whose benefit. There are important political matters at stake as well as the more personal ones of privacy.

Veliz outlines a series of scenarios that illustrate the range and complexity of the data economy, some of which are familiar and some less so. One of the impacts of the pandemic has been to make us more dependent upon digital technology such as Zoom and it is important to know the limitations of their approach to privacy (Veliz 2020: 14). Facebook and the subsequent Cambridge Analytica scandal we are now aware of (15), although this too claims to have been dealt with as also the security improvements with Zoom.

In what is in many ways the philosophical heart of the book, Veliz reprises the title 'privacy is power'. Can we be bothered about this issue as individuals when we might feel that we have nothing to hide (48)? This takes the argument into the subject of power. There is the soft power of persuasion and influence through the use of fake news and narratives and then the hard power where we are being bullied into courses of action we would not otherwise have taken. The connection is made between knowledge and power drawing on Foucault (51) but bringing this up to date: 'the power to forecast and influence derived from personal data is the quintessential kind of power in the digital age' (53). Perhaps it might be more accurate to suggest that we are already in the postdigital age where its presence is so ubiquitous that it is not even a matter of note let alone of controversy?

The problem is that even though we are vaguely aware of these possibilities we are too complacent and thus complicit in allowing the tech companies and their allies access to personal details: 'manipulative soft power makes us complicit in our own victimization' (59). So we are sold the convenient narrative by Eric Schmidt and Co that if we have nothing to hide then we have nothing to fear by allowing our personal data to be harvested, but privacy is actually about protecting ourselves from the wrongdoing of others rather than hiding our own wrongdoings. This is central to the argument. This is not just about us as individuals, but about the consequences for others and indeed for society and democracy. It is about respecting autonomy which is our right to self-govern as both individuals and as societies (63). 'Individuals have a strong interest in having their autonomy respected by others. We want others to recognize and honour our ability to lead our lives as we see fit.' (71) If the values and practices of liberal democracy are to be upheld then we need to resist both the soft and hard power exercised by the technology companies.

This is where I think the argument becomes more difficult. As those engaged in environmental debates are aware, such a view of autonomy is brought into question as being at the heart of the ecological damage we inflict upon the non-human. It is this very understanding of what it is to be human that lies at the root of the problems we now face. In which case will it still suffice to return to this Enlightenment view as a response to the digital, or do we not require a more nuanced alternative conceptual framework from which to launch the critiques of both surveillance capitalism and environmentally damaging economic growth? What notion of agency is operating here, and do we not require one of distributed agency acknowledging that humans are always already fully entangled with and implicated in the assemblages of human and non-human including that of the digital? In which case autonomy is always limited and constrained?

There is a passing recognition of this with reference to Winston Churchill 'we shape our buildings, and afterwards, our buildings shape us' (74). The reality is that this mutual shaping is permanent not simply 'after the event'. One would agree with Veliz though that privacy is a collective as well as an individual matter and that this throws another perspective upon the issue. In a liberal democracy – if that is truly where we are now – privacy is the blindfold of justice, in that it prevents the intrusion into our lives which allows external powers to divide and conquer by targeting us as individuals based on our differences. Although perhaps this also is a slight difficulty for the general argument in a culture where difference and otherness demand acknowledgement and respect?

Moving further into the territory of toxic data Veliz (2020) offers examples of how our data can be deployed to both manipulate and determine our lives. This of course is now the realm of regulation with GDPR[3] and the Information

[3] The General Data Protection Regulation 2016/679 is a regulation in EU law on data protection and privacy in the European Union and the European Economic Area. See https://eur-lex.europa.eu/eli/reg/2016/679/oj. Accessed 19 March 2021.

Commissioner's Office[4] in the UK. How should this be controlled, for instance, when it comes to elections, given the case of Cambridge Analytica? Have we learnt enough from that to have developed adequate regulatory mechanisms?

Veliz makes some very specific recommendations as to how to tackle the dangers of data harvesting: 'we have to put a stop to the trade in personal data' (117). This is partly down to us to lobby our politicians to bring such practices to an end. Similarly with personalized advertising (120). Cybersecurity standards need to be improved, which is once again down to government intervention and regulation and would require disconnecting systems that are too vulnerable to external attack. 'It is only a matter of time before a massive cyberattack happens' (142), at which point if everything is connected to everything else then we are in deep trouble! We need to have the will and capacity as individuals to delete data, assuming we can find out in the first place who is holding it and how much. Government surveillance needs to be curbed; our children need to be protected by ensuring that photos and details are not publicly posted without permission – schools have been doing this for some years now: we need to guard against the dubious storing and passing on of medical information. Above all we must beware of the use of crises such as the current pandemic to press ahead with developments that need to be critically exposed and examined. These are all reasonable objectives, although how realistic is another matter.

What I want to add is that there are at least two underlying issues which require attention. While it is important to be aware of the defensive moves each of us can make in order to avoid these excesses of intrusion, how is one to prevent these intrusions happening in the first place? It seems that much of the damage has already been done and that these counter tactics are a case of 'after the horse has bolted'. Although there are clearly implications for the areas of regulation and governance, the Tech companies are already so powerful and all consuming [full spectrum dominance as Hardt and Negri (2005: 54) might say], that even these feel like too little too late to really undo the damage that has been done. If so much of our data has already been harvested, recorded and is accessible to security agencies, enabling others to target us either for political or commercial purposes, what significant difference are subsequent avoidance mechanisms going to make? If this sounds like a counsel of despair then it surely requires us to go further back in the process and question the structures and very existence of the tech companies and their allies?

Then there is a second assumption which appears regularly in much of the literature in this field, which is along the lines of, well, we are each rational and sensible beings, who, once we are aware of the dangers of digital technology and the ways it might be deployed to our detriment, and are better informed about these, will take the necessary actions to counter their worst effects. This is a resort to the Enlightenment view of humans as autonomous rational individuals who make clear and reasoned judgements when we know our freedoms are at stake. One could argue

[4] ICO: Information Commissioner's Office is the UK's independent authority set up to uphold information rights in the public interest, promoting openness by public bodies and data privacy for individuals. See https://ico.org.uk/. Accessed 19 March 2021.

that it is this mistaken interpretation of humanity that has got us into this mess in the first place, as it is those who hold a more realistic and pessimistic view of us who are in the stronger position to shape and exploit the less rational dimensions of our nature. The evidence suggests that many of us do not make our judgements and decisions in quite this logical manner, hence we are subject to a whole range of other influences which tap into our affective or emotional responses. In terms of data privacy, we knowingly trade off our privacy for other gains which are regularly presented to us. How is one to counter that and convince ourselves that the risks outweigh the advantages to such an extent that we take alternative action? There is the rub surely? In the end it is either inertia, indifference, or a willingness to make these trade-offs that determines the risks we take over data privacy. It is these factors that leave us open to exploitation by the tech companies. We simply cannot be bothered as life is too short and we have too many other competing concerns.

The concept of disinhibition as described by both Latour and Stiegler offers us glimpses into this troubled area (Reader 2020). Put simply, in the fields of both environment and technology, we have known all along that there are significant dangers and risks in the developments we have been pursuing, but we go ahead and pursue them anyway. Partly out of short-term self-interest, and partly because we are unable or unwilling to resist the temptations of what these developments appear to offer on a more global level. Feel the fear and do it anyway. This is just the way we are, basically self-serving and stupid, incapable of those 'wise restraints' that Susskind (2020: 348) suggests should shape our judgements in these matters. If there is real evidence that humans are capable of behaving in other ways, perhaps it is more likely to be found in the more altruistic and other-regarding religious traditions that both acknowledge our failings but encourage us to do better. Veliz (2020) is great at encouraging us to do better, but without taking on board and interpreting the human weakness side of the equation I fear the impact of this excellent book will be more limited than she intends. How are we to counter these disinhibitions and also to tackle the dominance of the tech companies and their political allies at their source?

5 DeLanda and Assemblages: Distributed Agency

Further insights into how it might be possible to construct a different but evolving understanding of both reason and autonomy emerge from what is known as New Materialism (Reader 2017), notably with the concept of distributed agency. This is connected with the use of the term assemblage which argues that humans are always already part of developing and shifting reconfigurations of different components both human and non-human. Hence agency is not simply an attribute of lone autonomous individuals but more an aspect of these specific assemblages which require identifying in detail. Amongst other authors this approach is to be found in the work of Levi Bryant and Manuel DeLanda.

Where Bryant (2014) uses the term machine, DeLanda (2010) retains the term assemblage. As one might expect, the influence of Deleuze is once again apparent. DeLanda refers to Deleuze in providing an initial definition.

> What is an assemblage? It is a multiplicity which is made up of heterogeneous terms and which establishes liaisons, relations between them, across ages, sexes and reigns - different natures. Thus the assemblage's only unity is that of a co-functioning; it is a symbiosis, a 'sympathy'. It is never filiations which are important, but alliances, alloys; these are not successions, lines of descent, but contagions, epidemics, the wind. (DeLanda 2010: 33)

Although this offers a broad picture of how he wants to use the term, it only goes so far in addressing more critical questions such as when is an assemblage an assemblage and how and where does one draw the line? DeLanda is aware of such complications and of the challenge of distinguishing between different kinds of wholes and strata, but argues to retain the single term and then to drill down to individual detail as illustration.

The question to consider as we examine DeLanda's contribution in greater detail, is that of where human agency fits into the picture. He says the following about the theory. All assemblages have a fully contingent historical identity, and each of them is therefore an individual entity; an individual person, community, organization, or city. Because the ontological status of all assemblages is the same, entities operating at different scales can directly interact with one another in a way that does not exist in a hierarchical ontology. This would seem to be a distinct advantage from a theological perspective. Then, at any level of scale, we are always dealing with populations of interacting entities and it is from these interactions that larger assemblages emerge as a statistical result or as collective unintended consequences of intentional action. So there is a difference between the molar and the molecular scale of activity. Once a larger scale assemblage is in place, it starts acting as a source of limitations and sources for its components – an assemblage both constrains and enables its parts. Although DeLanda uses the example of cities one can also apply this to organizations such as churches!

As he continues his analysis, it is clear that his first point of reference is to geographical entities and he draws upon Deleuze and Guattari's concepts of territorialization and deterritorialization. The first refers not only to the determination of the spatial boundaries of a whole – as in a community, city or nation state – but also to the degree to which an assemblage's component parts are drawn from a homogeneous repertoire. So conflicts between different groups are more likely to occur when an 'us and them' attitude develops, and when the constraints upon one community are interpreted as the result of the presence or influence of an external group – scapegoating in other words. Coding and decoding, the role played by language in fixing the identity of a social whole, also play a part in this process. Rituals, norms and regulations are important as assemblages work out their identity in relation to others, something else that we see at work with religious communities and institutions. So where does the human subject fit into this and how important is some concept of human agency?

Individual subjectivity could be seen as the smallest scale of such assemblages, but only as long as the subjectivity of each person is itself conceived as emerging from the interactions between sub-personal components.

> .... a subject crystallizes in the mind through the habitual grouping of ideas via relations of contiguity; their habitual comparison through relations of resemblance; and the habitual perception of constant conjunction of cause and effect that allows one idea (that of the cause) to always evoke another (the effect). Perceived contiguity, causality, and resemblance, as relations of exteriority, constitute the three principles of association that transform a mind into a subject. (DeLanda 2010: 34)

Hence habit and routine, as well as language and social structure, enable subjects to form a sense of identity on the basis of which they can then relate to others. Social encounters, often in the form of ritual, can also be treated as assemblages. DeLanda says that network theory can be used to analyze how wider relationships form, and to measure the strength and frequency of contact. Church attendance or involvement in related activities would be a good example of this. Just how deep or intense do such relationships become and how much of this depends upon the degree of continuity of contact over time?

This is a crucial question when it comes to talking about spiritual and religious capital as sources of motivation for faith-based practical activity. Without going into further detail at this stage, what I would argue is that DeLanda's concept of assemblages, similarly to Bryant's of machines, enables a more complex and creative means of analyzing and interpreting the role of human agency, not only in relation to other humans, but also in relation to the non-human, be that animate or inanimate. It offers the possibility of contextualizing human action and decision making so that one can see that lone individuals are both impacted by the other components of specific assemblages and themselves have an influence upon them. It is the individual in relationship who is the subject of human agency, and that relationship can be with places, institutions, rituals, norms, and any section of the wider environment as well as with other humans. The collective of the specific assemblage is the appropriate focus for understanding human agency, and one has to examine each of these in detail to grasp what is happening. Assemblage theory is an aspect of New Materialism that has much to offer to the current discussion.

6 The Digital Ape

A final contrast with the more traditional Enlightenment interpretation of the human being as an autonomous and essentially reasonable and reasoning individual is to be found in Shadbolt and Hampson's book *The Digital Ape* (2019). It is worth a brief reference simply because, on the surface of it, its ideas and recommendations seem eminently sensible and difficult to argue against. In their concluding section, Shadbolt and Hampson (2019: 312ff) present what they describe as a series of bold assertions summarizing their argument in the wider text. Amongst these are: we have the right to make choices, enhanced by all the technical means available to us.

Such complex decisions involving large numbers of people require better descriptions of the world presented in terms we can understand. 'We need better presentation of "facts", true and imaginary, by politicians and others' (312). Agreeing with Veliz (2020) they also say we must take back control of our data, challenging the dominance of the big tech companies who hold too much of a monopoly of data collection and storage. We have a right to understand government policies in ways that enable us to make informed decisions, and also to understand the meaning of technological innovations in advance of their impact. Again this would require that we have all the facts available to us in order to understand the very devices now so central to our normal lives.

All of this does seem perfectly reasonable and sets objectives worth pursuing. We are responsible for our own destinies and have to take control, as best we can, of the processes now determining so much of our lives. 'We should regard the present emergence of hyper-complex systems as an equal threat' (to global warming and climate change) (Shadbolt and Hampson 2019: 313). Digital rights need to be encoded within the wider sphere of human rights. Data sets should be much more open to the public, competing institutions, corporations and groups, except where the data relates to individuals. Self-designing and self-reproducing machines, should be subject to the same moral and legal frameworks that we currently apply to medical research, cloning and biological warfare (314). Finally: 'we must define reasonable limits for the collection and analysis of information' (314). Presumably this would be essential in the field of the biodigital as we have already learnt. In other words, by exercising reasoned judgement with all the necessary knowledge about the digital technologies available to us, we can construct the legal, moral and governance frameworks within which we can protect ourselves against the dangers of both the technologies and their possible applications in harmful and damaging ways.

Nothing could seem more obvious and reasonable. The problem is, as with Veliz's (2020) proposals, much of this is already too late. To regain control of our data now is such a complex and massive undertaking that it is unlikely to be even attempted by all but the technologically skilled and enabled few. Everything else on the list of requirements comes down to matters of regulation and governance, relying on statutory authorities themselves connected to government departments or funding. How much of this is anything more than 'ethics washing' aimed to pacify objectors by arguing that all of this is now being properly dealt with, by experts of course. Those of us without the technological expertise or access to the information, are largely excluded from such processes. Functioning as reasonable and autonomous individuals will not be adequate to the challenges. For as long as we continue to consider ourselves as separate from the human non-human assemblages of which we are always already simply components we will lack the conceptual framework necessary to address the problems so eloquently identified by Veliz, Shadbolt and Hampson, and others in the field.

7 Braidotti on Posthuman Knowledge

What other sources are available to assist in constructing such frameworks? One of these is Rosi Braidotti (2019), herself drawing heavily on the work of Deleuze and Guatarri as do Bryant and DeLanda.

Central to her argument is the position that rather than understanding ourselves as lone autonomous individuals, we need to understand that we are essentially relational beings. 'Posthuman subjects are a work-in-progress; they emerge as both a critical and a creative project within the posthuman convergence along posthumanist and post-anthropocentric axes of interrogation.' (Braidotti 2019: 41) The influence of feminism is also evident in this argument as: 'bodies are both embedded and embodied, and have relational and affective powers' (42). As such we are capable of different things and different speeds of becoming. This is in contrast to the liberal Enlightenment view of the human subject, as subjectivity is both pre-personal and pre-individual, relational and in constant negotiation with multiple others. The challenge is to redefine the subject of knowledge and power without reference to the unitary, humanistic, Eurocentric and masculine subject. A vital neo-materialist philosophy is what is required for this task.

The concept of affect is central to this. The capacity to affect and to be affected is not to be reduced to individualized emotions, and has to be de-linked from individualism in order to take into account the complexity of our human non-human relational universe. Life is not exclusively human, but part of a thick and dynamic web of interconnections. Posthuman subjects establish relationships on three levels: to one's self, to others, and to the world. Agency is not the prerogative of the human alone. It is also no longer linked to classical notions of transcendental reason, and then consciousness is now not associated with the view that understands the rest of the created order as separate and distinct. In other words, this is another version of the distributed agency proposed by Bryant and DeLanda. 'This means that the posthuman subject relates at the same time to the Earth – land, water, plants, animals, bacteria – and to technological agents – plastic, wires, cells, codes, algorithms.' (46) This posthuman convergence as Braidotti terms it is already upon us, and far from being a terminal crisis is productive, dynamic and inter-relational. This should enable humans to fully participate in struggles for social and political justice through a commitment to an affirmative ethics.

Whilst the theory sounds appropriately radical what are the practical implications? What difference does this make to our understanding of human intelligence and how it functions? Braidotti (2019: 62) is clear that intelligence is not an autonomous computational capacity and not the same as speed of thought. It is rather the result of a multitude of social, environmental and psychic factors, and indeed matter itself is a self-organizing totality to which we all belong. She refers to MacCormack (2014) who has argued for a new natural contract that would neither torment nor fetishize non-human others. He argues that we should deploy forms of imagination that go beyond species hierarchy and the dialectical habits of thought that have defined our relationships to animals. Abolishing the category of the human is supposedly the answer.

Braidotti further claims that this also links to the notion of becoming as derived from Deleuze and Guattari. Distinguishing as they do between the actual and the virtual is pivotal for the development of posthuman knowledge. 'By positing a time continuum as a process ontology of becoming, the practice of social and cultural criticism of the current crisis can be supplemented by the more affirmative project of constructing sustainable alternatives.' (64) As was suggested at the outset of this chapter, the future is here and now and so there is no time to waste. The danger of the apparently reasonable governance-based approaches is that it is already too late by the time these are formulated, agreed, and implemented as both the non-human and the human as components of human non-human assemblages have moved on. As Braidotti (2019) argues, we need now to grasp what we are ceasing to be and what we are in the process of becoming. Critique has to be not just that of what has become but of that which is still in process of becoming, and critical thought needs to adapt to this dynamic in a non-linear mode. It is the becoming component of biodigital becoming that must be acknowledged and addressed.

8 Conclusion

Having examined a number of different responses to the issue of how to approach current developments in the biodigital sphere and identified in particular the weaknesses and limitations of those that rest upon traditional understandings of both autonomy and reason, one can conclude that they need to be replaced by expanded or augmented concepts linked to ideas such as distributed agency and a view that allows for becoming, evolution and development. If neither regulation nor governance meet the requirements of being able to intervene at earlier stages in the process of developments within the biodigital, then a willingness to engage the assemblages of human and non-human that constitute this field must become the norm. In this way a new philosophical conceptuality can have a positive and necessary impact as we strive to come to terms with developments that could easily outrun the human capacity to construct an ethical engagement with a world in danger of running out of control.

In particular one can argue that what now comes to the surface are possible criteria by which to evaluate emerging responses to this bioinformational convergence. First, do the concepts of reason and human autonomy being employed allow for the impact of affect and the embodied and embedded nature of the processes by which humans do in fact base their assessments of what is acceptable in terms of these new developments? If not then humans are operating with a limited and restrictive interpretation of what it is to be human. Second, do they take into account the view that reason itself is always in process of evolving and developing, so it is itself becoming rather than something fixed and static? Then, following on from this, exactly what trajectory is becoming evident in such evolution, and is it the case that reason as an aspect of the human non-human assemblages of this bioinformational convergence enables the critical public questioning of developments in advance of the regulation and governance which tend to come too late upon the scene when key decisions have already been made and policies formed? If not then it is likely that the die has already been cast and that what is presented to the wider public is no more than a form of ethics washing. There is surely too much at stake to allow this to be the dominant response.

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Reconceiving the Digital Network: From Cells to Selves

Mark William Johnson, Elizabeth Maitland, John Torday, and Sebastian H. D. Fiedler

1 Introduction

When Camillo Golgi looked down the microscope at neurological tissue and drew what he saw, he observed the material result of an evolutionary process (Golgi 1883). That result manifested itself in root-like complexes which Golgi assumed were a continuous 'nervous system' – effectively, a wiring diagram that became known as the 'reticular theory' of the nervous system. This view was challenged by Ramon y Cajal a few years later (Cajal and Azoulay 1894), who proposed a discrete form of organization involving a kind of cell, the neuron, which established connections involving specific cellular components and behaviours (dendrites, synapses, axons). Yet, both Golgi and Cajal were examining material results of a process of cellular organization and interaction that produced the images, but neither asked what process might produce the material constitution of cells, neurons, synapses, dendrites and axons. In the subsequent development of the understanding of networks, through to the present-day architecture of the Internet and artificial neural networks, focus has

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fallen on the creation of abstractions about this end-process, rather than considering the underlying mechanisms that must be in operation for a network to form in the first place. In the mathematical abstractions of networks which emerged in the 1930s, questions about the origin and growth of networks in biology were overlooked, and in their place, an assumed principle of ‘wiring’ took hold.

We argue that while this error of abstraction has led to some very powerful technologies that are transforming the way humanity organizes itself, something is clearly wrong in the technical world that we have built for ourselves: hoped-for liberation, cooperation and equality have not materialized. It seems that our abstractions have increased the gap between the way nature works and the way people think. The connection between biology and physics was one of the foundational principles at the beginning of cybernetics. The theory of networks which grew from this work, derives from research in mathematical biology in the 1930s, that underpinned early work on the central nervous system, pioneered by Rashevsky, Pitts and McCulloch. Despite the huge impact of this theory – which includes the Internet and machine learning – the role of the cell in the origin of networks has been lost. We argue that this exclusion of the micro-foundations of networks in cellular dynamics has far-reaching consequences, not just for learning, but for how we conceive of the Internet – particularly in the analysis of network connections between nodes, and how this is attributed to the viability of a ‘networked society’, a ‘knowledge economy’, or knowledge itself. Networks are epiphenomena of cellular development, where the ontogeny and phylogeny of cellular evolution play a critical role in the ongoing processes of network formation and development as cellular niche-construction and the endogenization of the environment. By omitting these biological cellular processes, the mathematical model of networks ill-fits life processes and, with them, learning processes.

In this chapter we consider a deeper ecological view, wherein we situate both ourselves and our technologies as manifestations of nature. We focus on the biology of this situation, and the mathematical abstractions we have made from biology that have contributed not just to the creation of the digital computer, the Internet, Artificial Intelligence (AI) and social media, but also to many aporia, which appear under the heading of the ‘biodigital’. Of these aporia, attempting to grasp learning by superimposing an abstracted notion of a network onto biology and communication seems obviously to be an epistemological error.

The chapter begins by first considering the cybernetic origins of modern network theory, alongside the concerns of the early cyberneticians about the misappropriation of the cybernetic insights. In highlighting progress in cellular evolutionary biology, we frame a more authentically biological (and indeed, more cybernetic) example of ‘connection’ around Vygotsky’s (1978) concept of the Zone of Proximal Development (ZPD). Drawing attention to cellular evolution, we outline current difficulties in explaining biological coherence, morphology, ontogeny and phylogeny. We explain how a cell-based evolutionary biology addresses these problems, and how this in turn entails a transformed conception of biological and human development which emphasizes boundary-maintenance rather than connection. Using two examples, we show how such a model can be both practicable and more faithful to nature when applied to socio-technical systems.

2 Back to Evolution: Cells and the Cybernetic Origins of Networks

One of the founding figures in cybernetics, Warren McCulloch, identified in neural structures circularity in what he called the 'heterarchical' organisation of the nervous system: there was no central point of control. One feature of the neural heterarchy was that the brain exhibited what McCulloch called 'redundancy of potential command' (McCulloch 1988), meaning that the same output could be achieved in many ways. Heterarchy also necessitated a different kind of logic that did not adhere to the Aristotelian Law of the Excluded Middle which is central to classical logic (McCulloch 1945). McCulloch's circular neural logic meant that paradoxical statements such as $A > B$, $B > C$ and $C > A$ were possible. It was this circularity which lay at the foundation of early cybernetics, ideas about self-reference, and provided the common ground where biological systems could be explored through experiments with machines with feedback.

However, while McCulloch and Pitts' initial work on neural networks was epistemologically focused (McCulloch and Pitts 1943), their perceptron model attracted the attention of engineers who created computer models with dreams of improving life through increased automation and AI. This uncybernetic appropriation of cybernetic thinking worried Norbert Wiener at the very beginning of the discipline (Wiener 1950). He later remarked: 'The world of the future will be an even more demanding struggle against the limitations of our intelligence, not a comfortable hammock in which we can lie down to be waited upon by our robot slaves.' (Wiener 1966: 69).

For McCulloch and Pitts, and for many of the early cyberneticians, the dangers of mathematical reduction were apparent. McCulloch himself was stoical in the face of the complexities behind the epistemological problems he saw:

> The inquiry into the physiological substrate of knowledge is here to stay until it is solved thoroughly, that is, until we have a satisfactory explanation of how we know what we know, stated in terms of the physics and chemistry, the anatomy and physiology, of the biological system. (McCulloch 1988)

In the absence of this, epistemological errors were likely, and as Bateson warned, these risked leading to ecological disaster. In highlighting the problems of another mathematical abstraction, the Darwinian evolutionary model, Bateson stressed that:

> Darwin proposed a theory of natural selection and evolution in which the unit of survival was either the family line or the species or subspecies or something of the sort. But today it is quite obvious that this is not the unit of survival in the real biological world. The unit of survival is organism plus environment. We are learning by bitter experience that the organism which destroys its environment destroys itself. (Bateson 1977)

These cybernetic critiques were ineffective in preventing technological distortions of the fruits of cybernetic epistemology. One possible reason for this is that the evolutionary cellular origins of neural connections were overlooked in the cybernetic description. If cellular evolution is admitted, then Bateson's Darwinian criticism would be that the unit of survival is ‘organism + environment + history’. This is to say that cellular evolutionary processes entail the complex elision between diachronic and synchronic processes, between deterministic genetic processes and probabilistic environmental change, where the cell’s priority is to maintain homeostasis within itself, and equipoise with its environment. As Noble points out (2008), it is rather like music. Starting with the cell’s evolution as the origin of life from the perspective of evolutionary biology means that networks are the result of boundary-maintenance processes, where ‘connections’ are a means of self-referencing and maintaining boundaries through a continual and emergent dance within a changing and uncertain environment. As the cell is the single point of reference for all higher forms of bio-psychosocial organization, it is an evolutionary model that can not only be proved empirically at a cellular level, but can be mapped onto the processes involved both in the development of the self through learning, and the maintenance of distinctions between different social organizations in social systems, from kin to families to universities to nations (Torday and Miller 2016). But to arrive at a better understanding of these processes, we have to deal with the consequences of a non-evolutionary ‘synchronic’ view in biology.

3 The Biodigital and Evolutionary Biology

It is very difficult to talk about the ‘biodigital’ without acknowledging significant gaps in our understanding of biology [see for example, Noble (2008), Ulanowicz (2009), Kauffman (2002) or Torday (2013)], alongside huge assumptions about the nature of digital phenomena, information and particularly networks, as they relate to bio-psychosocial organization (Davies 2014; Hui 2016, 2019; Simondon 2017; Kittler 2009). Simply put, there is a ‘biological’ problem and a ‘digital’ problem. Fundamental to the biological problem is the absence of a mechanistic foundation for biological science. The biological sciences have been descriptive of phenomena viewed in laboratories, but lack the kind of predictive framework that chemistry gained with Mendeleev’s periodic table of elements (Jensen 2013).

As has been recently argued by others (Nurse 2020; Noble 2008), this state of the biological sciences represents a historical phase of development that will eventually pass into a more foundational and predictive approach to the nature, evolution and behaviour of cells. A more solid scientific foundation for biology will, we argue, be transformative for education and the social sciences at large. For chemistry, the foundational moment came through the development of a deeper theory connecting electron behaviour, atomic mass and reactivity. The challenge for a more foundational view of biology rests on the empirical exploration of the connection between energy, matter and cells. Our critique of the network paradigm is motivated by an empirically-grounded perspective focusing on energy flow, and not natural selection as the mechanism of biological and cultural evolution.

While foundationalism itself presents epistemological challenges in the social sciences, we argue that building on foundations which overlook cellular communication and evolution is simply to fail to see the wood for the trees. Moreover, it has produced a 'network-oriented' epistemology that would be fundamentally changed with a different perspective on life and evolution. Just as evolutionary principles apply to the cell, and then to multi-cellular organisms, it is likely that the same principles will be repeated throughout biological, psychological and social phenomena. While this may seem abstract, we believe that such an epistemological shift can reveal to us things that we have always known about extreme conditions of physiologic stress such as near-death experiences, Maslow's (1999) 'peak experiences', the runner's 'high', or the exhilaration of a great piece of music or art. Since higher-order phenomena must in turn include consciousness and the complex technological environments we have created for ourselves, a deeper biological theory is also an opportunity to revisit some of the assumptions about digital phenomena, and particularly the 'network'.

4 Vygotsky's 'Connection'

A simple educational example hints at the kind of dynamic that was missed when abstracting the digital network. Vygotsky's notion of the Zone of Proximal Development (ZPD) (Vygotsky 1978), illustrated in Fig. 1, reveals how in a teaching and learning relationship, teachers seek strategies to find ways to establish communication through identification of what the learner knows (the learner's 'actual' development) and what the learner might do with support ('potential' development). In practice, the process of identifying 'potential' will be driven by the teacher exploring different strategies that both help to identify what is happening in the child, and to create a shared context between them in which communication becomes more probable: in effect, the teacher generates multiple versions of the same message. This process, which in biological terms is to create a 'niche' for themselves and the student, is important since as most teachers will know, sometimes learners can be reticent or even recalcitrant: there is a need to create the context which increases the likelihood of effective communication in learning.

The generation of multiple versions of the same message is not mere reinforcement, but the gradual creation of patterns that can be negotiated by both parties. Indeed, Vygotsky points out the importance of imitation in learning, emphasising that imitation is itself the result of developmental capability, and it is this developmental capability which is enhanced by the relationship with the teacher. Like a pattern on a wall, or a regular musical accompaniment, this kind of repetition, which in more technical terms is called 'redundancy' (because strictly speaking, only a single description is enough to convey its information), creates a context – it constrains what happens in relation to it.

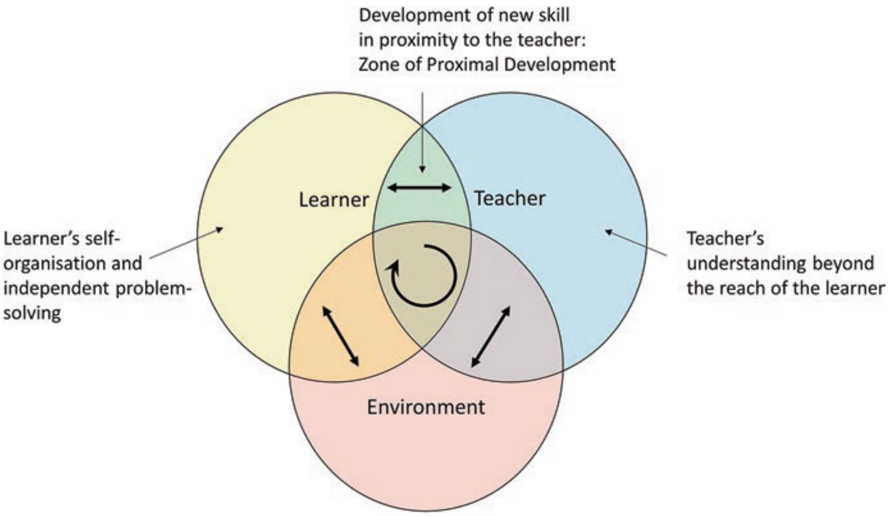

Fig. 1 Zone of Proximal Development as a 3-way interaction between a Teacher, Learning and the Environment

All relationships begin like this. 'Connections' – at least in terms of how we think about them in networks – come later, just as Vygotsky (1978: 90) argues that 'the developmental process lags behind the learning process'. All developmental connections have a 'gestation' in which there is initially an unequal relationship. The niche-building that emerges from it results from this one-sidedness of the communication. The teacher's repetition, and the communication that may eventually arise is produced by the potential difference between the actors. Mistakenly assuming that a 'connection' must exist from the beginning is likely to be interpreted as an 'error', with students being berated for 'inattention'. Rather than facilitating the creation of a niche for communication and growth, authoritarian processes can enforce attention and generate superficial signs of connection, particularly if they are reinforced with technologies of physiological monitoring.

At what point then, do we observe the situation of the nascent ZPD and judge that there is a 'connection' between the teacher and the learner? More specifically, at the point when there is no corresponding utterance from the student, is there a line (or an 'arc') to be drawn between the two? There is, after all, no 'mutual information' – no words that they share, that can be analysed. The production of pattern by the teacher is a sign of what may be to come – and yet there is no guarantee that anything will emerge at all.

A teacher's communications are the result of a dual process, which on the one hand maintains the coherence of the teacher's identity and understanding, and results in utterances (the pattern-making) in the teacher's environment that engenders communication from the student. Returning to the biology of this situation, at the most fundamental level, a cell's priority is to maintain the coherence of its boundary wall, while expressing proteins, which contribute to the making of order and organization with other cells in its environment. As the cell's process of communication is established with the environment, so higher-order processes are invoked which lead to the emergence of more complex structures. In education, we progress from simple concepts to complex discourses. In biology, simple cellular dynamics lead to the establishment of multicellular dynamics, functional differentiation in terms of cell-types and organs, the construction of the nervous system and the emergence of consciousness.

The remarkable thing about both processes of biological development and processes of the growth of communication is that they exhibit a degree of order and control that maintains an ecological balance across species, evolutionary history, and the individual ontogeny of organisms. From the moment that a zygote is formed, and in the earliest stages of embryological development, the division between the myriad of cell types is established, where those cells that contribute to the nervous system are distinguished from those that make up the organs of the body, or those which create the musculoskeletal system. These processes of ontogeny show remarkable similarities across species, as Haeckel (1866) showed in the nineteenth century with his famous aphorism 'ontogeny recapitulates phylogeny'– in other words, at the earliest stages of development, from initial cell division and formation of the 'morula' through to the development of the gastrula where the 'germ layers' in the embryo separate into cell types and functions, there is little to distinguish human from fish.[1] Given that the processes of organization that drive each cell to gain energy, maintain homeostasis and keep equipoise in its environment are in operation everywhere, what keeps everything in order? What determines that the ontogenetic processes are repeated throughout and across species?

5 Why DNA and Natural Selection Is Not a Good Answer

The conventional answer to this question is DNA, and that nature is in some way 'programmed' to create the life forms that are you, me and jellyfish. But as many biologists have pointed out, this is not a good answer because the process of protein expression is not contained within the 'code' of the double-helix alone: while genetics is deterministic, environmental change is probabilistic, and both processes are required for development. Instead, we see an interactive process whereby the behaviour of DNA in generating proteins is affected by the environment. The forms of life result from a dance between the genetic content of cells and the environment they find themselves in. When this fact is taken into consideration alongside

[1] In embryogenesis, 'morula' and 'gastrula' are stages of development. Initial cell division produces the morula, which is a 'berry-like' collection of cells. This then becomes 'hollowed' at the stage of the 'blastula', whose cavity then folds in on itself to form the three 'germ layers' of the gastrula. These three layers – called the 'ectoderm' (outer layer), 'endoderm' (inner layer), and 'mesoderm' (middle layer) serve as the source of cells for the skin and nervous system (ectoderm), the digestive and respiratory system (endoderm), and the musculoskeletal and cardiovascular systems (mesoderm).

Haeckel's (1866) observation that ontogeny recapitulates phylogeny, we are left with the question as to how it is that embryonic lifeforms are common across species, when the controlling mechanisms for those lifeforms must have emerged in very different environments and at different points in history. If fish appeared before humans, then what is the relationship between our fish inheritance and our specifically human development? Moreover, is this historical vestigiality central to our own processes of development and ultimately, consciousness?

The Darwinian answer to this is that evolution occurred by natural selection, and that gradual mutations in DNA produced behaviours that increased the chances of survival. However, this overlooks the organism's behaviour in its environment and the cellular processes that produced the phenotypical change in the first place. For example, starvation of oxygen was instrumental in the development of the lung. The conditions produced by greenhouse gasses in the primeval environment caused depletion of oxygen from the water due to increase in atmospheric temperature, and the stress of hypoxia changes the cellular dynamics so the cells have to reorganize themselves. Lung surfactant lipoproteins in mammalian alveoli present evidence for the fact that it was the swim bladder of the fish that became the mechanism of gas exchange in the mammalian lung. In other words, the cellular phenotype is dependent on the environmental context: the environment imprinted itself onto specific cellular changes – a process known in biology as endogenization.

It is now widely accepted that through recurrent processes of endogenization, cells have acquired a variety of components that were once independent organisms in their environment and which have become part of different cell types (Margulis 1998). In the process, the functional differentiation between subsystems in organisms changes. The once-stable cellular organization of the fish's swim bladder was no longer viable, and was configured to a new function in a different environmental circumstance. But the cells carry their evolutionary history: clues to the lung cell's provenance are available to us through studying the effects of disease. Under stress of emphysema, for example, human lung cells revert back to their evolutionary past and behave as cells in the lung of the frog. Studies of the epigenetic effects of environmental stress such as cigarette smoke show physiological effects in grandchildren of offspring. The imprinted evolutionary history both constrains cellular behaviour and drives it forwards: the search for connection continues the process of endogenizing the environment, maintaining viability and contributing to the coherence of the organism. This networking behaviour is then the product not only of adaptation to present environmental circumstances, but accommodation with cellular phylogeny. The problem with the network metaphor is that in merely looking at the end-result of an evolutionary process, sight was lost of how time and history are tied up with its results.

All cellular development requires energy. Cells gain energy through a process called 'chemiosmosis' and the adsorption of growth factors. The cell's priority is to maintain the coherence of its boundary wall in an ambiguous environment, while expressing proteins which contribute to the making of order and organisation with other cells in its environment. As the process of communication is established with the environment, so higher-order processes are invoked that lead to the emergence of more complex structures. Simple cellular structures lead to the establishment of multicellular dynamics, the nervous system and the emergence of consciousness.

The educational case is similar: complex discourses emerge from initial simple concepts. In the Vygotskian example, it is clear that the progress of sophisticated development takes time in which patterns are established in the communication between teacher and learner. This raises a question about communication as an epiphenomenon of cellular development. The consciousness which sits behind our communications is an aggregate phenomenon of cellular organization implicating billions of cells each type of which carry a different evolutionary history, with different endogenizations within its constitution, where each part of the body has at root some common ancestor. If the seeking-out of ‘connection’ is a process of endogenization that recapitulates every stage of cellular evolution, then the highest order biological functions – consciousness, learning and social organisation – is also an unfolding process that continually references a primeval common ancestry of an initial cell, and its initial processes of adaptation to its environment.

From cellular origins to consciousness, there is a repeated pattern. The cell’s actions in seeking connection are a response to two orthogonal constraints: a constraint from the outside-in, where the cell must balance its development with an environment, and a constraint from the inside-out, where the cell must work within the constraints imposed on it by its own evolutionary history. Between these two dimensions is an underlying fractal pattern wherein past development forms a template for steering future development. In line with the evolutionary biology of Rosen (2005), the cell contains an ‘anticipatory system’: a model of itself, its history and its environment. Such a pattern is discernible in communicative phenomena too, and (as we will discuss) in our social behaviour. But this underlying pattern itself poses the question as to its origins: more basically, that the patterns traced by organic matter in some way are prefigured in the patterns of inorganic matter.

All patterns contain ‘holes’ without which we would not recognise them as patterns. These holes, in turn, must arise through some complex dynamic process which produces the pattern. What are the dynamics that make the nothingness of holes, and are they present in physics as well as biology? Recent developments in physics have drawn attention to how physical laws present a zero totality. Rowlands has shown how zero can be produced algebraically from the complex dynamics inherent in physical systems at Newtonian, Einsteinian and quantum levels of scale. Rowlands has gone further to suggest that if zero is an operating principle uniting the laws of physics, it also appears to be operative in biological systems, where he shows how zero totalities give rise to Fibonacci patterns and the structure of DNA (Rowlands 2014). The underlying logic of networks as a biological process may in turn sit on a deeper logic of zero in physics.

6 The Network Pathology

Networks have become a fundamental paradigm of thought in many and varied disciplines, including biology, cognition, economics, management, sociology, politics and learning. Networks do not just apply to any particular phenomenon (for example, the brain's 'neural network'), but theories have been proposed concerning the ontological and epistemological context of learning and development, with the proposal for network-based analytics of learning (Siemens and Long 2011), or conceptions of knowledge based on distributed connections. In educational technology, the concept of 'networked learning' has provided a theoretical focal-point for orienting understanding of digital learning practices and outcomes. While Goodyear and colleagues' (2005) definition of 'networked learning' as using technology to 'promote connections' was intended as a corrective to naïve interactionist conceptions of educational technology, it glosses over the ontological nature of connection, and particularly the biological roots of its conceptualisation.

In the intervening period from Goodyear's initial definition, 'networked learning' has evolved to encompass a range of different practices and theories in educational technology, from Illich's 'learning webs' (1995) through to Learning Analytics and sociomaterial epistemologies of learning (Gourlay and Oliver 2016). In the midst of this explosion of the network metaphor, 'connection' has become obscured. Is the connection between people in a social network of the same kind as the connection between human and non-human actors in Latourian Actor Network Theory (Latour 2007)? The computer-derived network metaphor, which itself arose originally through biological observation, risks turning our perspective on broader biopsycho-social processes into computer-oriented processes. The under-inspected nature of 'connection' reveals functionalist tendencies in learning analytics (for example) to be underpinned by the same theoretical blind spots as the sociological perspectives of those who critique them.

At the biological level, connections between cells form what we recognise as a 'network' (neural or otherwise), but the cell's growth and development is determined by the balancing of the cell's ontogeny and phylogeny with its environment. The latter contains different proteins and chemicals known as the 'extra-cellular matrix'. Neurons connect by virtue of an internal logic concerning the maintenance of internal homeostasis and the preservation of the cell boundary, as with all cellular connections. This internal logic is missing from the network metaphor, which instead describes the structures that these processes create as an end-product.

Fibroblast cells provide a good (and observable) example. In wound healing, fibroblasts quickly form a network around an injury site that serves the purpose of healing, but to the cell, it is a means of maintaining the viability of the fibroblast. It occurs because the fibroblasts fill in the 'void' created by injury due to their loss of homeostatic control: the stress of the wound threatens the coherence of the identity of the endodermal epithelial cells, causing the reprising of their role in development. The extra-cellular matrix gradually stabilizes the prevailing homeostatic conditions. It's only when structure and function are perturbed that the matrix breaks down in order for the cells to reinstate their cross-talk. This organic process of positive and negative feedback between the extra-cellular matrix and cellular development forms a self-regulating system in which 'connection' is an epiphenomenon.

Similar processes are also a key feature in the development of neurons and their networking behaviour, as specialized cells within the central nervous system and the basic unit of the brain. The internal logic of the cell, however, cannot be simply concerned with the external environment: if it were, its development would be directionless. Direction is provided by feedback and self-regulation by cells seeking stability and homeostasis, which entails an accommodation with cellular properties accumulated through the evolutionary history of the cell. Patterns of development in past environmental conditions are encoded and activated according to present environmental conditions. In other words, seeking homeostasis means re-entering a stable state that the cell 'remembers' from past environments. It may be postulated that this cellular recapitulation is ultimately driven by the desire to re-enter the primordial cellular state.

The fundamental error of the connectionist metaphor is that networks are not formed by networks, but by cells maintaining their boundaries. To lose sight of this is to lose sight of the processes involved in connections that construct niches that make connection possible. As a consequence, applying connectionist logic to social phenomena is disastrous because the biological conditions for niche construction are removed under the assumption that what matters in organisations is efficiency in the connection of nodes and arcs. While information may flow through the wires of cleverly connected units in an organisation, what is removed is the redundancy that is the food of niche construction and network growth. As Ulanowicz (2014) has shown with regard to ecosystem dynamics, what we are left with may be highly efficient in a stable environment, but deeply vulnerable and un-adaptive to environmental change. Connection means loss of information in the sense that organisations with network efficiency lose the ability to process changes in the environment, and generate new models of organisation as strategies for adaptation: redundancy provides adaptability.

7 Skin Brains and Conversations

The neuron has a more fundamental connection to the notion of boundary. This is because the cells that make up the nervous system come from the same germ layer (the ectoderm) as the cells which form the skin. The skin is the primary boundary within which each of us lives. It determines the distinction between our physiology and our environment. The neuron's development from the ectoderm at the gastrulation stage of development is evidenced by the fact that many neuro-degenerative diseases manifest as both skin conditions and as cognitive impairment. In earlier phases of evolutionary development, the skin can clearly be seen as a proto-brain (as in jellyfish, for example). This ontogenetic connection between the skin and the neuron is illuminating because it connects the notion of 'boundary' with both consciousness and with cells. Neural connections form in the context of balancing the ambiguities of the neuron's internalised history alongside the ambiguities of the neuron's environment in the cellular infrastructure of the brain. The logic of neural connection is a logic of resolving evolutionary history with local conditions, and the result of the unfolding of this logic is the creation of higher order functions such as consciousness. At a biological level, the neuron is the most highly developed calcium pump in the body, and this behaviour, which was established in early cell development, is a historical reference to the origin of all cells.

In this way, ontogeny and phylogeny overlap in the process of maintaining the boundary: not only in the underlying forces of nature that drive cellular connection, but in the conscious behaviour of minds that seek connection between one another. While our physiology is distinguished by the skin, our sense of self is bound up with higher-order processes of communication that become the stuff of conventional thinking about networks. But behind every social 'connection' lie deep layers of physiological activity that are themselves bound to constraints accumulated through evolutionary history. What drives the neuron to secrete growth factors is an unpacking of its own ontogeny and phylogeny – acquired behaviours through historical evolution in primordial evolution, which manifest in specific functionally-differentiated behaviours. What drives us to reach out to each other is similarly an unpacking of these same processes at a higher level. At each level, boundaries are defined and maintained, from the lipid bilayer to the self.

In order for any boundary to exist, there must be a process that maintains it. This process must be self-referential in the sense that it must continually balance ambiguity in the environment (external to the boundary) and ambiguity within the boundary itself. In other words, if *A* is the internal ambiguity, and *B* is the external ambiguity, then the self-referential process is: *A* entails *B* and *B* entails *A*. This self-referential process of distinction-making is broadly expressed not just in biology (Rosen 2005) and mathematics (Spencer-Brown 2008), but in sociology. For example, Searle's (2011) social ontology which distinguishes the internal declaration of a distinction in a status function, and the collective intentionality that maintains that distinction.

The boundary-preserving view is the opposite of the connection-oriented view that dominates theories of networks, and associated theories of education, economics, sociology, etc. which derive from them. The connection-oriented view maintains that what matters is the transfer and organization of information across a network. In the boundary-preserving view, information becomes an epiphenomenon of biological processes of self-organisation, where what matters is the continual generation of a niche for survival by individual components. Where networks privilege information, boundary construction privileges pattern, constraint and redundancy.

The Vygotskian example that we began with provides one example of the generation of redundancy, and were such situations to be investigated, the pattern of utterance and the manner of engagement would be observed. However, today's social networks provide a richer foundation for the exploration of boundary-related networks. A self is a boundary, and as Bail (2021) has recently argued, social media behaviour can be seen as an act of preservation of self.

8 Operationalising Boundary Maintenance: Two Examples

The process of creating a niche involves the generation of pattern, where pattern increases the chance of a connection being formed. In other words, niche creation *catalyses* connection. If there is a principal challenge in operationalising a better understanding of networks and their relations to biology, it is in revealing ways in which the autocatalytic processes behind networking can be measured. Attempts at doing this have been made from the perspective of information theory, and (separately) from the perspective of institutional organisation where techniques have been used to identify the 'personal constructs' (Kelly 2013) of individuals in an organisation. Here we discuss briefly these two approaches, and possible fields of application.

8.1 Example 1: Analysing Boundary Maintenance

For many years, autocatalysis has been proposed as a mechanism to explain the dynamics of ecosystems (Ulanowicz 2009) and organic growth (Deacon 2012; Kauffman 2002) and more broadly, self-organisation and niche-construction (Foerster 2003). In economics, Leydesdorff and Ivanova (2014) has analysed autocatalysis using Shannon's information theory (Shannon and Weaver 1949) in work on innovation and development, while Ulanowicz (2014) has proposed similar information theoretical analysis of autocatalysis in biological ecosystems.

Information theory has the advantage of being a relational measurement that takes into account both the foreground of what happens in communication (messages, information), and the background (meaning, redundancy, pattern). As such, Shannon's equations are useful in studying and measuring the degree of self-organisation between entities (Foerster 2003). This raises the question as to whether Shannon's equations can signify the amount of self-organisation between cells (which is the amount of mutual information they share), and whether studying this can present a more accurate picture of the ontogeny of networks.

Behind the different calculi of Leydesdorff and Ulanowicz is the basic idea that there is a hidden 'negative' background behind the observable 'positive' networked behaviour in a system, and that while information theory equations can reveal the positive component of networking in terms of the amount of information exchanged, it can also reveal the 'negative' component – which Leydesdorff terms 'mutual redundancy' (in keeping with Shannon's conception of redundancy), and Ulanowicz calls (more broadly) the 'apophatic'.

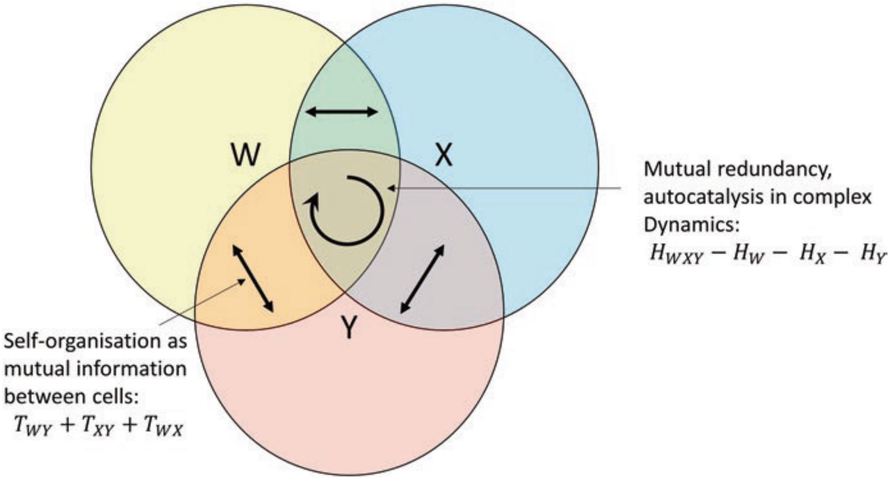

Fig. 2 Leydesdorff's dynamics of mutual information and mutual redundancy in 3 dimensions (adapted from Leydesdorff and Ivanova 2014)

For Shannon, redundancy was a necessary accompaniment to information exchange because no communication situation is free from noise. Redundancy was the added bits of information that effectively repeated or reinforced a message to ensure that it could be transmitted over a noisy channel: it creates the conditions for successful communication. The concept of redundancy interested scholars of information far more than the information concept itself. Bateson (1977), for example, noted that redundancy lay at the heart of meaning-making, and Ulanowicz (2009) goes so far to say that 'the most important thing about information is *not*-information'.

Leydesdorff and Ivanova (2014) produces a measurement of redundancy in a similar three-dimensional situation to that of our Vygotskian example (Fig. 2). He points out that the information exchange, or 'transmission' occurs through the overlaps of pairs of sets, while the 'mutual redundancy' occurs in the complex dynamics between the three variables W, X and Y where they overlap. In Fig. 2 this is indicated where the self-organised transmission information is given as $T_{WY} + T_{YX} + T_{WX}$. Meanwhile, the amount of mutual redundancy which catalyses communication can be given by $H_{WXY} - H_W - H_X - H_Y$, where H is Shannon's measure of uncertainty, which he considered to be a synonym for 'information'.

Leydesdorff's model and metrics are comparable to the model of the teacher and learner in Fig. 1. There, transmission – which is the amount of self-organisation – between a teacher and learner may be initially zero (since the learner may not initially respond), while there may be transmission between the environment and each person. With a low amount of self-organisation observable in communications, the mutual redundancy will in part be increased through the teacher's generation of redundancy in the relationship (saying the same thing in different ways), while the learner's immediate lack of response will also be the result of their relationship with their environment, which produces more options than they have the means to select. The Vygotskian example can be interpreted through Leydesdorff's lens, where the teacher's generation of redundancy gradually creates mutual redundancy between the teacher and the learner (for example, through shared activities, imitation, etc.). This dynamic of mutual redundancy gradually creates the conditions for self-organisation between the teacher and learner. This then produces the transformed self-organisation between the learner and their environment (what Vygotsky calls 'development').

8.2 Example 2: Boundary-Preservation in a University

While the Leydesdorff and Ivanova (2014) example provides a high-level way of identifying metrics of boundary maintenance, in a more practical way, the social and political environment of institutions is something that continually has to adapt to a changing world – particularly in the context of technological change. Organisational change, however, comes down to individuals, their relationships, their views of the world, and how their personal choices relate to organisational objectives. This also relates to the maintenance of boundaries that are formed by the way that each individual constructs their world. Understanding the dynamics of personal constructs can be a valuable tool in organisational development as institutions seek to reorient collective expectations to a changing environment.

Kelly's (2013) theory of 'personal constructs' presents a higher level, but related, perspective on boundary maintenance and individual behaviour. Kelly makes the environment/individual distinction in terms of what he calls 'core constructs' and 'peripheral constructs'. For Kelly (2013: 356), 'core constructs are those which govern a person's maintenance processes – that is, those by which he maintains his identity and existence', while 'peripheral constructs are those that can be altered without serious modification or core structure'. This distinction between core and peripheral constructs also calls for different types of intervention practices. Like Vygotsky (1978), who distinguishes the normative activities of school 'learning' from deeper self-organisation of 'development', Kelly (2013) sees 'peripheral constructs' resulting from normative activities such as school learning, where changes to core constructs are the result of therapy. There is a fluidity between the two, and as with the dynamics in the Zone of Proximal Development, any construct within a personal construct system may turn out to be part of the core structure and its (boundary) maintenance processes, thus rendering original assumptions on its peripheral nature and relative permeability (via intervention and communication) surprisingly invalid.

Kelly devised techniques for analysing personal constructs, and some of these techniques – particularly the 'repertory grid' – have been applied to personal development in education (Harri-Augstein and Thomas 2013), and to institutional complex dynamics (Kruse et al. 2020). Universities are organisations of people in functionally differentiated roles, where personal constructs define boundaries maintained between departments, responsibilities, discourses and positions. Individually, what is observed as pattern at a social level is the result of balance between environmental conditions (which in a social setting are communicative conditions) and internal conditions determined by physiology and what might be termed 'psychic' conditions (Luhmann 1996). As a result of this balance, communicative utterances result from selections, and as Husserl, Schutz, Luhmann (1996) and Parsons (2012) have emphasised, whatever is selected is done so according to sets of expectations about the environment: what Husserl calls a 'horizon of meaning.' For Kelly (2013), a personal construct is a means of anticipating the environment: the summative result of accretions of experiences, judgements, accumulated over time.

Understanding personal constructs as boundary-making processes highlights some of the organisational challenges in universities that result from uncritical thinking about networks. As Hayes (2021) and others have commented, obsession with metrics, rankings and KPIs in institutions create expectations around abstract mathematicisations of performance, rather than deeper phenomenological understandings of the boundary-making processes that result from both physiology and psychology. Since metrics exclude the processes whereby the conditions for richer connections are formed, this can lead to a transactional emphasis in the institution, which privileges connection over niche-construction. Consequently, those functions within the institution concerned with creating niches are threatened in favour of what are perceived to be efficiency measures.

The dynamics of this can be drawn with a simple example. In a Faculty of Law, there can be imagined tension between upholding the traditional discipline of Law, and the emerging importance of technology in the legal profession. Some in the Law faculty will wish to update the curriculum, introducing AI and technology law to students, while conservative forces will wish to keep such things at bay. The two groups can be considered to be identifiable in the differences between personal constructs. And the dynamics between personal boundary-making processes have an effect on higher-level boundary processes.

This is shown in Fig. 3 as a cognitive map (Eden and Ackermann 2004) of different groups within a Law faculty. The shaded part of the diagram, A, illustrates the principal tension between conservatives and digital enthusiasts. The arrows between them indicate how one group influences the other. In this case, 'digital enthusiasm' accentuates the 'conservatism' of the study board, while the conservatism accentuates the sense of urgency among the digital enthusiasts. Feeding into this core dynamic are many other agendas that serve to uphold this dynamic. For example, the need for students to be employable after their studies can be translated both into a need for digitalization and a need for conservatism (in what is still a conservative profession). Meanwhile, the growth of Law-tech as an industry reinforces the basic opposition, in that it is opposed by conservatives, and supported as key evidence by digital enthusiasts.

Processes of constructing the world are the result of balancing environmental conditions with the internal constraints of psychology and physiology, where each carries a memory of history – both biographically, and at a deeper physiological

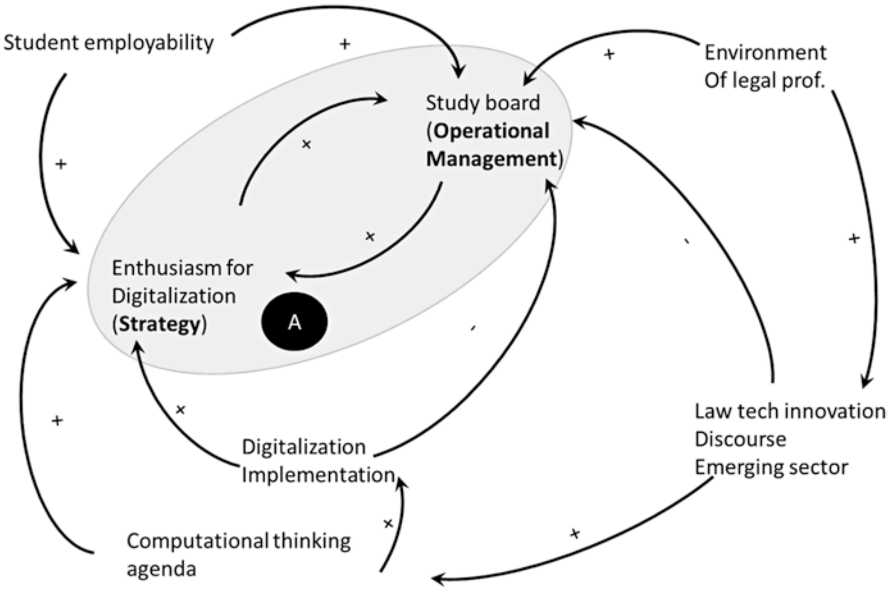

Fig. 3 Institutional tensions between expectations in different groups in the Law faculty at one of the authors' universities

level. At a psychological level, personal construct analysis can shed light on how individuals perform this balance in different circumstances, and with this understanding it is possible to make interventions in the environment of those individuals to potentially change the way their own internal balance is maintained.

More deeply, the process of boundary-maintenance goes deep into physiology and evolutionary history. As Schutz (1951) points out, communication occurs through a process of 'tuning-in' to the inner-world of the other. Since each of us has a shared physiological history in our cells, those interventions which go 'deepest' are experienced as the most 'visceral', where physiology and psychology meet. This is the domain of Kelly's 'core constructs' (2013) where interventions are likely to have the most powerful effects. For the ancient Greeks, it was theatre and music. For us, art remains powerful, but we have many more ways of profoundly affecting one another through social media, machine learning and powerful graphical representations.

9 Conclusion

This chapter has made the case for a deeper understanding of evolutionary biology as a foundation for the way we think about networks. Alongside the evidence of cell behaviour under conditions of disease and similarities across species, all of which point to mechanisms of boundary maintenance rather than 'connection', we have also pointed to similar processes of niche-creation in learning processes, institutional organisation, and have suggested methods for their measurement. We have made the case that thinking about networks from the perspective of evolutionary biology can be transformative in the way we think about technology and social organisation, and a foundation for new kinds of socio-technical designs. Embracing niche-construction in learning and institutional adaptation places creativity and aesthetics at the heart of intellectual development. On this point, cybernetic theory and ancient educational wisdom meet. It is what motivates both the simplicity and beauty of Comenius's *Orbis Sensualium Pictus* (1658/2018), and Gregory Bateson's emphasis on seeing the inquiring and creative mind as nature (Bateson 1980).

To overlook cellular evolution in thinking about networks – whether digital, neural or otherwise – is an epistemological error. We have suggested that this error acts as the root cause of the many pathologies of technology and organisation today. Neither are the many critiques of technology, society and education free from this foundational epistemological oversight. We have argued that the deep problem lies in the biological sciences, where descriptive science lacks the ability to provide mechanistic and predictive explanations of biological phenomena, and by extension social phenomena. A holistic evolutionary perspective which is empirically grounded, focusing on the cell as the origin of life can correct this error. Given the historical development of chemistry from description to mechanistic explanation, we consider it likely that biology will eventually follow the same path, while current positivism around 'neural networks' will eventually be discarded as a kind of biological alchemy.

More broadly, scientific progress is dependent on institutional conditions: like life, better science requires a niche in which to grow. There are ways in which the conditions for better science can grow alongside better institutional organisation. The application of novel ways of examining niche construction in communication and institutional organisation can be part of a process to establish more supportive niches for new experiments and evidence-building. At the same time, in pedagogic practice, just as Comenius (1658/2018) exploited printing in his seventeenth century picture book, so today's technology presents previously unimaginable opportunities for creative expression and aesthetic experience. We have suggested that the combination of existing analytical techniques focused on problems of socio-technical and pedagogical organisation can move us towards a position where the destructiveness of our current epistemological errors can be addressed.

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On the Collective Algorithmic Unconscious

Joff P. N. Bradley

1 Introduction

In the final years of his life, Bernard Stiegler (1952–2020) took stock of the pharmacological possibility (poison and cure, breakdown and breakthrough) of humanity's collective intelligence by turning to Russian geochemist Vladimir Vernadsky (1863–1945), Jesuit priest Teilhard de Chardin (1881–1955), and biologist Alfred J. Lotka (1880–1949), among others, to account for the biosphere or history of organic life on earth and to consider their respective senses of the noosphere[1] or 'terrestrial sphere of thinking substance' (Teilhard 1969: 151). For Vernadsky (1945), the noosphere – the 'terrestrial zone containing life' – was construed as negentropic *living matter* acting upon the earth – a process which resists or slows entropy, and in Teilhard's theosophy or terrestrial Gnosis, especially in his *Le phénomène humain* [*The Phenomenon of Man*] (1955), it was deemed 'the skin of the earth,' destined to reach a final spiritual Omega point. What Stiegler took from this was to envisage the noosphere as symbolising negentropic possibility or

[1] The noosphere – literally mind-sphere – is a concept which emerged in Paris, 1926. The mathematician Édouard Le Roy, French philosopher and student of Henri Bergson, Pierre Teilhard de Chardin (noosphere as 'thinking layer of the earth'), and Vladimir Vernadsky are all connected with elaborating upon the idea. It is said the idea was raised at the Sorbonne University in the 1920s. The noosphere concept sees life on Earth as a unity constituting the biosphere and geosphere, with the consciousness of life as a unity discontinuous but coextensive with life itself. It describes life's terrestrial evolution, which subsumes and transforms the biosphere. The human is *living matter realised* according to Vernadsky.

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bioinformational resistance to the entropic tendency of information as it is now disseminated on the World Wide Web.

Thinking the passage and connection from the biosphere, noosphere, to the technosphere and beyond, to the exosphere (exospherical control technologies or *Gestell* – the ring of satellites encircling the globe), Stiegler began to talk of the noetic necromass as emerging from the exosomatic humus, that is, dead living matter or humus housed in vast archives, ancient libraries, schools and universities, in other words, concrete forms of human knowledge or tertiary memory retentions stored and passed down the generations. He foresaw the necessity of a 'battle of intelligence' to retrieve from the noetic necromass the 'improbable' possibility of producing negentropic knowledge or positive bifurcation. For him, negentropic knowledge or positive bifurcation was a sign of resistance to the homogeneity of thinking, a means to slow the entropy or break up of knowledge. Positive bifurcation was a line of flight that somehow escaped the codification of established paradigms and patterns and could not thereby be anticipated. It expresses the singular as such. Stiegler was increasingly critical and pessimistic about the entropic tendency of Big Data corporations, so-called platform capitalism, and the trend towards algorithmic governmentality, which he claimed destroyed creativity and the possibility of difference as such. For Stiegler, the World Wide Web in its current iteration was destroying human knowledge through processes of homogenisation and standardisation through the reliance on algorithmic decision making.

For Stiegler, 'the astral figure of humanity' (Stiegler 1998: 89), the project of the becoming-astral of man, the spiritual elevation of (hu)mankind, was imperilled by this tendency. From my perspective, the promise of collective intelligence (Lévy 1999) is being derailed by a toxic, stupefied 'collective algorithmic unconscious' (my suggested concept to explain the mental ecology of the moment) – a process which appears hell bent on disseminating mental pollution of the very worst kind. Through his reading of Gilbert Simondon, Stiegler is at pains to stress that what is at risk is the destruction of the psychic and collective individuation, and with it the collective transindividuation of the noetic necromass. Due to widespread digitisation, Stiegler was concerned that 'the astral figure of humanity' was being transformed into a monstrous figure of posthuman becoming.

2 The Mechanosphere of Collective Intelligence

Writing in the 1980s and early 1990s on the cusp of the digital computer revolution, the psychiatrist and philosopher Félix Guattari discerned the opening up of 'new universes of reference' (*nouveaux univers de reference*) (2013) or universes of value and through them the transformation of perspective and scale. Simply, computer-mediated environments engineered new ways to perceive the world. Yet several decades on, critics claim, and we can include Stiegler among them, that such universes of reference have been handed over to the marketing industries and information technology experts, with disruptive and deleterious results on the human imagination (Bradley 2020a; Bradley and Kennedy 2021).

The claim is that if we are given entirely over to information there is a corresponding deficit of knowledge production. According to Husserl, knowledge production has been the traditional preserve of 'the functionaries of the humanities' (Steinbock 1994: 585–584), of which philosophy is pivotal. Yet without pedagogical curation, without therapeutic and curative care by the functionaries of the humanities or the archivists of the knowledge (*savoirs*), what we are left with is collective amnesia, a forgetting of the noetic necromass, a crisis of the memory or what Stiegler calls the *mnemosyne* as such (Bradley 2021b). This is a diminishment of the improbable, or 'the unhoped-for coming of the immemorial' (Stiegler 2018).

3 Algorithmic Collective Unconscious

The grave consequence of this crisis of memory is that if less and less knowledge is passed down the generations, there is a corresponding disindividuation process, that is the proletarianization of knowledge, the loss of the *savoirs* – knowledge of how to do, to live, to think, to philosophise, and at its most extreme – with half of humanity now online across countries rich and poor – a vast planetary, collective unthinking. Through the severance of transindividuation circuits, Stiegler argues there is an emergent schism between the generations, a radical forgetting of knowledge and history, a dangerous forgetting of what is held in common, a disruptive forgetting of what it means to be human. Society as a consequence becomes more and more uncontrollable (Stiegler 2012) and life, more and more unliveable and more and more brutal and short.

It is indeed clear that biodigital and other advances are fundamentally altering what it means to be human and philosophical knowledge is less central in debates about the future of humanity. But there remains an agon of authorship over the future of the humanities of which philosophy is much involved. Let me point the reader to the remarks by the late Stephen Hawking who, in *The Grand Design*, pronounced that scientists 'have become the bearers of the torch of discovery in our quest for knowledge' (Hawking and Mlodoninow 2010: 5). In other words, philosophy is dead as science has answered all the metaphysical questions of (hu)mankind, of which 'what is it to be'? is pivotal. This rather provocative viewpoint comes only a few years prior to the World Congress of Philosophy[2] held in Beijing, China, 2018, where some 7000 scholars from across the globe met and discussed with humility the conference theme 'Learning to Be Human.' That philosophers still ruminate on the nature of the human in the time of technological advance strikes me that Hawking's dogmatic manifesto might be somewhat premature.

[2] See http://wcp2018.pku.edu.cn/yw/index.htm. Accessed 29 March 2021.

In this impasse of knowledge and reason, Stiegler's own antidote is to ask of the possibility of new forms of intellectual openness or negentropy – a kind of philosophical glasnost, if you like. For Stiegler, negentropy – the improbable as such – is a way to bring openness into the world and to resist its closure. Without openness nothing singular or exceptional enters. Faced with this prospect, what arguments can be made for the negentropic potential of human intelligence found in poetry, art and philosophy – in the humanities as such? What is the strength of the argument regarding the radical reorganisation on the World Wide Web, of information sharing and knowledge production? What does it mean to say as Stiegler argues that we must simply return to the 'base of knowledge' (Stiegler and Sloterdijk 2016)? To answer these questions let us turn to a critic of Stiegler's philosophy in the first instance.

4 On Collective Unthinking or Planetary Bêtise (Stupidity)

In *Morphing Intelligence: From IQ Measurement to Artificial Brains*, Catherine Malabou speaks of the necessity and prospect of building emancipatory forms of knowledge and the necessity of an 'emancipatory political vision of a cybernetic being … We must therefore work to build a fair and emancipatory political vision of a cybernetic being – together, bringing the relation of the two intelligences – natural and artificial – to its greatest affinity' (Malabou and Shread 2019: 123). Noting that French philosopher, cultural theorist and media scholar Pierre Lévy continues to foresee the possibilities of new educational configurations which might allow for the redefinition of the concept of collective intelligence itself, Malabou writes:

> Many sociologists and philosophers engaged in research into distance learning and web classes… believe that new educational configurations will allow us to redefine the concept of intelligence by breaking with the single-IQ model and opening it up to a wide variety of individuals very different in terms of age, nationality, language, expectations, desires, and pacing. (2019: 123–124)

Like Lévy, Malabou affirms the transformation of collective intelligence itself – both artificial and natural – even as it passes on to automatism and beyond. Her question concerning the future of education is a timely one as she asks: 'How can the "universal without totality" of cyberculture and collective intelligence be distributed among the different fields of knowledge without reestablishing new hegemonies and new centers?' (2019: 128). Here it is a question of warding off the new forms of domination which might emerge from extant systems of subjection. What comes from subjection – *subjects*. Malabou's (2020) answer is that Stiegler's criticisms regarding the current iteration of the World Wide Web do not hold up to critical scrutiny, as he does not satisfactorily account for the ambivalent commingling of symbolic and biological life, mind and machine. For her, binaries are disintegrating and fragmenting into ever more complex posthuman compositions. Malabou's point is that we are entering into a new paradigm of knowledge of sorts which is non-representational and more performative, where the human and non-human entangle and become otherwise. Such a paradigm embraces modes of explanation whose logic is human-centred yet more-than-human. Such modes include the post-human, new and relational materialism, agential and speculative realism, decolonial theory, and indigenous philosophies.

Promoting a more productive and plastic sense of creativity against Stiegler's arguably more desperate and pessimistic world view, Malabou affirms the pharmacological integration of artificial intelligence and collective intelligence based on new forms of learning, for example, distance learning, and she suggests that Stiegler simply got it wrong on this question as he failed to note the incalculable pedagogic value of distance learning projects (on the perceived failed promise of MOOCs, see Stiegler 2003). While she finds the possibility of a new educational paradigm of cooperative learning or the 'autodidact society', that is the learning society of amateurs, and while Stiegler foregrounds the importance of curation of knowledge, Malabou is cautious to note the pharmacological dangers of 'technological automaticity associated with cyberspace encourages autonomy' (Malabou and Shread 2019: 126–127). She continues to see much that is positive in this form of autonomy.

Yet while Malabou tempers this enthusiasm, noting and following Jacques Rancière in *The ignorant schoolmaster (*Rancière and Ross 1999*)* that domination is a constant threat as the system of subjection (the *dispositif* – the heterogeneous mechanisms of capturing and transforming living beings into subjects) must itself be necessarily transformed to stop the reproduction of domination itself, she does not address the graver psychological effects of this form of autonomy. In this instance, Korean philosopher Byung Chul Han (2020) and Franco Berardi (2010) offer more compelling and committed views as they explore what is lurking behind such forms of apparent autonomy – that is, the endemic modern problem of isolation and loneliness. Indeed, for Lévy too, social domination is a function of cognitive speed and exploitation of memory (Peters 2015) and thus he is aware that there is much risk in the unfettered unfolding of collective intelligence.

Malabou writes that, '[e]ach individual is free to do as they wish there, to produce themselves and organise their knowledge as they see fit', yet the issue of endemic loneliness, addiction, attention disorders, perseveration (Csikszentmihalyi 2016) are not examined in detail in her work. Indeed, we can say that Malabou shares this overly optimistic vision of cyberspace with Michel Serres, who describes the so-called Thumbelina generation as rewriting the brains in glorious 'incandescent joy' (Serres and Smith 2015: 19): 'The learning process, which has fallen into the box, has left us the incandescent joy of invention. Has this condemned us to become intelligent?'

Furthermore, Malabou shares much with Lévy and his apparent boundless optimism for cyberspace which 'ceaselessly redefines the outlines of a mobile and expanding labyrinth that can't be mapped' (2019: 127). In other words, we can say that she finds much to celebrate in the 'mass collective hallucination' (as William Gibson famously calls it in his 1982 science fiction book *Burning Chrome*) of bioinformational cyberspace which becomes ever more universal, acentered and non-totalisable. Let us now turn to Lévy to compare his extropian vision of collective intelligence before questioning the technophilic and uncritical embrace of cyberspace.

5 Romance of the Rhizome

Long an advocate of collective intelligence and the promise of cyberspace, and especially in his work in the early 1980s and 1990s which influenced his friend Félix Guattari a great deal, Pierre Lévy (1997, 1999, 2001) began to develop several theories including superlanguage, dynamic ideography, the cosmopedia or knowledge space, trees of knowledges, virtual worlds of shared significance. In them he celebrated the possibilities of augmented collective intelligence. Indeed, Lévy to this day remains optimistic about new forms of collective intelligence and enthusiastically describes Information Economy MetaLanguage (IEML) as a tool that utilises and transforms participatory digital memory into open forms of knowledge.

For Lévy, like Stiegler, the task is to develop tools which can resist the homogenisation of the World Wide Web. A new form of 'semantic coordinate system would take the human sciences one step further and increase our potential for collective intelligence' (Peters et al. 2020: 44). For example, IEML is a system for encoding meaning that can augment transparency, interoperability and the computability of operations that take place in digital memory. Lévy contrasts IEML with companies like Google and Facebook which promote artificial intelligence but always on the condition and basis to exploit data for commercial ends. IEML, on the other hand, deploys a semantic open dimension to create and transform meaning as well as its computability. Lévy writes of the necessity of *radical transparency*:

> The crucial condition of this epistemologico-political program is transparency, since this quality supports both the formalisation necessary for calculation and the critical reflexivity peculiar to philosophical humanism. But in this case, it is no longer a question of the ordinary transparency on which we agree without difficulty, but of *a radical transparency which aims at the molecular mechanisms of meaning production: linguistic semantics, interpretation in context, reference operations, coordinated emergence of authority and belief.* (Peters et al. 2020: 39) (emphasis added)

However, in a spirit less critical than Stiegler, Lévy speaks positively of the passage and evolution of knowledge to a fourth revolution in the augmentation of symbolic manipulation. Passing from (1) self-conservation, (2) the manipulation of symbols, (3) the mechanisation and industrialisation of the reproduction and diffusion of symbols, Lévy heralds a fourth era of augmentation and algorithmic acceleration:

> We are now at the beginning of a fourth revolution where a ubiquitous and interconnected infosphere is filled with symbols—i.e. data—of all kinds (music, voice, images, texts, programs, etc.) that are being automatically transformed. With the democratisation of big data analysis, the next generations will see the advent of a new scientific revolution … but this time it will be in the humanities and social sciences. The new human science will be

> based on the wealth of data produced by human communities and a growing computation power. This will lead to reflexive collective intelligence, where people will appropriate (big) data analysis, and where subjects and objects of knowledge will be the human communities themselves. (Lévy 2015: 750)

This progression seems consistent with the perspective of Michael Peters who sees Integrated World Capitalism (a concept of Guattari's) as passing to a fourth stage of capitalism, 'no longer oriented to producing primary (agricultural), secondary (manufacturing), or tertiary (services), but now oriented to the production of (signs, syntax, and … subjectivity' (Peters in Dillet et al. 2013: 377). Such apparent euphoria is clearly at odds with Stiegler who questions the new process of transindividuation, defined as how knowledge is passed down the generations, now seemingly by hand, now seemingly from mobile phone to mobile phone. Stiegler writes:

> Twenty-five years after the Web first appeared, a new process of transindividuation, assisted by networked computers that circulate information at near light speed and passing through exospheric infrastructures, continues to impose itself upon the hundreds of languages that constitute the semantic universe of humanity. (2020a: 182)

For her part, Malabou (2020) is sceptical about Stiegler's pessimism regarding impersonal, unscrupulous, algorithmic power and dismisses the argument that human inventiveness is something unique and somehow able to elude the reproduction or simulacra of cybernetic computation. For her, computers manifest forms of creativity indistinguishable from human creativity and she suggests that inherent to algorithmic power are forms of creativity beyond simulacra, beyond the repetition and predictable outcome of computer code. If this is true, this implies a degree of incalculability which Stiegler (2020a) argues is the sole preserve of the *error* of the human. If so, and miraculously, the inorganic comes to learn to think and to create.

Yet Malabou argues that the contrast made by Stiegler between quantitative 'calculation' and the qualitative 'improbable' does not hold: 'The subtlety of algorithmic calculation today derives precisely from the fact that it is capable of simulating noncalculation, that is, spontaneity, creative freedom, and the directness of emotion' (Malabou 2020: 150–151). On the other hand, Malabou is insistent that the development of artificial intelligence is the most important development in capitalism. It is the future of capitalism itself – the development of intelligence is coterminous with the development of capitalism. And it is here that Stiegler, Lévy and Malabou may enter into fruitful dialogue.

6 Utopian Impulse

Collective intelligence is defined as the capacity to cooperate intellectually in 'creation, innovation and invention' (Lévy in Peters 2015: 259) and Lévy explores how collective intelligence processes can be expanded by digital networks. It is 'a scientific, technical and political project that aims to make people smarter with computers, instead of trying to make computers smarter than people' (Lévy in Peters 2015: 261). Lévy insists that the futural consequences of reflexive collective intelligence cannot be imagined fully today. In *Collective Intelligence,* Lévy affirms the 'dynamic period' from the 1990s to the present, in which cyberspace, a 'mode of creation and navigation within knowledge' (Lévy 1999: 10) has untold ramifications for human intelligence, which is becoming, and borrowing as Lévy does from Deleuze and Guattari, ever more deterritorialised.

As such a new model of humanity beckons. Influenced by Deleuze and Guattari, Lévy speaks of how 'nomadism of today reflects the continuous and rapid transformation of scientific, technical, economic, professional, and mental landscapes' (1999: xxiii). Here, we can find in the description of the deterritorialising vectors of virtualisation an offering of the utopian impulse. Indeed, cyberspace offers 'a new bearing, a new vision, a kind of Utopia: renewal of the social bond through our relation to knowledge' (1999: 11).

7 Noetic Necromass

Drawing on Vernadsky's *The Biosphere* of 1926 and Derrida's *La Vie la mort*, Stiegler derives the concept of the noetic necromass, which might be defined as the residue of biomass, understood as cell detritus, dead biomass, dead organic matter, dead phytomass, but Stiegler understands the concept in the context of the history of intelligence and the history of technics (*tékhnē*). In the time of the psychozoic era, the epoch of Reason, in the geological envelope of the earth, the noetic necromass is the gift of the past, the knowledge of the past, the gift of knowledge offered by the past to the coming generations. According to Ross (2020: 82), we can understand necromass as follows: 'the ancient organic remnants that have been turned from biomass into necromass, at the microcosmic scale forming the humus, and at the macrocosmic scale the pedosphere, which is to say, the set of complex elemental components forming an essential precondition to the continued existence of the biosphere' (2020: 82). For Vernadsky, the biosphere qua totality is formed from the biomass such as trees, animals, virus, bacteria etc. The biomass feeds on the necromass, that is dead matter, with the help of the Sun (Stiegler 2019). This becomes the humus which Vernadsky calls *inorganic organised matter* or dead living matter as such. Now as the noetic necromass for Stiegler is the accumulation and retention of human artefacts and new technical forms, the question is how to access this noetic necromass.

Schools and universities are institutions which can access the noetic necromass because they cultivate new forms of noetic life or knowledge. Stiegler insists the 'mission' of universities is to reconstruct deep attention with digital technologies of spirit and mind. Stiegler's point is that access to such noetic necromass is conditioned by technology and technics and in our time these forms of technology have turned toxic and entropic effectively curtailing the dissemination of negentropic knowledge.

And this is where he is more sceptical about the prospects of cyberspace and collective intelligence than Lévy.

For Stiegler, the distinction between what is properly the technosphere and biosphere no longer holds because what we are witnessing according to his *Nanjing Lectures* (2020a) is a kind of becoming technospheric of the biosphere – a passage to the exosphere, that is the system of low altitude satellites speeding around and above the earth. In other words, a colossal transformation of external memory – what he calls elsewhere the 'global mnemotechnical system' (Stiegler 2015; Bradley 2018) or what we can name concretely as neurotechnologies such as Elon Musk's Neuralink (Stiegler 2020b). Stiegler describes the current state of the technosphere as follows:

> [O] ur situation here and now, that is, in the biosphere in 2019, a biosphere that has become a technosphere, based not on libraries but on data centres, in which markets, along with universities, knowledge, technology and ways of life have all been globalised, and where proletarianisation and denoetisation, too, have become general and widespread. (Stiegler 2020a: 335)

And again tracing the passage from the biosphere, technosphere to exosphere and beyond, he states:

> This recursivity is that of which cybernetic feedback loops are the computational grammatisation, now effected through three billion smartphones spread across all continents of the biosphere, which has thus become a technosphere and an exosphere. (2020a: 293)

Access to the noetic necromass is dependent on technology and the history of technics but the trouble is that the current iteration of the World Wide Web and dominant forms of platform capitalism are destroying the noetic necromass through a process of generalised proletarianisation, a generalised loss of knowledge and skills – a process which 'reduces to dust' the noetic humus, that is the three million year-long transformation of the biosphere into the technosphere through exosomatic noesis – that is the storing of knowledge outside the living being of the human. In *Qu'appelle-t-on panser? 2. La leçon de Greta Thunberg,* Stiegler writes that an integral and generalised proletarianisation – accelerated by platform capitalism 'dries up and reduces to dust the noetic humus derived from the three million years of transformations of the biosphere into the technosphere' (Stiegler 2020a, b).[3] In stark language, Stiegler insists platforms such as Amazon, Google and Netflix have seized dominance and control over access to the noetic necromass and are accelerating its effective desertification. And as such, the noosphere – or world of thinking – is being destroyed, as it is dependent on necromass for its literal intellectual sustenance.

Straightforwardly, Stiegler is concerned that the knowledge of the past is not being passed on to future generations; it is turning to pure dust. The production of knowledge is completely overdetermined by automatisation. This has dramatic consequences because the noetic necromass contributes to the future forms of living noesis – that is, it opens paths toward the future. Under capitalism, the very passage

[3] Author's translation from French.

from the geosphere or biosphere to the noosphere or mechanosphere (according to Deleuze and Guattari and Lewis Mumford) is depleting the noetic atmosphere which emanates from the fertile but equally depleted fund of the noetic necromass.

Here we find a shared interest between Guattari and Stiegler. When Guattari writes that the ‘current crisis of the media and the opening up of a postmedia era are the symptoms of a much more profound crisis’ (Guattari and Genosko 1996: 266) his thoughts resonate with the contemporary moment in which the World Wide Web in its current iteration is precisely experiencing a crisis of its initial democratic formation and promise. For his part, Stiegler along with collaborator Sir Tim Berners Lee has called for a freer, more open and newer reconfiguration of information science, a new kind of communication. The hope is this will ward off a profound mental crisis that propagates endemic levels of Internet and game addiction, social withdrawal and loneliness.

To resist proletarianisation, the capturing of attention by the marketing industries, and the desertification of the noetic necromass, Stiegler calls for the reconstitution of the technosphere through a new pharmacological form of noodiversity – a process of the differentiation of knowledge. This is why he insists we must create dynamic open systems productive of bifurcations and of exceptions. Following Nietzsche’s concern with the thermal and entropic death of the universe with the apocalyptic death of the Sun, Stiegler ruminates on the possibility of a new form of noosphere in the twenty-first century. In the wake of the Anthropocene era, he speculates on the pharmacological possibility-impossibility of a neguanthropic mutation of the biosphere (*une mutation néguanthropique de la biosphere)* into the noosphere or technosphere (Stiegler 2020b).

8 Mechanosphere

Before turning to Lévy and to his philosophical vision in which we find that the future global civilisation could be extensively and irredeemably based on the digital and exospheric interconnection of computers – and from which a new collective intelligence will emerge – let us add a comment about the mechanosphere in Deleuze and Guattari’s philosophy because a distinction must be made between technics (*tékhnē*) and the machinic. Rejecting the dualism of nature and artifice and suggesting ‘biological’ evolution has always been a question of technics, Deleuze and Guattari insist in *A Thousand Plateaus*: ‘[t]here is no biosphere or noosphere, but everywhere the same mechanosphere’ (Deleuze and Guattari 1987: 69; see also Ansell-Pearson 2012: 125). Deleuze and Guattari’s theory of creative involution thus subsumes the noosphere or what we might call the World Brain (Wells 1938; Bradley 2018) under the term mechanosphere. Yet while Deleuze and Guattari find no telos in the noosphere (Lemmens 2018), this fact is important given Stiegler’s recent emphasis on the work of Teilhard de Chardin and Vladimir Vernadsky.

For Genosko (2016: 43), the machine qua concept is not synonymous with Teilhard de Chardin’s (or indeed Vladimir Vernadsky’s or H.G. Wells’s) sense of the noosphere or World Brain because the noosphere or conscious mind, as a skin wrapped around the planet, is more akin to an 'etherialised version of the megamachine' as elaborated upon by Mumford in *The Myth of the Machine* (1970: 314). Yet if Genosko is right to question the idea that the noosphere is part of an evolutionary process not unlike Guattari's machinic evolutionism of 'collective apparatuses of subjectification' then a case can be made for thinking machinic collective intelligence as consistent with the noosphere. Indeed, Guattari in 1992 speaks of the necessity of a 'new planetary consciousness' and a new alliance with machines. This new planetary consciousness is described as a 'mec[h]anosphere surrounding our biosphere' (Guattari and Genosko 1996: 267). In other words, it is less 'the constraining yoke of an exterior armor' but rather the 'abstract, machinic efflorescence, exploring the future of humanity' (1996: 267–268).

9 World Philosophie

Writing on the brink of the new millennium in his *World philosophie: Le marché, le cyberespace, la conscience* [*World-Philosophy: Market, Cyberspace, Consciousness*], Lévy (2000) outlines his future vision of education and celebrates the very best of the human, claiming cyberspace – 'the great planetary virtual society' (2000: 74) – will accelerate the virtual cultivation of the human form: 'Culture has become a single urban fabric, economic, hypertextual, cognitive, techno-scientific, affective. The fabric of meaning gradually finds its unity in the noosphere' (2000: 176).[4] In the chapter *L'éducation du future*, Lévy describes the indefinitely expandable world of the human, and insists that the human is the first species to explore the 'infinity of sounds, images, ideas, tastes, perfumes, deeds, techniques, knowledge, forms of all kinds and the supreme infinity and that includes all others: the infinity of love' (2000: 177).

Cyberspace, collective consciousness, or the noosphere (he cites Teilhard de Chardin several times) can only help to expand consciousness and learning and will aid the conquering of new territories of experience or new terrains of consciousness. By uniting cyberspace and education there will be an awakening of humanity through new forms of accelerated learning which (hu)mankind has yet to witness. Although at times one suspects the euphoria got the better of him, Lévy speaks of the need for a humanistic education of the 'integral being' which can accelerate the expansion of 'the universal consciousness' (2000: 213–214). For the children of the third millennium, Lévy asks what universe of possibility will manifest through cyberspace and the evolving collective intelligence. What will be the consequence and what state of mind? He asks rhetorically: 'Do we want peaceful children? Full of love? Creative? Open? Aware? Evolving? Planetary? Let's just get out of the way

[4] Author's translation from French.

and lead by example. Let us give them the right education that we did not have. Let's innovate' (2000: 179).

This euphoria of vision and paean to capitalism can be compared to Stiegler's bleaker perspective which finds modern society leading to the 'massacre of innocence' (Tisseron et al. 2011). According to Stiegler, while the mobile phone and computer screens on which young people spend much of their free time have both toxic and curative pharmacological powers, it is neglectful in the extreme to hand children over to the whims of the market and advertising as this has catastrophic implications for the capture and domination of the attention of children – for their 'available brain time.' For Stiegler, youth are emotionally and mentally massacred by the advocates of the techno-extropian futural fantasy, that is, those extropian fanatics who idealistically proclaim everything will work out efficiently when we hand over learning to the computer, AI and the marketing industries. In both *Dans la disruption* [*The Age of Disruption*] (Stiegler et al. 2018) and *Qu'appelle-t-on panser? 2. La leçon de Greta Thunberg* (2020), Stiegler decries the experience of youth who view the world without future or horizon, who live without epoch. The desires of youth are clamped down, leading young people to be cut off from the world and leading them to turn into and upon themselves – as testified by the spiralling cases of hikikomori or social recluse in Japan and now elsewhere.

Compare this to *World philosophie* in which Lévy says (hu)mankind – in a kind of process of undermining and overmining (Harman 2016) – now delves into both the deep reaches of the cosmos and the micro universes of energy, of matter, of life itself (see Bradley 2020b). Communication and calculation tools have reached unimaginable levels of penetration and humanity is connected (and connected to the earth) like at no other time in history. There is simply an expansion of consciousness – if you like a self-consciousness of the role of Man by the collective mass of (hu) mankind as such – a fact never witnessed hitherto and of magnitudes which Teilhard de Chardin and Vladimir Vernadsky both affirmed. Lévy says: 'The more we travel, on the planet or in the books, on the Internet or in society around us, the more our mind opens' (2000: 52–53).[5] And again: 'Communication between men have doubled, reflected, multiplied in the interconnection between slowly deposited information in libraries and explodes today in cyberspace. There is only one hypertext document left' (2000: 52–53).[6] Sounding at times close to Vernadsky, Lévy says, (hu)mankind, given its technical and demographic power, has become the main agent of revolution for the whole biosphere (2000: 55).

What is interesting here is to understand Stiegler's philosophy of technology in light of Lévy's jubilant anthem and Vernadsky's geochemist work on the biosphere and noosphere. Why? As Stiegler thinks the noetic necromass in terms of the noosphere, what I want to question is the idea that the noosphere is emergent from the biosphere and the technosphere. All things being equal, is Stiegler a dyed-in-the-wool humanist? Is it possible to find a certain consistency between Stiegler and

[5] Author's translation from French.

[6] Author's translation from French.

Vernadsky on the role of the human in the time of the biosphere's collapse into the technosphere? I offer this provocation because Vernadsky in the 1940s argued that humanity was becoming the most powerful geological force on the planet given its unique consciousness and singular powers of reason and creativity – a view at odds with the more sceptical post-philosophical paradigm mentioned above. With this in mind, it seems that Stiegler reintroduces the concept of humanism – as Vernadsky explicitly does in his late speculations – precisely at the time when the Anthropocene and the posthuman paradigm displace the human figure from its centre and helm.

Sharing this interpretation of humanism, and we can find a sense of this in both Stiegler and Vernadsky, the chief question for Lévy is one of cybernetics and helmsmanship: 'Man leads all the biosphere in a cycle of rapid renewal. Now we dominate the biosphere. But is this we who serve the Earth or the life that uses us to evolve even faster?' (2000: 55).[7] Yet for him with the development of ecological awareness, the noosphere becomes visible in the form of cyberspace: 'Cyberspace is the ultimate metropolis, the world metropolis, the city of humans' (2000: 60).[8] This will continue as (hu)mankind has an 'extraordinary appetite for interconnection, which embraces choice, freedom, solidarity, interdependence and consciousness' (2000: 61).[9] In this apparent paean to capitalism, Lévy says the movement of the intellect, of cultural unification and spirituality would be incomprehensible and impossible if it were not accompanied by the simultaneous movement of world unification through the capitalist market and by the growth of a huge interconnected, planetary technocosmos.

As he says: 'The contemporary economy stems from a dynamic intelligence and collective consciousness and there is no separation of the technical and material activities from intellectual resources and the spiritual spell of (hu)mankind' (2000: 66).[10] The secret of the future human society, for Lévy, is the ability to listen and manipulate the collective consciousness that 'fluctuates' in the millions of channels of cyberspace (2000: 67).[11] Here Stiegler would surely intercede and insist that in Lévy's praise for the market there is no criticism of the marketing industries which capture and ruin desire.

Yet Lévy insists that it is through the new dynamic and circulating marketing industry that collective consciousness becomes aware of itself (2000: 67). As the virtuality of cyberspace knows no boundaries, this suggests for Lévy a dissolution of national and regional distinctions and the emergence of a single, open, plural, nomadic and deterritorialising collective consciousness or multitude: 'When there will be neither Orient nor West, then (hu)mankind will awaken its mind on the scale of collective consciousness' (2000: 153).[12] Indeed, he proclaims there is only one

[7] Author's translation from French.

[8] Author's translation from French.

[9] Author's translation from French.

[10] Author's translation from French.

[11] Author's translation from French.

[12] Author's translation from French.

spirit and humanity of dimensions 'omnidirectional, interior and exterior, East and West' (2000: 153)[13] and writes:

> The more consciousness is awake, the more it is free, the more it discerns potentialities in what is offered to it in contemplation and the more it generates a rich, living world. All of cosmic history is an exploration of potentialities present at the origin. The whole cosmic story is one of creation and it continues to be creation. (2000: 160)[14]

'The unique fire of consciousness' [*le feu unique de la conscience*] like for Teilhard de Chardin, is set alight when humanity reaches its zenith, its incendiary stage, its Omega point:

> Freed from memory by writing, we accelerated the story. Free from reason by computer calculation, we are in the process of bringing together our collective agency until we find out together what is most universal, most eternal and more concrete in the present moment, the light that shines and burns in him perpetually, the unique fire of consciousness. (2000: 170)[15]

All said and done, Lévy understands cyberspace or the noosphere is imperfect, and cannot be the sole panacea for (hu)mankind's woes rather as a gigantic algorithmic device able to deliver knowledge lightning fast, leading to the betterment of (hu) mankind:

> By organising the collective feedback of human consciousness, cyberspace accelerates everything. Conflicts, misfortunes, suffering, there will always be but this will become known more quickly. At least, we will know where we are and we can learn, just in time. (2000: 174)[16]

And again the collective algorithmic intelligence or noosphere will be able to predict or forecast the future. The noosphere will warn of disasters and ecological imbalances through 'the consciousness of Humanity, of Life, of Earth,' a consciousness radiating 'the joy of existing' (2000: 174–175).[17]In Lévy's phenomenologico-Hegelian phantasmagoria, cyberspace or collective intelligence is both subject and Substance. Absolute Knowledge is realised, the virtual and actual become one and the same, and through this process the unconscious gains self-understanding: 'In cyberspace, the collective unconscious becomes conscious, that is to say, it unites with itself, interconnects, defragments and unfolds in the integrated light of the virtual world' (2000: 175).[18] Moreover, the noosphere in its process of complexification is not only Hegelian but Spinozian:

> Imagine a single substance (to use Spinoza's word) turning on itself, bending, organising itself becoming more and more complicated until it produces ever more vibrant, sensitive qualities, then forms consciousness and conscious forms more vast and subtle, to finally

[13] Author's translation from French.

[14] Author's translation from French.

[15] Author's translation from French.

[16] Author's translation from French.

[17] Author's translation from French.

[18] Author's translation from French.

> become aware of itself in the human who concentrates to the highest degree the creative power and the capacity of awareness of this unique substance. (2000: 208)[19]

Following Teilhard de Chardin, Lévy suggests cyberspace or collective intelligence is bound for an Omega point of perfection and love. Like Serres's view of Thumbelina, the biological gives way to the virtual or the noological in full hallucinatory incandescence and radiance. On its way to its ultimate destination, man touches the infinite in creation, perception and love:

> With the emergence of man, it is the universe that ignites and lights up itself… Hence this idea, so well expressed by Teilhard de Chardin, that the evolving cosmos is a sort of 'someone,' who converges on the human… We are not separated from the world. On the contrary, we are the most lively, the most sensitive, the most creative point. (2000: 298)[20]

10 Closing Remarks

Cyberspace or collective intelligence [the distinction seems to dissolve in Lévy's work] is the singularity, an event of creation and destruction which delivers over to the whole of (hu)mankind planetary love: 'As the universe moves away physically in the time of the Big Bang, human freedom takes the human to a spiritual Big Bang that transports him to the dimension of love' (2000: 217).[21] Verily, on this account, man is at his most incendiary stage. This protentional possibility of planetary love is contrary to the perspective of Stiegler who sees the very opposite of love in what I have called the collective algorithmic unconscious. Stiegler highlights the industrial exploitation of the drives by the marketing industries and claims there is an ever growing threat of the planetary-wide dissemination of stupidity (*bêtise*). In the loss of sublimation, there is a danger that desire itself can regress to the level of the drives. And again, from this there is a passage from control to uncontrollable societies. If noetic beings – that is mindful souls – that is those capable of care for the future – regress to the level of the drives the consequences are grave. There is no love only fury (Stiegler 2013), no mindful soul but only the contortion and distortion of desire. Desublimation liquidates the authority of the superego leaving only the 'hideous beast' (*la bête immonde*) (Stiegler 2012: 48).

In view of the question of the promise of collective intelligence, several critical thinkers from the continental tradition have been addressed to offer a necessary riposte to Lévy's sometimes overly optimistic position. Stiegler is a necessary thinker to temper this enthusiasm, as are writers such as Catherine Malabou, Félix Guattari, and Han Byung Chul, because they give greater attention to the pathological effects of collective unintelligence (hikikomori syndrome, addiction, the acting of violence) in the time of new knowledge ecologies. Rather than the collective

[19] Author's translation from French.

[20] Author's translation from French.

[21] Author's translation from French.

unconscious uniting with itself as Lévy says, the collective algorithmic unconscious breaks up, disconnects, fragments, implodes, and becomes ever more impenetrable and unfathomable. The depersonalisation of Freud's conception of libido and sublimation takes us over to a place where marketing holds sway.

With this in mind, it is timely to revisit Lévy's concept of collective intelligence (Lévy 1999) as well as Félix Guattari's affirmation of planetary computerisation in *The Three Ecologies* published in 1989 (Guattari 2014; see Andersen 2016). This is to understand their prescient work historically and to update it to the present moment. This would be to consider Stiegler's grasp of the pharmacological possibility and necessary reconfiguration of the World Brain (Bradley 2018, 2020c, 2021a) or 'global mnemotechnical system'. For in his despair about the current climate crisis and the Anthropocene, the state of education across the planet and the social and mental ills befalling youth, Stiegler, unlike Lévy, was realistic enough to grasp it was largely improbable to believe in a positive bifurcation that could arise from out of the World Wide Web in its current organisation. The improbable for him was a kind of necessary 'miracle,' the incomprehensible according to Deleuze, the singularity as such. For without this miracle, the collective bioinformational noosphere turns day by day into a vast blackhole of collective unthinking, where the 'collective algorithmic unconscious' as I have put it gains greater and greater opacity.

The 'collective algorithmic unconscious' draws out some of the desperate ramifications from the domination of Manuel DeLanda's Panspectron or what we have mentioned above as the exosphere. Manuel DeLanda offers the term Panspectron to describe the social diagramming practice of analytical algorithms linked to databases and networks (DeLanda 1991: 205). From his research on the history of war technologies, he developed the concept of panspectric surveillance and In *War in the Age of Intelligent Machines* (1991) DeLanda explains the concept of panspectrocism technologies as follows, differentiating his concept of the panspectron from Jeremy Bentham's panopticon – the famous diagram of surveillance famously elaborated upon in Foucault's *Disciple and Punish*. DeLanda writes:

> Instead of positioning some human bodies around a central sensor, a multiplicity of sensors is deployed around all bodies: its antenna farms, spy satellites and cable-traffic intercepts feed into its computers all the information that can be gathered. This is then processed through a series of "filters" or keyword watch lists. The Panspectron does not merely select certain bodies and certain (visual) data about them. Rather, it compiles information about all at the same time, using computers to select the segments of data relevant to its surveillance tasks. (DeLanda 1991: 206)

On this reading of the migratory history of intelligence from the human to the technological there is less promise of liberation and more the spectre of domination from the collective algorithmic unconscious. While some thinkers such as the British philosopher Nick Land speculate and indeed celebrate the forlorn drift of collective intelligence into 'efficient decentred communicative networks,' a process which leads inexorably to the collapse of education institutions (Land in Stivale 1998: 95), Stiegler contests this view and demands we rethink the nature of collective intelligence and knowledge as such. We must return to the base of knowledge. I agree and think it is right to question the prospects of educational emancipation and subjection in light of the pharmakon of new knowledge ecologies and hegemonies and the foreboding suggestion of a collective algorithmic unconscious as the question 'Are we more autonomous or enslaved by collective intelligence?' remains desperately unanswered.

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Technē and Indigenous Exosomatic Memory: Heidegger, Stiegler, and Cutting the Gordian Knot of Modernity

Ruth Irwin and Te Haumoana White

1 Worlding as Technology

Heidegger describes 'thrown-ness' as the already existent world into which we are thrown (1927/1962). People learn to navigate the world they are thrown into because of the way others casually use tools. The table is not used as a raft, but rather an upright object that holds other objects aloft. These corporeal interactions often require no language and yet they form the basis for shared cultural understanding and values. The ordinary, adept creation and use of objects, tools, and craft was called *technē* in Ancient Greek. Language, and the names for communal interpretation of things and events, evolve over generations in tandem with these shared, phenomenological, understandings of the world we are thrown into.

Our bodies interact with technologies, accentuating some senses above others. Heidegger noticed that sight is privileged in *modern* technologies, through the telescope, the microscope, the camera, the screen. We can magnify sight and sound to an amazing extent, making it possible to perceive subatomic particles in particle accelerators, to view the universe unhindered by the atmosphere through telescopes like Hubble, and visit the ocean depths in submarines that cope with enormous pressure. These technologies have expanded our understanding of the universe, reaching into arenas that humanity has never perceived before.

Heidegger argues that technologies shape, and are shaped by, perception and experience. *Technē* shapes the way we understand the world we are thrown into, even as they expand the frontiers of knowledge as never before. As technology changes our depth of knowledge about some things, it also flattens and obscures the

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vibrancy and meaningfulness of older, more originary relationships with our phenomenological experience of the external milieu. The fluid cold ocean currents and deep ocean pressure do not impact our breathing (increasing anxiety) or inadvertently carry our body far from an original dive point, when we are viewing the ocean floor on a remote camera screen. Technology changes the phenomenological experience from immediate, multisensory and multi-dimensional to two dimensional images and datafication.

As new technologies reveal new ways of knowing, Heidegger argues that older understanding of knowledge becomes 'forgotten' (1935/1973). The determinism of the scientific mechanics of the universe tends to silence other forms of understanding the world and deepens the alienation between modern humanity and other species, geologies, and strata in the ecological surroundings.

Heidegger (1977) argues that modern *technē* enframes the way that people think. He calls this the technological *Gestell,* or enframing of thought. Modern *technē* is fundamentally different from earlier kinds of cultural technology. Heidegger's work on the enframing of thought, or the *Gestell*, is vitally important to understand why we are so trapped in the progressive ordering/entropy of the Anthropocene. In 1956 Heidegger wrote *The Question Concerning Technology* where he argues that the 'essence' of modern technology has changed significantly from earlier culture (Heidegger 1977). In modernity, the essence of technology 'is nothing technological'.

Earlier cultures had allowed the pace of seasonal change, the natural fall of the river, or the rate of domesticated animals procreation to dictate the rate of production and consumption. These parameters shaped culture and population. In modern times, something profoundly new emerged, which changed the pace of production from one set by seasonal flows, to one set by consumer demand. Heidegger argues that when this transition occurred, *everything* began to be understood as potential reserve, waiting for consumer demand. A river was no longer a water channel, but potential electricity generation. Mountains are reserves of timber, copper, zinc, gold, and other precious metals. People are 'human resources' waiting to be called into the machinery of consumer production. The outcome of this shift in mindset has been a deep alienation of people from the pace and needs of their locale.

Ecological damage goes unrecorded, and if it is noticed, it has been difficult to get newspapers and other media, or major corporations and governments, to register the problems sufficiently to regulate them. The cost-benefit exercise has dominated the discourse of modernity and ecological concerns were an externality to those calculations until very recently. However, other than during the first Covid-19 global shutdown in March – July 2020, there has been no reduction in greenhouse gas emissions.

2 The Anthropocene and the Entropocene

The Anthropocene is a new geological era, that is marked by a new geological strata of micro-plastics which can be found as a layer in the highest mountains, the furthest reaches of the polar circles, and the deepest ocean trenches. The atmospheric changes caused by greenhouse gas emissions, the resource exhaustion and pollution, and the largest extinction event since the dinosaurs died out millions of years ago, all mark this new epoch, dubbed by the Royal Society, as the Anthropocene. No part of the planet, and no human culture, whether they are involved in consumer culture or not, are exempt.

The Anthropocene can be seen as a type of entropy. Entropy is a 'law of nature' that emerged from chemistry, where if two molecules are allowed to mix, they will intersperse until the heat of all the atoms are evenly distributed throughout the available space.

Modernity is characterised by the ordering of order, or the reorganising of raw materials into technological artefacts that are then distributed worldwide by global marketing, production, assembly, shipping and consumption. Much of this accelerated 'development' was powered by cheap and abundant fossil fuels. Soddy (1926) and Georgescu-Roegen (1971) describe this acceleration of raw materials into widely distributed production, and then waste, as an accelerating economy of entropy. Economic growth is entropy by another name.

Alienation and technological acceleration are at the centre of the Anthropocene. Over a hundred years of pouring carbon dioxide into the atmosphere has increased the greenhouse gas effect. Other human-made chemicals, along with the immense damage to biodiversity when mining the raw materials out of the earth, and the failure to consider waste during the design or manufacture of consumer goods, have created widespread destruction of ecological niches all over the planet. The complete disregard for sustainable logging, and industrial agricultural practices based on nitrates and toxic pesticides has decimated soils, forests, and wildlife habitat. While small, localised improvements have been created (UN Decade of Biodiversity) on the whole, extinction and pollution is accelerating (Ripple et al. 2020; Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services 2019). The Anthropocene can be understood as the rapid disintegration of planetary ecology into cascades of entropy and disorder. As Stiegler puts it, the Anthropocene is more accurately described as the Entropocene (2018).

This is a type of 'progress' gone devastatingly wrong. But rather than remain caught in the enframing of modernity, Stiegler suggests we need to seek a negative entropy, or negentropy as an antidote, or pharmakon to reverse the worst impacts of the accelerating Anthropocene.

In response to the dystopian eschatology of the entropic Anthropocene, Stiegler coined the term, the Neganthropocene. Negative entropy is not a well worked out concept, but the idea is similar to photosynthesis, which takes the entropic light of the sun's radiance and converts it from heat into photosynthesis. This reverses the tendency towards a general heat equilibrium of the universe and converts that energy into nutrients for the plant. Stiegler hopes that just as toxins in small doses can have pharmaceutical health benefits, there might be ways of taking broad entropic frameworks such as the acceleration of technology and repurposing it, in small doses, towards a neganthropy. But thus far, the ideal of neganthropy has not fundamentally shifted the modern enframing of thought elucidated by Heidegger, which continues to dominate the modern way of understanding everything. Most communities are subsumed in the modern enframing of thought, and certainly all people, all species, and the hydro and atmospheres are impacted by the Anthropocene.

3 Exosomatic Memory

In a remote village, in the most remote island nation on the planet, Te Haumoana waves his hand towards a steep ridge of straggly trees that scatter up the steep ridge, across the road. 'Those are the Tainui trees.' The grove of ordinary looking bushes glimmer in the westerly evening sun. 'They came here on the Tainui canoe.' 'What??' For Ruth, this was startling. How could those bushes arrive a thousand years ago on the Polynesian voyaging ancestral canoe, the *Tainui*?

This deceptively simple discussion took place in December 2019, when Ruth was in New Zealand and stayed with Te Haumoana for an extensive interview on Māori philosophy and politics (Irwin and White 2019). Our conversation, and this written collaboration, is one between Māori and Pakeha because Te Haumoana is Rangitira of the Poutama tribe, and grandson of the famous 'renegade', Te Oro, and Ruth is sixth generation settler of Irish descent. Ruth's Irwin's family have silenced their complicity in the land wars, which ravaged Te Haumoana's tribe in the 1860s, but no doubt Irwin ancestors participated in these outrages, somewhat further north, in the Waikato.

From Ruth's perspective, my own indigenous Celtic origins are held mistily, perhaps mystically, but really I mean through a fog of half-forgotten gestures and sayings, and a fierce post Christian, and entirely irrational, internalised family antagonism to 'alternative' knowledge, especially meditation, herbalism, or anything that might once have been associated with witchcraft. This active obliteration of our Pagan Celtic roots has in part thrown me back on my Kiwi heritage, growing up with Māori community, the stories, games, language lessons, visits to Marae, and as my interest has developed, I feel incredibly grateful to have gained so much insight through the generosity and wisdom of *mātauranga* Māori; the Māori way of knowing.

For Te Haumoana, this conversation is part of sharing and propagating a better relation with ecology, to disrupt the alienation and antagonism of modern genocides against people and places. His active resistance to new road building through Mt. Messenger, through the courts, social media, and in protests are further examples of leadership, *kaitiakitanga* (caretaking) and public educative engagement.

The story accepted by early European historians was that Māori arrived in New Zealand in the Great Fleet, of seven great ocean voyaging canoes, of which the

Tainui was one. Most tribes trace their genealogy, or *whakapapa*, back to one of these seven canoes, although some tribes claim earlier antecedents, including Poutama, and when Ruth was living in Fiji, locals laughed about continuous visits to New Zealand 'to go raiding'. On its first exploratory voyage, the *Tainui* stopped at various points along the west of the North Island; Kawhia, Raglan, Mokau, as it explored down the coast for good places to settle. Mokau is where Te Haumoana lives, and it is a very old settlement which is proud to host the enormous anchor stone of the *Tainui* canoe, now safely ensconced in a concrete plinth so it cannot be stolen by marauding European museums.

Te Haumoana explained that the enormous, ornately carved prow of the canoe, and the running boards, are all bound onto the dugout hull with vines or *muka* (cf. Johns et al. 2014), were coming loose after their long ocean journey. Somebody pulled the twine out to replace it, and it struck where it was put in the ground, establishing the first grove of Tainui trees (Te Haumoana White, personal communication, December 2019).

Mnemonic devices like the Tainui trees saturate the landscape. Everywhere Te Haumoana and Ruth go are similar stories; the slow growing nikau palms, which Ruth had always thought were endemic, are particularly tall and old in the valley behind Mokau village. Te Haumoana tells the story of how they came here with the earliest Polynesian settlers, and they mean 'no coconut'; *ni* is coconut and *kau* is no. Presumably this palm was important for thatching houses and other uses. It makes sense that these plants also arrived with Polynesians, because New Zealand has no other palm trees. The landscape is full of narrative, creating a living worldscape of meaning.

The Tainui trees tie the locals to the technology of the great ocean going, voyaging canoes. They tie people to a world understood as an ocean full of islands, with the skill of steering the fastest boats in the world via the stars, ocean currents, knowledge of birds, driftwood, cloud formation, and other natural events, which 'point' the canoes towards land, even when it is invisible over the horizon (Lewis 1972; Irwin 2008). Natural events are a rich tapestry of indicators through which the world is knowable. The *technē* of nature constitutes the 'always-already' world which pre-exists each individual (Heidegger 1927/1962).

Techniques of memory are entwined with environment and epistemology. The stand of Tainui trees recalls the origin story for the tribe, where ancestors travelled from Ha'awai'iki, and the trees tie the locals to their ocean and landscape, culture, history and knowledge of the ecological context. Another name for the Tainui trees is Kumarahou, and it is an important medicinal plant. Somewhat astonishingly, Te Haumoana later told Ruth that when he looked up its Latin name on the Internet, he discovered that *Pomaderris apetala* is not from Polynesia, but actually originates in Australia. These trees add to hints of recurring Polynesian visits to the ancient Aboriginal 'grandparents' of indigenous peoples (Susan Moylan-Coombs, personal communication, 2020).

4 The Phases of Exosomatic Memory

Memory is crucial to the generation of thinking and identity. Episodic memory is normally associated with the individual. Following Alfred Lotka, Leroi-Gourhan, Heidegger and Derrida, Stiegler expands memory from the individual to examine how communities and societies leverage memory as cultural transindividuation. Instead of immediate experience or one-on-one knowledge transfer, exosomatic memory duplicates knowers across the eco-social milieu and anyone already initiated into the worldscape of semiotic meaning can explain this to a new learner.

This takes the emphasis off individual memory and thus individual education. Instead of educational testing aimed at the individual accreditation and vocational added value (Marshall 1996, 1998), exosomatic memory is a systems approach. The narrative level of comprehension is attached to technological objects and methods of communication. It is both the content of meaning and the systemic substructure that the content attaches to. Subjects and 'objects' are always in relationship.

In the literature, exosomatic memory is traced back to the earliest artefacts, or 'signals' that externalise knowledge into the materiality of things. These artefacts, including adzes, arrows and cave paintings, allow ideas to pass across generations, partly through immediate experience and practice, but also through phenomenological, affective apprehension of the artwork or technology (Leroi-Gourhan 1945). Interpretation of the written word, or the artwork, is not static but is generative, as it proliferates and evolves in interpretation (Derrida 1978).

De Saussure's early work on structural linguistics is an important contributor to this debate. De Saussure argued that there is a big difference between the fluidity and double checking of 'parole' or speech, and the (mis)interpretive power of reading the written word (1916/1966). There is a 'black box' of interpretation between the intention of the writer and the way the reader comprehends it. Whereas, while there are often failures of communication in speech, it is easier to attend and correct these misreadings, in an organic, embodied, almost self-correcting way with the immediacy of sending and receiving of speech and gesture.

In the wide-ranging discussion about 'the Death of the Author' Barthes (1977), Derrida (1978), and Foucault (1998) carefully delineate how the 'representation' of meaning resides in a dynamic system. At once meaning emerges from multiple sources; in the underlying grammar, the author's milieu of ideas circulating when the author set down their ideas, as much as the author's intent, and also in the physical context and deportment, and active, historically contextualised agency of reading. The text has a life of its own, changing in interpretation as words fill with new nuances, and the concerns of the day contextualise how the text is read in unfolding ways. Barthes argued that writing cannot be attributed to the creative genius of a sole author, but instead is a communal practice of dialogue where interpretation of ideas emerge along with new understandings of historic discourse, and where some meaning falls into forgotten crevices as the modern world abandons all sorts of elements of the past.

The literature tends to assume a 'progressive' periodisation of exosomatic memory; starting with stone age tools, artwork, upright bipedalness, gesture, faciality and language (Leroi-Gourhan 1945). Stiegler calls this a cinematography of exosomatic transindividuation. The second phase comes with writing, where ideas are 'represented' through art and script. The printing press increased the range of this representational phase. The 'simulacra' (Baudrillard 1983) of the Internet is the third phase. Stiegler argues that cybernetics introduces a new, passive approach to the screen, defined more by donating attention span than to critically thinking. Following Mark Poster (1993), James Marshall traces three distinct phases of exosomatic epistemology.

> First there is face to face and orally mediated exchange; second there are written exchanges mediated by print; and finally, electronically mediated exchanges … Meaning, in the first stage of meaning, is characterized by symbolic correspondences; in the second stage, by representation; and in the third stage, by simulation. (Marshall 1996: 273)

Stiegler characterises the grammartisation of different visual and written technologies as a periodised exosomatic memory, that enables learning to transcend the immediacy of experience and take place by subsequent generations. Following Leroi-Gourhan (1945), Stiegler cites cave paintings as a 'cinematic' example of ideas transferring from one to another without direct conversation being necessary. This enables modern humans to presume they enter the same conversation.

Leroi-Gourhan was fascinated with the evolution of thinking that could be found in the ancient surviving artefacts of Palaeolithic *homo sapiens*, and in the interconnection of bodily comportment, technology, and environmental milieu. Leroi-Gourhan argues that memory, language, and epistemology emerge with the evolution of *homo sapiens* into upright bipedals. This brought the face into view, allowing gesture and speaking to become more visible, and freed the hands for complex grasping. With faciality and hand facility, he argues, the cortex could evolve, and technology and language begins to emerge. Like a lot of other anthropologists and philosophers since Aristotle, Leroi-Gourhan assigns the ability to create and use technology and language as the species-being of humanity.

The 'grammatisation' that Stiegler develops to conceive of the 'arche-cinematic' pictographs of the Palaeolithic cave paintings, through to the video messaging of contemporary smart-phones, emerges from these important debates over semantics, representation, and meaning, and at the same time, to the embodied way we occupy the 'always-already' 'thrown' world (Heidegger 1927/1962). Daniel Ross refers to this in his excellent introduction to Stiegler's book *The Neganthropocene* (2018), where Stiegler

> refers to the broader analytical process by which temporal and perceptual flows of all kinds are rendered discrete and reproducible through being spatialized. Through this extension, he is able to push the origin of the grammatization process backwards in time to the 'arche-cinematic' reproductions of Upper Palaeolithic cave painting, and to extend this process forwards, not just to the grammatization of visual and auditory perception that occurred with radio and cinema, but, prior to that, to the grammatization of the manual gestures of the worker or the craftsman that are spatialized in being programmed into the machinery of the industrial revolution, and finally to what is unfolding right now: the grammatization of

> ‘everything’ made possible by the inscription of binary code into central processing units composed of silicon. (Ross 2018: 20)

Derrida’s argument is that distinctive shifts occur in epistemology and the constitution of the self, in the transition between the oral tradition, the technology of writing, and the ‘informatics’ of networked computing technology. With writing the responsibility for memorising became increasingly located in the archive.These distinct shifts in technologies of the self and their changes in exosomatic relation also changes the nature of knowledge and the way people think and ‘speak’ (or write/ paint/ video/ blog/ vlog/ game). The Internet has produced new conundrums about access, veracity, and amplifying algorithms that interlocutors have never needed to deal with before. Jim Marshall makes an important point about the ‘evolution’ of the way language constitutes the self, especially in the age of the Internet.

> Both the authority that accompanied oral communication — that of who the speaker is — and the authority of written communication — where the notions of truth, evidence, and of being an authority are important — became tenuous. If unwanted communication cannot be controlled then traditional notions of being in authority become very tenuous. Of course, a ‘solution’ to this is to control emitters and emittees so that they are passive senders and receivers. (Marshall 1996: 271)

Very importantly, instead of conceiving of these different modes of exosomatic memory as progressive, Marshall argues they do not replace each other in the typical characterisation of an evolution. Marshall argues they co-exist. This is exactly what occurs with the Tainui trees.

5 Heidegger and the Modern Enframing of Thought

Heidegger’s important concept of the technological horizon of thought, that shapes the way modern people subsume all ways of knowing to the machinery of consumerism, is an important lens to appreciate Leroi-Gourhan, Derrida, and Stiegler’s exteriorisation of memory in the techniques of cinematography and writing. Heidegger noticed that the modern era is dominated by the narrative of consumerism which ‘challenges forth’ our ways of knowing, the natural environment, culture, art, and our internal techniques of the self. Everything becomes understood as resources to be potentially exploited by the demands of consumerism. Everything is in ‘standing reserve’ – even land, domesticated animals, rivers, water, forests, wildlife, atmosphere and the ocean, molecules, quantum subatomic particles, genes, the moon, and solar system – as the demands of consumer capitalism learns to exploit wider arenas, colouring how human understanding extends into new frontiers.

Heidegger (1977) argues that the process of storage has the paradoxical impact of freeing local communities from the constraints of natural disaster, or threat to production, and at the same time, alienates our communities from their local environment, so that people no longer have awareness of seasonal flows of abundance, or the impact of pollution, because they are locked up in their busy consumer worlds.

This alienation from nature, and definition of all aspects of the world as a potential resource in the machinery of consumerism, characterises modernity in all its forms.

According to Heidegger, Leroi-Gourhan, Derrida, and Stiegler, technology operates as both the parameters that shape thought and a catalyst for exosomatic memory. Yet this focus on technology as though it must always be artificial, 'artefact', rather than naturally occurring sets up presumptions that exclude the indigenous way of incorporating the natural environment into knowledge and epistemology as an exosomatic device. By doing so, these philosophers remain stuck in the western enframing of thought where humanity are reified above other species, and our modes of behaviour, organisation, and redistribution are excluded from environmental consequences.

Our conversation about the Tainui trees elucidates how exosomatic memory is an age-old paradigm, that predates and exceeds technological techniques. Remembering techniques of oral memory helps to recontextualise the technological artefact as one technē amongst others. This destabilises the alienation embedded in modern epistemology as determined by the enframing of consumerism (Heidegger 1977). The ancient techniques of memory and narrative open up deeper modes of integration with ecology and care, without the necessity of abandoning contemporary technologies to meet a romanticised pastoralism.

The technological enframing of thought that characterises the Anthropocene is undermined in other ways too. It is built on an alienation of rational humanity over and above animals and the natural world. But increasingly these distinctions are disintegrating, as science and technology demonstrates how intricately interconnected everything is. Artificial Intelligence, and the grammartisation of 'everything' through the inscription of binary or quantum code on silicon and other materials is extending the concept of intelligence too, from an anthropocentric focus towards the idea that intelligence can be distributed in networks, or bodies, in wider ways of understanding the evolution of thinking, reproduction, and evolution than ever before (Tegmark 2017).

Conforming to the Enlightenment assumption of elevating humanity above other species for our apparent superiority in wielding tools, Leroi-Gourhan, with Stiegler following, argue that *homo sapiens'* exteriorisation of knowledge into art and technology is the moment in which we became distinctly 'human'. Other animals – crows, kea, chimpanzees, octopus – and others, also use tools but this is ignored. The unusually long childhood of human children is also often attributed to the need for wider, transgenerational modes of memory and learning, that exceeds the experience and experimentation of the individual in favour of broader exosomatic cultural narratives and epistemology.

Despite Leroi-Gourhan's ideas remaining within the anthropocentric conception of human superiority, his are important, and have been very influential and raised the relationship between embodiment and epistemology (upright bipedalism, faciality, the tool grasping hand), technology, and a more respectful approach to Palaeolithic peoples. He understood technology as constituting the conceptual apparatus of human cultures, as a screen, or 'curtain of objects' that intervene between the environmental 'exterior milieu' and the cultural 'interior milieu' of the ethnic group. The technologies create conceptual 'tendencies' that impose a 'membrane' or lens that constitutes the way they access understanding of their exterior milieu. Leroi-Gourhan's important books influenced Derrida's books *Of Grammatology* (1974), and Deleuze and Guattari's discussion of faciality and the milieu in *Anti-Oedipus* (2004) and *A Thousand Plateaus: Capitalism and Schizophrenia* (1999).

6 Passivity and Accelerating Informatics

Derrida (1978) developed the exosomatic memory in relation to writing. Literate people no longer have to remember everything, and the repository of memory is delegated to the written word. Stiegler updates this to the smart-phone and the iPad, where the contemporary attention span is getting shorter and shorter, and the Internet as a simulacra of lived experience, and the repository of immediately accessible information is increasingly relied upon. The extensive memorisation practices of ancient peoples are becoming lost.

Celtic bards, for example, knew long sagas that took days to recite, and the genealogical knowledge keepers in traditional Polynesian cultures could trace genealogies back 30 or more generations. As memorisation is disrupted, the worldscape of mnemetic techniques begins to be forgotten. There are many examples of this. Celtic understanding of the landscape can still be found in Ireland where each field has an old Gaelic name, which describes events that have occurred there. But many of these named fields have been cleared of their stone walls and turned into large industrial agricultural production. Māori have a 'script' of meaning attached to the woven mats and wall screens called *tukutuku*, and carvings, and tattooing or *moko* are all brimming with meaning that inscribes identity and genealogy for others to understand. But many people in contemporary Aotearoa/New Zealand have no recognition of the chevroned flounder pattern, or the association of the spiralling *koro* with the fern and network of kin relations called *whakapapa*.

Knowledge holders cannot refer to the external milieu as abundant in symbolism and meaning if nobody else in the community understands it. Modern Māori creatively engage with these shifting normative resonances and the alienation of urbanisation by extending the worlding of *tikanga*, or lore, through the exosomatic techniques of the book or the webpage instead relying only on the shared cultural and technological meaning imbued in trees and geological features (Nikora et al. 2021). A diversity of mnemonic techniques reinforce each other.

Likewise, the cinematography of late Palaeolithic rock art can only be partially understood when the absence of 'worlding' that makes the cave paintings resonate with other elements of reality is missing. How do modern humans understand the 20,000-year-old image of a mammoth? We have no association with taste, or the communal hunt, or their trumpet calls. We have no recollection of the totem. The modern interpretation of this visual cinematography throws up new interpretations unavailable to the ancient world, but it also only gives a limited window into the somatic worlding that once took place there. This is acknowledged in his later work by Leroi-Gourhan (1993) who distances himself from earlier interpretive projections.

But these changes in exosomatic *technē* have many ramifications. In the Pacific, there was a different economy of knowledge, where access to understanding certain technologies and protocols is protected and held by particular families or chosen disciples. Knowledge of art making, weaving, carving, boat building, navigation, star maps, botany, performance, song, speech making, oratory and argument, and genealogical lineage, all build mechanisms of value and regimes of status outside of consumerism. The entire economy of protected knowledge, its value, and who has access to it, is affected by universal education and the open access model of the Internet.

7 The Acceleration of Technology

Stiegler updates the argument of exosomatic writing to encompass the rapidly accelerating late capitalist information technology, which he argues is now faster than the synapses in the human brain. With an inverse interpretation of Elon Musk and Max Tegmark's (2017) excitable faith in the progress of Artificial Intelligence, Stiegler's AI resonates with a dystopian deterioration of the ordering of human modes of working and thinking.

Stiegler argues that the acceleration of technology, through the speed of its network capacity – an argument exacerbated by the further acceleration looming in quantum computing – have overtaken the capacity of the human brain to keep up. Consequently, the human mind is increasingly passive and receptive rather than active and creative. AI leads research searches along pathways that are informed by postcode, country, gender, and prior searches. AI creates 'bubbles' where like-minded people reconfirm each other's ideas and assumptions, and alternative opinions are filtered out. The lack of exposure to alternative viewpoints mean that people are unaware, and increasingly intolerant of divergent interests and opinions. By living in a cyber 'bubble' people participate less in their wider community, with less understanding of the impacts of policies or economic functions on different class, gender, sexuality, disability, or ethnic groups in their own communities. Diversity is operating but people are less aware of it. Democratic agonism (Arendt 1959) is less skilfully negotiated because people are increasingly passive, apathetic, and isolated in their self-confirming screen simulacra of culture.

AI has been manipulated by wealthy donors and thinktanks such as Cambridge Analytica (Cadwalladre and Graham-Harrison 2018), to spread and deepen reactionary climate denialism and helped Boris Johnson and Donald Trump's election campaigns. Alienation is exacerbated when people limit their opinions to those they 'discover' on the Internet instead of paying attention to the world around them. Arguably, this prolonged the dominance of climate denialism in the political sphere, until 2018–2020 when the enormous forest fires in the USA, Siberia, Continental

Europe, Australia, and the Amazon wrenched ordinary people out of their myopia. It took the deaths of over three billion animals in Australia alone – to bring carbon dioxide emissions into the public policy arena.

8 Accelerating Cybernetics

Stiegler regards accelerated cybernetics as encouraging increasingly passive receptivity to stories and concepts, rather than active noetic thinking (2018). The alienation described by Marx on the land clearances, has accelerated with the personal computer, and networked society. Covid-19 has pushed people out of the office towards 'working from home' so that immediate corridor conversations are further reduced, and nearly all interactions are facilitated through smart devices. The daily regulation of time through sunlight hours was relegated to clock time, and this has been reconsidered yet again, as global corporations 'never sleep' with fully functional offices in different time zones around the world. The clocking off at 5.00 pm has dissolved to shifts that align with work in foreign time zones. People are at once, more alienated from their local ecology, and more knowledgeable about global affairs.

Local living knowledge gets displaced (not surpassed), Heidegger argues, by modern *technē*, which obscures older ways of knowing. The subtleties of a wind change, an ocean current, or the type of range a sea bird has from land, are lost when people are reliant on global satellite navigation technology, and maps of shipping lanes and weather reports. Localised, specific, cultural knowledge is increasingly overcoded, regular, normative, and subsequently less alive to evolutionary change. It has become statistically normative, ossified, and dogmatic at exactly the moment that humanity assumes the modern mantle of technological mastery. Normative overcoding includes human beings, who were understood as rational utility maximisers by Hayek (1960), Novick (1974) and other neoliberal theorists, regardless of gender, age, ethnicity, or culture. Neoliberal discourse dominated public policy in almost all nations since the 1980s.

Cyberspace has taken that normative idealisation of the rational individual, and obscured further physical, historical embodiment in real-time. The dispersal of the self in cyberspace where place and cultural history can be invented or circumvented is in some ways the ultimate alienation.

> In the Age of Information, and in relation to identity, the new self will be decentered and dispersed, as in post-structuralist theory, without spatio-temporal and bodily constraints. But, furthermore, the physical body has nothing to do with identity in electronic communication. It is almost as though the self has become invisible. (Marshall 1996: 272)

Yet at the same time, the dispersed self, without body or historic specificity is always an illusion. Not only do bodies reflect the passivity of long hours sitting but people behave in peculiar ways in cyberspace. The illusion of invisibility alters the quality of human interaction.

9 The Proletarianization of Epistemology

Stiegler pivots from the important recognition of truth in the Anthropocene as the 'forgetting of Being' expounded by Heidegger, in his book *What is Metaphysics* (1935/1973). By diving into the linguistic semantics of Leroi-Gourhan, Simondon, Foucault, and Derrida, Stiegler takes the idea of the person 'thrown' into an 'always-already' world (Heidegger 1962: 65) in a new direction. Technologies like writing, and smart cybernetics enable the exosomatics of memory. Creative talents such as music, narrative, and scientific exploration take place through the expression of these technological artefacts – both in content and form. The ideas expand from the immediate sphere into a globalised network, where storage could take place anywhere, making it possible to pass on information through technologies, to future generations. By tracking exosomatic memory through its evolution from cave paintings (Leroi-Gourhan 1945) to the Ancient Greeks, Marx and then Heidegger's critique of modernity, Stiegler is able to critique cybernetics and AI at the levels of noetic thinking and technologies of the self, work and redistribution, and the dystopian progress of the Anthropocene.

The alienation of labour from the farms they had lived on for thousands of years not only dislocated the population; it reduced their rich knowledge of the landscape and eventually replaced it with the monotonous and reductive labour of production line factories. Workers became increasingly competent at one small monotonous element of the overall assembly of the product. This replaced active thinking and knowing with a proletarianization of labour and noetics. While this reductive mode of working has characterised factory labour for a long time, there is now a middle-class creep, as proletarianization enters all sorts of professions through robotics and mass computing power of Artificial Intelligence. Ross explains how the semantics of exosomatic technologies are encroaching ever further on our internal psyche and modes of thinking,

> now, in the twenty-first century, it is rational and conceptual knowledge that finds itself increasingly absorbed into an ever more powerful computational apparatus: the successive epochs of grammatization have thus ultimately led to the progressive extension of the proletarianization described by Socrates and Marx to all areas of understanding and finally reason (Ross in Stiegler 2018: 21).

The ultimate completion of proletarianization, Stiegler writes, is when the American Treasurer, Alan Greenspan explained he had no idea how the stock market works because it is run via algorithms.The future of knowledge has implications for the future of work and vice versa. The evolution of technology, from stone age digging sticks to the metal shovel, and then the diesel-powered digger, transformed the nature of work and the nature of phenomenological experience. Robotics and AI are beginning to also make middle class labour redundant or proletarianized. The stock market, legislation, legal contracts, quantitative research and multiple other professions are becoming automated. The unique creativity of knowledge in these fields are becoming increasingly uniform. What's more, machine learning obscures the reasons for particular results emerging, so the parameters of tasks codified into the algorithms transforms and narrows as the machine learns to predict statistically likely correlates.

This has had devastating consequences in some fields, such as welfare provision, where algorithms have taken over case workers and people have had their entitlement to welfare checks denied or lower-class school students having their predicted grades lowered (Coyle 2021). Machine learning exacerbates the 'bubble' where specific groups, defined through gender, age, postcode, and shopping preferences, are mutually reinforcing, and other specific groups similarly defined, are excluded because historic bias is recompounded, and expectations reconfirmed. Women are less likely to be exposed to adverts for financial advice, for example.

Stiegler argues that the acceleration of AI and robotics will make labour as a form of exchange increasingly redundant. This raises important questions, because labour as the standard of exchange value has dominated economics since the large-scale land clearances made it impossible for people to generate subsistence living from their land. The alienation of people from their territories forced labour to become the primary value of exchange (Marx 1887). Education has been built upon the vocational legitimacy of accreditation, so that employers are assured of certain accredited skillsets. But as the men who apprenticed themselves to the ship building industry in the 1970s or those with computer credentials from the 1980s already know, skill sets become rapidly redundant with the speed of technological change.

For many decades, lifelong learning has set out upskilling redundant labourers, but Stiegler's point is that the scale of redundancy in many middle and upper management roles will be so large that far too few jobs will be left for employment to be a meaningful product of exchange. The implications are the need for new forms of valuation. Tie this to the rapid phasing out of fossil fuels, to be replaced with renewable electricity, hydrogen or other forms of energy, and an aging global population, and the nature of work is changing rapidly.

> The question of the Anthropocene, which, therefore, has the structure of a promise, emerges at the moment when, on the other hand, full and general automation is being set in place as one outcome of the industry of reticular digital traces. This reticulation industry must be thought as the chance for a new epoch of work, where the epoch of employment will be brought to an end, and where this will occur through a 'transvaluation' of value, wherein, as Marx put it: 'labour time ceases and must cease to be [the] measure [of work or labour], and hence exchange value [must cease to be the measure] of use value'. In this situation, the value of value becomes neganthropy (Ross in Stiegler 2018: 45–46).

In 2015, Ruth Irwin argued that the UN population statistics artificially increased the birth rate (which has been falling steadily for decades) to pump up the continuous growth of the global population (UN Population Statistics 2019). This is essential for consumer and GDP growth, and especially for the continuation of growth in property prices (Irwin 2015). We argue that peak population is nearly upon us – probably as early as the 2090s – which will stall and start shrinking the housing market by the end of the century. The entire premise of economic growth, which is fundamentally based on interest rates on capital that injects extra money into the system without tying it to work or any other form of productivity stalls without it (Soddy 1926). Growing population has kept property buoyant and as this stagnates, the fundamental requirement for economic growth also crumples. Thus, the need for material consumption – and commensurate CO_2 emissions (Hickel 2016) – for the sake of 'growth' will also begin to deflate (Irwin forthcoming 2022). This reorganisation of priorities for patterns of economic redistribution offers us a brilliant opportunity to reconsider economics altogether, with ecology and interspecies well-being at its centre.

Accelerating technology, combined with peak and then shrinking population requires a transvaluation of values. The greenhouse gas inventory is in the process of setting in place new tracking requirements – called scopes 1, 2, and 3 – to track emissions at all stages of the production, use, and waste cycle. The call is for a circular economy, which inhibits global production and yet facilitate more responsible global distribution. The circular economy applies surveillance measures to make the conditions for better design and production, and an end to built-in obsolescence.

These changes are joined by a seismic shift in philosophy and politics, as the era of postcolonialism finally takes real hold. Up until now, racist assumptions of universal truth, have prioritised western modern values and practiced cultural genocide of humans and other species, both physically and figuratively in most 'developed' nations (Braidotti 2009, 2013). However, as these claims to universality are unpicked, and 'other' cultures take up the mantle of epistemology once more, the impasse of the technological *Gestell* so well described by Heidegger can finally dissolve.

10 The Indigenous *Epistêmê*

Te Haumoana's alertness to the Tainui trees is an important illustration of how authentic, integrated knowledge, affection, care, and attachment to the land stands in contrast to the alienation of western modes of epistemology and economics. In the context of growing climate emissions, consumerism and economic growth, these ancient modes of onto-epistemological cohesion and attachment are increasingly vital to restore. Ecology as an exosomatic *technē* is absent from western literature, even when the analysis of memory and epistemology seeks its earliest iterations in Palaeolithic societies.

We argue this failure of comprehension emerges from the assumption of separation of nature from culture that shapes western epistemology since Descartes' sceptical liberation of the rational mind in *The Meditations* (1641/1980). Exosomatic memory is an important shift away from the privileged position of the rational individual, and it helps to show how cultural artefacts produce communally held understanding of the way the world works, and these shared nodes of epistemology enable memory to become transgenerational rather than limited to the learning and experience of one short-lived individual.

The epistemological enframing of thought by modernity has been so all-encompassing that such important thinkers as Heidegger, Leroi-Gourhan, and Stiegler were all attempting to break out of it albeit with very limited success. They each prioritised *technē* as the locale of exosomatic memory. But there are broader ways of conceiving of *technē* and of exosomatic memory. Heidegger began thinking about technology as the always-already world into which each person is thrown (1927/1961). Like Leroi-Gourhan (1945), Heidegger's early work was on the way the tool and the body co-create each other, the opposable thumb and fingers of the hand combining with the hammer collectively constituting the 'self'.

Before the need for speech, the thrown world constitutes meaning. The flow of ideas and technologies of the self, along with a momentum of transition and change, are shaped by the always-already technological milieu. Leroi-Gourhan argued that the versatility of the hand, the upright gait of early bipedal humans, and the 'faciality' of expressive language enabled humanity to develop the pre-frontal cortex and extensively develop creative technological progress. Bipedal faciality and technology co-evolved.

Stiegler too, accepted Heidegger's (1927/1962) and Leroi-Gourhan's (1945) focus on technology at the exclusion of the ecological milieu. Older by far than stone axes, or the representation of the artist's depiction on a rock face are the exosomatic associations of mother earth herself.

Te Haumoana's narrative of the Tainui trees show us how plants, animals, and geological features serve as important exosomatic signifiers, that constitute the 'always-already' world as much as technological artefacts like a chair or a table. Many of these 'items' are so ubiquitous that we 'forget' to notice them (Heidegger 1935/1973). When we were young, climate discussion was limited to a small group of scientists. By the ordinary population, climate was completely taken for granted. As the fish in the sea do not 'notice' the water they swim in, modern humanity failed to notice the ecological milieu because we had successfully assumed it was an ongoing cornucopia, that allowed modern society to prioritise consumerism and individual labour as signifiers of status and economic value.

As a valuable contrast, for indigenous peoples, nature does not contrast against culture, nature is *technē*. Technology items are predated by *technē*/nature in the service of transgenerational memorisation. Major mountains, the river, certain species, particular old trees, they all make up the 'world' of signification, with layers of technological meaning including medicine, food, shelter, and spirituality. In contrast with modernity, which has been alienated from this type of knowledge, these natural phenomena create the taxonomy of meaning that makes sense of the world.

Unlike thinkers in the West who attribute higher status to human beings, as a generalisation, indigenous people recognise the faciality, languages and *technē* of other species. There are many examples of symbiotic relationships, such as an African honey eater that calls humans to follow them (sometimes for 20 miles) so that the person will find and break open a honey hive, allowing the human's access to valuable honey, and the birds to pick over the opened-up beehive. The human is the tool the bird wields to open the hive. Māori were the vector of transport for the Tainui trees to immigrate from Australia. Species intersect in all kinds of ways, and the privileging of humanity as the only agents was an immature and narcissistic assumption of superiority from which indigenous epistemology can ingeniously disengage.

Recognising the agency of ecology does not result in an abandonment of modern technology. Technology is rather reconceived as facilitated by a variety of species, whom all modify their habitats to some extent. Accepting the indigenous orientation of exosomatic memory enables modernity to slice through the Gordian knot of technological enframing and its ensuing alienation of culture from nature. As Mark Poster (1993) and Jim Marshall (1996) point out, all three modes of exosomatic memory operate *at once*.

New technologies are rapidly evolving, and the speed of the Internet will accelerate even further once quantum processing is cracked. The pre-frontal cortex is finding it hard to keep up with the rapid change in technological innovation, as it no doubt had difficulty at the beginning of metallurgy and the invention of the first printing press. New technologies, in our case robotics and AI, transform the process of exosomatic memory and with it, creativity, and critical thinking. But computing is also creating interest in the way information can be inserted into the 'substrate' of various materials (Tegmark 2017), breaking the boundaries of 'life' from animals to inorganic self-organising features such as a solar system. Information systems are creating synergies with new biological science on the way that trees and mushrooms 'talk' and that animals and insects elicit certain toxic responses from trees as they resist being overgrazed. Big data is being employed to record and recognise the speech patterns and words of several species of whale, of chaffinches and meercats, to name a few. Language, like tool use, can no longer be merely associated with the human.

The intersectionality of all elements of the ecological milieu is increasingly apparent in a wide range of discipline areas. Emissions Scopes 1, 2, and 3 introduce entropy into existing practices of economy and surveillance. But new forms of entropic accountability do not shift deepset values. The transvaluation of values requires firm boundaries, and a sacred Yes to life itself (Nietzsche 1982). Indigenous people all over the world have been struggling to be heard, to overcome the colonial universalism of Enlightened modernity, and to bring ecology back into the forefront of consciousness.

Artificial artefacts created a 'screen' as Leroi-Gourhan put it, between subjective apprehension of the wider world. This remained within the Idealistic interpretive 'black box' analysed so well by Descartes in 1641. Indigenous cultures embrace the exosomatic memory and meaningfulness of unadulterated natural events and items, incorporating tools into a wider natural technological milieu. The web of kin relations forms the basis of worlding, that inserts humanity as one species amongst a plethora of agents, organic and inorganic. This shift in ethos and orientation is subtle, and it does not exclude sophisticated tool use.

An *attunement* with the ecological environment characterises indigenous culture. As the westerly sun shines on the hill above Te Haumoana's house, the Tainui trees quiver in the heat. Resonating with meaning; the great ancestral canoe, the ocean full of islands, with Australia, with medicine, the Tainui trees *sing*. Alive, alert, each leaf strives upwards. Clean, salty, oxygenated air circulates the hills.

Branches delicately whisper as the earth's breath eddies, lazily rising to meet the hovering clouds that tangle with the mountain ridge. The dusty flowers spread a subtle pollen on the air. Chlorophyll glows. The plants exude aliveness, and an upward striving for light. Twigs and leaves adjust, momentarily dancing in the sweltering sunlight, a generalised alertness, spreadeagled, glorious.

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Part II
Emerging Configurations and Practices

Biodigital Technologies and the Bioeconomy: The Global New Green Deal?

Michael A. Peters, Petar Jandrić, and Sarah Hayes

1 The New Green Deal

Presented in December 2019, the European Green Deal has established the legislative framework for achieving European Union's climate neutrality by 2050. The Explanatory Memorandum (2020) puts the objective in unambiguous terms:

> The European Green Deal Communication launched a new growth strategy for the EU that aims to transform the EU into a fair and prosperous society, improving the quality of life of current and future generations, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use. The European Green Deal reaffirms the Commission's ambition to make Europe the first climate-neutral continent by 2050. (European Commission 2020)

The European Green Deal suggests that reaching the target requires coordinated investment in environmentally-friendly technologies, support for industrial innovation, cleaner public and private transport, energy-efficient buildings, decarbonising the energy sector and 'working with international partners to improve global environmental standards' (European Commission 2020). In the U.S. Joe

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Biden's election website supports 'the Biden plan to build a modern, sustainable infrastructure and an equitable clean energy future':

> At this moment of profound crisis, we have the opportunity to build a more resilient, sustainable economy – one that will put the United States on an irreversible path to achieve net-zero emissions, economy-wide, by no later than 2050. Joe Biden will seize that opportunity and, in the process, create millions of good-paying jobs that provide workers with the choice to join a union and bargain collectively with their employers. (Biden for President 2020)

The website plays up the difference with Donald Trump's science denial and his withdrawal from the Paris Agreement. It also announces that Biden will 'make a $2 trillion accelerated investment, with a plan to deploy those resources over his first term, setting us on an irreversible course to meet the ambitious climate progress that science demands' (Biden for President 2020) with investments in infrastructure, auto-industry, transit, power sector, buildings, housing, innovation, agriculture and conservation, and environmental justice. The figure of two trillion is about the double notional level of investment as Europe. China's president Xi Jinping announced that the country aims to achieve carbon neutrality by 2060 in his much-publicized video speech at the United Nations General Assembly.[1] He pledged 3.4 trillion yuan for China's New Green Infrastructure with commitments to reduce reliance on coal and clean energy revolution, making it central to the next Five-Year Development Plan (2021–2025). The vision of an 'ecological civilization' has also been an important part of domestic policy discourse. Xi's announcement is significant, because China is responsible for around 28% of global greenhouse gas emissions.

At the end of 2020, when Covid-19 is peaking in second wave infections and deaths, the co-incidence of Europe, US and China new green deal policies, together with the international cooperation of many nations, seems like a promising intersection of national and global intentions. These concordances do not only promise some real progress about reaching climate targets but also create an international culture of collaboration based on *biodigital technologies* and their implications and contribution to the *bioeconomy*. In this chapter we chart out the scientific backdrop of biodigital technologies, review recent bioeconomy policy initiatives, historicize these technological changes and policy initiatives, and point towards possible directions for future development of the bioeconomy.

2 The Scientific Backdrop: Biodigital Convergence

Biodigital convergence is a complex mesh-up of new conceptual and practical reconfigurations between biology, physics (nanotechnology), and information science. These reconfigurations are dialectically intertwined with a strong

[1] See https://youtu.be/5Zm2dKMiWZM. Accessed 24 November 2020.

technologization of today's sciences. In line with different foci of their work, scientific researchers often speak of the 'Nano-Bio-Info-Cogno *Paradigm*' (Peters 2020) (emphasis added), while institutions such as the US National Science Foundation speak of the 'NBIC *technologies*' ('nano-bio-info-cogno') (Institute of Medicine and National Research Council 2006) (emphasis added).

Implied in a new scientific 'unity at the nanoscale' (Bainbridge and Roco 2006: 49) are also radically changed relationships between science and technology. We now live in the age of techno-science, where technological development has taken the lead in scientific inquiry; based on increased technological capabilities, existing and new scientific theories now have more practical applications than ever. In this book, *Bioinformational Philosophy and Postdigital Knowledge Ecologies*, authors explore philosophical and social implications of this great convergence at length. In the context of the bioeconomy, we need to turn to its new practical applications now that humanity has scope for environmental self-renewal and enhancement, which is key to sustainability.

Compiled from the Institute of Medicine and National Research Council (2006), Table 1 represents a classification scheme for biotechnologies covering the main areas of development. Many of these short lines, fit for neat table presentation, contain truly revolutionary changes in ways we understand and do science and technology. DNA synthesis, for instance, is the holy grail of border-crossing between life and matter. In the words of Craig Venter, '[w]e can digitize life, and we generate life from the digital world. Just as the ribosome can convert the analogue message in mRNA into a protein robot, it's becoming standard now in the world of

Table 1 Main areas of development of biotechnologies according to the Institute of Medicine and National Research Council (2006)

Acquisition of novel biological or molecular diversity	Directed design	Understanding and manipulation of biological systems	Production, delivery, and 'packaging'
DNA synthesis	Rational drug design	RNA interference.	Plants as production platforms – 'biopharming'
DNA shuffling	Synthetic biology	High-affinity binding reagents (aptamers and tadpoles).	Microfluidics and microfabrication
Bioprospecting	Genetic engineering of viruses	Computational biology and bioinformatics	Nanotechnology
Combinatorial chemistry, and generating chemical diversity		Systems biology	Aerosol technology.
High-throughput screening		Genomic medicine	Microencapsulation technology
		Modulators of homeostatic systems	Gene therapy technologies
			Complementarity and synergy of technologies

science to convert digital code into protein viruses and cells.' (Venter 2012) Referring to 'the use of genetically modified plants to produce a wide range of pharmaceuticals and industrial products' (PlantForm 2020), the notion of plants as production platforms, or biopharming, offers a revolutionary transition from *production of medicines* to *farming medicines*; this transition can easily scale to production of food and other products.

DNA synthesis and biopharming alone could transform the face of the earth – and in Table 1, they are just two amongst many technologies with similar transformative potentials. Therefore, some consider this convergence of bio-, nano-, and information technologies, along with the neuro- and cognitive sciences, a transformation that will prove as powerful as the Industrial Revolution (Salter et al. 2016). It is against the techno-scientific backdrop, that we now see the emergence of bioeconomy.

3 The Emergence of Bioeconomy

The notion of the bioeconomy was developed in the OECD book *The Bioeconomy to 2030: designing a policy agenda* (2009) which contains the principle policy conclusions:

1. Prepare the foundation for the long-term development of the bioeconomy.
2. Reverse the neglect of agriculture and industrial biotechnologies.
3. Prepare for a costly but beneficial revolution in healthcare.
4. Turn the potentially disruptive power of biotechnology to economic advantage.
5. Reduce barriers to biotechnology innovation.
6. Promote the integration of biotechnology research across commercial applications.
7. Create an ongoing dialogue among governments, citizens and firms. (OECD 2009)

In a recent Special Issue, Trends in Bioeconomy, Aguilar et al. (2020) show that while the concept of bioeconomy is still very new, over 50 countries from all over the world have now developed related strategies and initiatives. Among the common features are 'the need of a strong and vibrant science and technology base, the development of infrastructure and capacity building, and developing a coherent policy framework'. Scientists writing in this issue suggest that a new conceptual framework is now developing synergistically with other initiatives at global and national level on sustainability. 'Bioeconomy is evolving from the mostly policy and industrial drive towards a more active inclusion of societal issues such as: investing on education and research; favouring a healthy and innovative industrial environment and, promoting a genuine dialogue with all societal stakeholders related to bioeconomy.' (Aguilar et al. 2020) Reaching far beyond economy's traditional areas of interest, bioeconomy requires a holistic approach which includes areas such as science and technology, education, political science, and many others.

One of the early leaders in the field is the Bioeconomy Council appointed in 2012 by the German Federal Government's Minister of Education and Research and the Minister of Food and Agriculture. The Bioeconomy Council brings together 17 members and their knowledge from different disciplines and links research, businesses, and civil-society organizations to develop practical and 'knowledge-based bioeconomy' and strategies for a global sustainable economy. In 2020 the Council made a direct appeal to Government arguing for the need of political action in four related areas:

1. **Promoting sustainable consumption and investment decisions** by means of appropriate framework conditions and incentives so that companies can establish themselves with biobased innovations in Germany.
2. **Ensuring policy coherence** in order to advance the bioeconomy effectively and efficiently. The new strategy for the bioeconomy needs to be coordinated and implemented across departments. The coordination of the High-Tech Strategy could act as an example.
3. **The bioeconomy can make a significant contribution to global food security, to climate, biodiversity and environmental protection and to a better quality of life.** It is important to emphasize these contributions and to consider them in the national agendas on climate protection and sustainability.
4. **Assuming responsibility and encouraging science, business and society to work together to shape the transition to a sustainable bioeconomy**. In concrete terms, change requires (a) an implementation plan for the new strategy, (b) a platform that links the most important bioeconomy actors and initiatives in Germany, (c) a new scientific advisory body consisting of independent experts and (d) an umbrella concept for the societal dialogue and participation of the population.

'The alarming news about global species extinction has once again shown: **We must now take action and worldwide bring our consumption and production behaviors in harmony with nature.** The Bioeconomy offers important approaches and solutions for this,' emphasizes Joachim von Braun, Chairman of the Council (The Bioeconomy Council 2019) (emphases from the original).

The German Federal Cabinet adopted the new National Bioeconomy Strategy on 15 January 2020 which focuses on:

- Expanding biological knowledge and the use of biological processes and systems.
- Increasing availability of biogenic raw materials to the industry via cycle-oriented concepts.
- Integrating the bioeconomy strategy within the German economy.
- Scale up current and future cross-border cooperation. (Bundesministerium für Bildung und Forschung 2020)

The bundling of the federal government's bioeconomy policy and recommendations of the bioeconomy council into an overall strategy serves to link the previous goals and measures even more than before with the further development of the national research strategy.

At a European level, a similar strategy is put forward in the report 'Leading the way to a European circular bioeconomy strategy'. Given that 'the current economic model has a systemic failure by assuming unlimited resources', a new economic paradigm is needed 'that puts the basis for human prosperity within the planetary boundaries' (Hetemäki et al. 2017: 12). Citing first of all the world agreement 'in 2015 on Agenda 2030 (the Sustainable Development Goals, SDGs) and the Paris Climate Agreement, it is also widely agreed that the business-as-usual model – the policies, production and consuming habits we have followed so far – will not help us to reach these goals' (Hetemäki et al. 2017: 5). In an update, some of these authors now respond to the European Green Deal and argue that bioeconomy is 'the missing link to connect the dots' (Palahí et al. 2020). This requires looking at the essence of the economic model we have created and rethinking how we produce and consume. 'What is needed is a system change, to dematerialise our economic model and upgrade resource efficiency logic to resource sufficiency, based on the decoupling of economic growth, or better wellbeing, from resource use and environmental impacts.' (Palahí et al. 2020) This entails replacing our quantity-oriented, profit-driven economy with an economy that is focused on delivering people's needs in a sustainable way.

This replacement is a process that 'challenges the current balance and distribution of power and interests' (Palahí et al. 2020). The combination of digital and biological transformation has significant implications for companies as it changes the design and handling of production processes and their products. Working with the physical world as digital, means that many companies now need to become technology businesses too, if they are to survive (Peters et al. 2021a). Writing about complexism and biology in generative design, Cogdell (2018) points out the problem that '[u]ntil architects, designers, manufacturers, consumers, and politicians integrate life cycle analysis into their everyday decision-making, claims of "sustainability" remain unsubstantiated' (Cogdell 2018: 214). The necessity though to replace 'the *linear fossil-based economic paradigm* on which we have relied since the Industrial Revolution' comes in the price of escalating resource use, global environmental degradation and unprecedented human-induced climate impact. The 'industrial era has provided global economic convergence, but at the risk of sacrificing the safe operating space of our planet' (Hetemäki et al. 2017: 10). Yet a long-term viability of the bioeconomy still depends on a more coherent and holistic approach towards the social, economic and environmental aspects not yet addressed.

To 'join the dots' in the Green Deal, Palahí et al. (2020) point to three key features of the bioeconomy:

1. Bioeconomy is fundamental for inclusive prosperity and fair social transition, but it entails a more complex ownership of biological resources. While costs, transporting and processing biomass is more costly than fossil resources, it offers the possibility of a more inclusive distribution of income, jobs, infrastructures and prosperity especially in rural areas, in line with the Green Deal's inclusive growth ambitions.

2. Moving towards a carbon neutral EU does not only require moving towards fossil free *energy*. It also requires efforts to move to fossil free *materials*, and replace carbon intense products like plastics, concrete, steel and other materials like synthetic textiles. The transformation in the Green Deal is not possible without using a new range of renewable biobased materials that can replace and outperform carbon-intense materials.
3. Bioeconomy addresses past failure of the economy to value nature and biodiversity and place nature and life at the center of the economy. Biological diversity determines the capacity of biological resources to adapt and evolve in a changing environment. Biodiversity is therefore a prerequisite for a long-term, sustainable and resilient bioeconomy and new biobased solutions to replace fossil products are crucial to mitigate climate change – biodiversity's main threat, in line with the aims of the Green Deal of *preserving and restoring ecosystems and biodiversity (page 13).* (Palahí et al. 2020) (emphases from the original)

The bioeconomy powered by nature and emerging from nature has, if managed in a sustainable way, major potential to help deliver the ambitions set by the European Green Deal. It is an important missing piece of the complicated puzzle to overcome the past dichotomy between economy and ecology that very much defined the twentieth century. We can build a new and synergistic relationship between technology and nature, between ecology and economy, that can define the twenty-first century: the century where we would finally start respecting the laws of physics and integrating biology (Hetemäki et al. 2017: 10).

Therefore, alongside new means of production that are consistent with bioeconomy (Philp and Winickoff 2018) developed through biodigital technologies, our task is to engineer *environmental self-renewal* that becomes the basis of long-term sustainability (Peters et al. 2021a, b). Key to this is both meeting and reviewing the Sustainable Development Goals (SDGs) and also the role of Education for Sustainable Development (ESD), whose goals cannot afford not to engage, with the implications of this biodigital context. 'The tipping points will eventually change not only our lives and environments, but also our discourse on sustainability. Some "old" problems will be resolved, but new challenges and risks will arise. ESD for the future cannot afford not to address the implications of the technological era.' (UNESCO 2020) As modern biotechnology continues to provide breakthroughs in terms of addressing diseases, reducing our environmental footprint, relieving poverty, feeding the hungry, using cleaner more efficient energy, providing clean drinking water, protecting biological diversity on land and in oceans and improving manufacturing processes, this brings us closer towards practically achieving many of the SDGs.

In the holistic bioeconomy, many areas of society need to change alongside the biotech sector. Globally there need to be policies and incentives that will enable researchers, investors, companies and governments to foster biotechnology innovation. Regulatory systems, higher education science programs to train the next generation of scientists, biotechnology laboratories and strong intellectual property systems are further considerations. Additionally, it is necessary to 'to implement sustainability governance for the bioeconomy which safeguards against negative impacts while fostering positive options' (Niestroy et al. 2020). In this sense sustainability becomes something of a balancing act, with debate on SDG trade-offs and on the substitutability of SDG targets:

> Without regulations, policies, and investments ensuring sustainability, or in case the substitutability of SDG targets is not allowed, the bioeconomy concepts have the potential to jeopardize the achievement of several SDGs. In contrast, the sustainable bioeconomy scenario assumes strong sustainability measures that reveal the extensive potential of the bioeconomy to support the achievement of the SDGs. (Heimann 2020)

Saachi et al. (2020) place education at the centre of a model for a bio-based economy. They underline the necessity of developing a more flexible educational framework that might facilitate interdisciplinary combinations '[t]o cross the boundaries of a single sector and integrate tools, language and knowledge drawn from different disciplines and sub-disciplines' (Saachi et al. 2020). Arguing for the design of high-level education programmes that cut across subjects such as science, innovation, economics and education, they suggest this approach is more likely 'to promote and guide society towards bio-based innovation'. Specifically they point out that:

- Bio-based economy requires crossing the boundaries of single sector competences.
- A novel and flexible educational framework can help creating a shared language.
- The transition to a bio-based economy entails the support of social sciences.
- Personal consciousness can guide and leverage desirable technological transitions. (Saachi et al. 2020)

Looking more generally, Jandrić and Ford show that development of education fit for our biodigital moment 'is a global cognitive and affective project, which stretches beyond environment and indeed education'. Therefore, they conclude that '[w]e need critique and criticism as well as courage, creativity, imagination, hope, and organization. We need new goals, and new practical measures towards reaching these goals. We need new utopias, new pedagogical and political programs, designs, and experiments that fit our pandemic age of the (post-)Anthropocene.' (Jandrić and Ford 2020)

Based on the 'rethinking' that sits at the centre of a new bioeconomy, models, strategies and policies reviewed in this chapter represent early steps in our opinion towards anticipating the future and reinventing our theories and practices in and for the biodigital context. We predict that many new postdigital knowledge/education ecologies will emerge at the intersections of disciplines and sectors as they cluster around common sustainable scenarios and goals (Peters et al. 2021a, b).

4 Conclusion

Biodigital convergence and its various implications from biotechnology to bioeconomy seem to promise a Copernican shift in our current way of life. However, it was not that long ago, that predictions of a similar magnitude were expected from other technologies – and our experience in handling past expectations can offer a lot to this latest challenge. A few years ago, while we prepared the book, *Education and Technological Unemployment* (Peters et al. 2019), technologies of the day were digitalization and automation. Bombastic titles such as 'The future of employment: How susceptible are jobs to computerisation?' (Frey and Osborne 2013), and 'Technology at work v2.0: The future is not what it used to be' (Frey et al. 2016), have been widely read and discussed from academic journals through daily newspapers to office watercoolers. With the advent of the Covid-19 pandemic, now everyone seems to speak of viruses and biotechnology (Neary 2020). Yet in huge areas of human activity, such as work, education, and private communications, the main answers to global lockdowns are firmly situated in the digitalization/automation paradigm. Whatever could be done online, is now done online; whatever could be automated, is now automated (Bonilla-Molina 2020; Jandrić 2020).

In these processes, our insights into automation and the changing nature of work (Peters et al. 2019), and many earlier insights in diverse fields including philosophy of technology (such as rejection of instrumentalisms and determinisms) and digital education (such as the posthumanist nature of learning online), have now transformed into lived experiences. As we write this chapter at the end of 2020, for instance, anyone working from home while home-schooling children and/or taking care of the elderly intimately feels relationships between digital technology, work, and education (see Jandrić et al. 2020, 2021a, b). After doing a lot of research on these pandemic-induced transformations,[2] we are quite proud (although not necessarily happy) that our pre-pandemic theoretical insights have largely stood up to this global test of practice.

Focused to pandemic responses from within the digitalization/automation paradigm, the world is still not in the age of bioeconomy. However, the first signs of the new age of bioeconomy are all around us. A few years ago we read OECD reports on the future of work in the age of digitalization and automation: we now read OECD reports on the biodigital future of work. A few years ago we analysed 'data capitalism (Fuchs 2019), algorithmic capitalism (Peters and Jandrić 2018: 32), communicative capitalism (Dean 2009; Ford 2018), surveillance capitalism (Zuboff 2019), technoscientific capitalism (Birch and Muniesa 2020), high tech and low pay capitalism (Marcy 2009)' (Jandrić and Ford 2020); we now speak of bioinformational capitalism (Peters 2012). These concepts and ideas do not arrive in a neat temporal progression and are far from isolated. For instance, Zuboff's (2019) concept of

[2] See, for instance, *Postdigital Science and Education*, Volume 2, Issue 3, which contains 56 articles about early responses to the pandemic: https://link.springer.com/journal/42438/volumes-and-issues/2-3. Accessed 24 November 2020.

surveillance capitalism contains a good measure of biodigital thinking relevant for the pandemic moment.

Biodigital convergence is not a completely new paradigm; it is merely the latest (and by now the widest) techno-social convergence, based on earlier convergences (such as digital-analog), which are built into its very core. Looking at theory, biodigital convergence is an intrinsic building block of earlier concepts such as the postdigital condition described as 'hard to define; messy; unpredictable; digital and analog; technological and non-technological; biological and informational' (Jandrić et al. 2018: 895). In many fields, we have already been well aware of the biodigital challenge for a while now – with the Covid-19 pandemic, however, the biodigital challenge has risen in importance and prominence in the blink of an eye. Thankfully, our earlier works and their lineages provide us with sound conceptual tools for dealing with the new biodigital challenge in and beyond our pandemic moment (Peters et al. 2021a, b). When we researched digitalization and automation of work and education (Peters et al. 2019), no-one could predict the Covid-19 pandemic – yet when the pandemic arrived, and when lockdowns started, these insights have been hugely important in developing adequate responses.

Today, we again need to anticipate the future and reinvent our theories and practices in and for the biodigital context. Under pandemic conditions, our work has been transformed by an increasing sense of global oneness and solidarity (Mañero 2020; Suoranta 2020), some environmental benefits such as a decrease in carbon emissions (Lewis 2020), and also many losses from most obviously human lives, to the sorrows of living in a time of 'no touch' (Sapon-Shevin and SooHoo 2020). Political responses to the pandemic vary from balanced approaches based on solidarity (Kerres 2020) to the downright craziness of the Trump administration (McLaren 2020), and we now see emerging initiatives such as the Global New Green Deal that may well herald a new green age that at last takes sustainability seriously. Yet in our age of bioinformational capitalism (Peters 2012), all these changes and initiatives will be worthless without a solid material base. It is with this conclusion, that we urgently need to develop new understandings of bioeconomy fit for our biodigital moment in history.

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Agriculture 4.0: Bioinformationalism and Postdigital Hybrid Assemblages

Catherine Price

1 Introduction

Agriculture is undergoing a new technology revolution. Many of the new technologies being introduced are viewed as being needed for sustainable and resilient food systems. These technologies include robotics, sensors, Big Data, augmented reality, Internet of Things, artificial intelligence, machine learning, blockchain, ubiquitous connectivity (Klerkx et al. 2019), gene editing, genetic modification, cultured meat or cellular agriculture nanotechnology, synthetic food production, 3D food printing, and microalgae bioreactors (Klerkx and Rose 2020). Concepts such as urban agriculture, vertical farming, aquaponics (Pigford et al. 2018), bioeconomy, and circular agriculture (Klerkx and Rose 2020), are being developed and are operational, but have yet to reach full scale implementation.

The implementation of these technologies is leading to the fourth agricultural revolution or Agriculture 4.0 (Rose and Chilvers 2018; Klerkx et al. 2019; Klerkx and Rose 2020; Barrett and Rose 2020). The reasons for using technologies such as these include reduced inputs and costs, improved productivity and profitability, better data analysis and improved decision making for farmers, a reduction in physical labour and for replacing migrant labour (Barrett and Rose 2020). With gene editing there is the potential for higher yields and disease resistant crops (Rose and Chivers 2020).

In 'Covid19: When Species and Data Meet' (Price 2020), I argued that the interactions between human, other biological entities, and the digital could be considered a postdigital hybrid assemblage. This chapter seeks to answer two questions. Firstly, how can we understand new agricultural technologies from a postdigital

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hybrid assemblage perspective? Secondly, can the concept of postdigital hybrid assemblages help us understand the impact of the biodigital in the agricultural sector?

In answering these questions, the chapter argues how biodigital changes look set to disrupt modern farming practices. The biodigital is 'the mutual interaction and integration of information and biology' (Peters et al. 2021a). The vast array of technologies available in the agricultural sector enables information to be collected about livestock, plants, soil, water, and climate. The biological more-than-human world is being subjected to many new technologies, especially through agriculture. For the argument here, the biological more-than-human world refers to animals, plants, trees, bacteria, and viruses, and that which sustains life such as soil and water. Understanding how the biodigital is operating requires thought that can explore the boundaries and intersections between digital technologies, humans, and the biological more-than-human world. It is the multispecies entanglements found in the biological more-than-human world which sustain life on Earth. There is a need to understand how power is operating in these assemblages and who has control. There is also a need to understand the 'double-edged nature of technological innovations' which highlight both the possibilities of solving problems with technologies and also the unintended consequences (Clapp and Ruder 2020: 60). It is imperative that both the benefits and challenges of agricultural technologies, and the impacts these have on humans and the biological more-than-human world are understood.

In the following section, I discuss the Next Green Revolution and digital technologies. Examples of digital technologies found in Agriculture 4.0 are introduced. The discussion then moves on to gene edited and genetically modified crops and animals. This section examines various social and ethical implications associated with the introduction of genetic technologies. In the next two sections, I explain how we can understand Agriculture 4.0, and the postdigital hybrid assemblage. I then discuss technobiopower and how this is operating within Agriculture 4.0. The chapter concludes suggesting that the postdigital hybrid assemblage helps us understand the biodigital in Agriculture 4.0.

2 The Next Green Revolution and Digital Technologies

The Green Revolution in the 1960s saw the recycling of soil nutrients in agriculture replaced with purchased inputs of chemical fertilisers, and the application of pesticides, herbicides and insecticides to growing crops (Shiva 2016). Technology was a superior substitute for nature. Whilst there are plenty of benefits to the Green Revolution such as increased efficiencies and higher yields, there have been costs (Little 2019). In developing countries, the shift from diverse crop varieties to monoculture crops based on uniformity and external inputs changed not only the ecological practices of agriculture, but also social and political relationships as power in the food system transferred from villages to global agricultural seed companies and agrochemical companies (Shiva 2016). Additionally, the nutrient gap between rich and poor populations has grown wider, biodiversity has been lost especially in areas such as Brazil where land has been cleared for livestock production, and run-off from excessive fertiliser application on farmland has led to algae blooms in rivers and lakes, suffocating aquatic life (Lang and Heasman 2015; Little 2019).

New agricultural technologies are seen as being the Next Green Revolution (Little 2019). This revolution includes digital technologies and genetics. Developments are being funded by conventional agricultural technology companies, but also from those outside the sector such as IBM, Google, and Microsoft (Little 2019). Along with these large companies, entrepreneurs can be found in sectors such as genetics, aquaponics, vertical farming, big data and artificial intelligence. Food production, especially in the development of new technologies is becoming an area where there is a lot of investment. This is not without its challenges as some 'are in it for do-gooder reasons – to feed the world sustainably and equitably while curbing climate change – while others see a gold mine' (Little 2019: 25).

Whatever the motivation, the intention is to build a better and more resilient food system which is also 'smarter' (Little 2019). The food system is said to be resilient if its normal steady state is disrupted, and it can reorder itself into a new state (Lang 2021). Digital and genetic technologies may disrupt the food system. Where the Green Revolution signalled the arrival of industrialised agriculture, the Next Green Revolution may perpetuate industrialised agriculture through the use of Big Data. The large agri-food and agri-chemical companies are benefiting and becoming more powerful, and they are also strategically marketing these new technologies (Bronson and Knezevic 2016).

Agriculture is uniquely placed with the development of new technologies. Because biology is as important in the growing of crops and rearing of animals as it is in the genetics of breeding, technology is interacting in many different ways with biology. The coming together of biology and the digital can be thought of as the biodigital. Peters et al. (2021b: 6) argue that 'biodigital development represents the stuff of science fiction concerning 'cyborgs', human/machine clones, robots and AI'. Certainly in the agricultural industry, what could be viewed as science fiction, has already arrived. Before looking at the biodigital in greater detail, it is first worth discussing some of the new digital agricultural technologies in more detail.

Sensors, drones and satellites collect data about location, weather, behaviour, consumption, and energy use (Klerkx et al. 2019). These technologies are monitoring animals, plants, soil and water. Digital technologies such as these which are used on-farm, enable data to be collected and analysed. The data collected on-farm can be paired with big data analytics to aid decision making (Clapp and Ruder 2020). Technologies can be used for management tasks on-farm and off-farm and include the broader value chain and the food system (Klerkx et al. 2019). All of these technologies promise the farmer they will 'make the farm pay' (Bronson and Knezevic 2016: 3) and are attractive business propositions. There are many digital technologies already available to farmers, and I now provide a few examples.

Microsoft's Cortana Intelligence Suite has been used in a pilot project in India to help farmers achieve optimal harvests. Microsoft (2017) describes this technology as follows:

> Using powerful BI [Business Intelligence] tools, this dashboard provides important insights around soil health, fertilizer recommendations, and seven-day weather forecasts derived from the world's best available weather observations systems and global forecast models. This data is then downscaled for the highest possible accuracy at the village level, to transform how small holder farmers tackle climate change to drive effective decision-making for their crops. (Microsoft 2017)

This dashboard provides the Indian farmers taking part in the pilot project with detailed information, enabling them to grow crops successfully. Through the digital dashboard, biological and environmental information are combined, illustrating one example of the biodigital in agriculture.A very different example of the biodigital in agriculture is Ida (2021), which is a sensor that fits onto a collar around a cow's neck. The sensor measures seven behaviours: (1) eating; (2) ruminating; (3) walking; (4) standing; (5) lay down; (6) chewing; and (7) idle. As the sensor uses machine learning, it is able to add new behaviours as well as providing guidance to farmers. With this technology, the sensor learns what biological activities the cow is undertaking. The interaction is between the cow and the sensor, but the information that is gathered can be used by the farmer. This technology takes understanding a cow's behaviour to a level which could not be achieved otherwise.

Automation in farming is also being developed. The Small Robot Company (2021) in the UK have developed three robots called Tom, Dick and Harry who work alongside Wilma. Wilma is the artificial intelligence advice engine. Tom is a scanning robot which is used for crop monitoring and mapping. Dick is a robot used for non-chemical weeding. Wilma uses the data collected by Tom and converts it into care instructions for the farmer. The farmer can then send this information to Dick, and the robot carries out the weeding. With this technology, the farmer does not physically have to carry out any work. All the farmer has to do is forward instructions, so the biodigital in this case, automates agricultural work.

The next examples are from John Deere, which is a leading tractor and agricultural machinery manufacturer, and they have two different technologies. Firstly, John Deere tractors are fitted with sensors which stream data about soil and crop conditions. However, farmers have to subscribe and pay for the data that is collected (Bronson and Knezevic 2016). Secondly, the John Deere Operations Centre is an app which enables farmers easy access to data. It is marketed as being easily accessible: with the 'Operations Centre on MyJohnDeere.com, you always have your farm in your pocket. It is easy to use and connects you with your machines, fields and operators.' (John Deere 2021) Farmers can use the app to manage machines, as a field notebook, to plan work, make informed decisions, save time and share data. It is all about putting the farmer in control. With this technology, the biodigital is about the farmer having the information about their farm with them at all times, wherever they are.

The final example is of FieldView, which is the digital platform of Bayer-Monsanto. Bayer-Monsanto (2021) describes this digital platform as follows:

> FieldView quickly accepts historical data and adds four years of satellite images so all your history is in one place. The package is usable on most devices and in multiple ways, from day-to-day harvest management and variety trials to seed prescriptions for next year.
>
> FieldView then builds on this, bringing key data from any current work including the latest trial results, spraying and crop reports almost instantly into the cab iPad in an easy, highly interactive system.
>
> As well as insights for the big decisions, the real-time aspect saves effort and cuts costs in daily operations. (Bayer-Monsanto 2021)

This example of the biodigital illustrates how power is operating in the agricultural sector. Companies such as Bayer-Monsanto, BASF, and DowDuPont dominate the agricultural industry. The concentration of power within these companies can be seen with the merger of the 'Big Six': Monsanto, Syngenta, Bayer, BASF, Dow and DuPont into the 'Big Four': DowDuPont, Bayer-Monsanto, BASF and ChemChina-Syngenta (SeedWorld 2019). It is also these companies which are responsible for a large part of the research and development into gene edited and genetically modified crops, and for the production of agrochemicals.

3 Gene Edited and Genetically Modified Crops and Animals

The development of gene edited and genetically modified (GM) crops and animals fall under the umbrella of biotechnology. Biotechnology is based on the assumption that life can be made (Shiva 2016), with human intervention occurring on the cellular or subcellular level (Russell 2004). New innovations will lead to increasing numbers of novel modified plants and modified animals (Peters et al. 2021b). Certainly with agriculture, gene edited and genetically modified plants are already commercially grown, whilst gene edited and genetically modified animals are in development. Different countries also have very different experiences of GM crops (Macnaghten et al. 2015). The European Union (EU) have restricted their use (Lang 2021), whilst countries such as the USA, Canada, and Argentina were early adopters (Macnaghten et al. 2015).

The right of people to feed themselves can be undermined by the development of new technologies, and genetically modified crops are no exception. Mexico provides a good example. Maize originates from Mexico and there is believed to be around 60 landraces and thousands of native varieties (Carro-Ripalda et al. 2015). Around 2 million traditional smallholder farmers cultivate maize on their small farms for subsistence, with 20 million acres of land being used for growing the crop (Carro-Ripalda et al. 2015; Fitting 2014). For Mexicans, maize is culturally important as a crop and food, and it is a fundamental component of urban and rural people's diets (Carro-Ripalda et al. 2015; Fitting 2006, 2014).

In 2001, an article was published in *Nature* by Ignacio Quist and David Chapela, claiming the discovery of cauliflower mosaic virus (used in most transgenic maize) in native maize fields in Oaxaca, Mexico (Carro-Ripalda et al. 2015). The virus was thought to have originated in maize imported from the USA, and the unintended gene flow was seen as a threat to the Mexican native maize varieties as well as the culture of the Mexican people (Carro-Ripalda et al. 2015; Fitting 2014). Where GM maize was grown, it was considered a form of imposed globalisation. Globalisation imposes one particular culture on all others (Shiva 2016), and many Mexican people have given up farming and migrated to cities (Flood and Rosenthal Sloan 2019). This mass migration is attributed to government policies relating to the import and regulation of GM maize which have worked to displace rural farmers (Fitting 2014).

As the example with GM maize illustrates, a commodified seed produced through technological processes can dispossess farmers of their seed rights as well as reducing biological diversity (Shiva 2016). The system of production forces farmers into monoculture farming where only a single type of crop is grown. Monocultures are homogenised and lack diversity, but the global control of 'raw materials and markets makes monocultures necessary' (Shiva 2016: 101). Commodification and the owning of life has far reaching implications beyond the laboratory. Monocultures are associated with ecological violence and are a 'declaration of war against nature's diverse species. The violence not only pushes species toward extinction, but controls and maintains monocultures themselves' (Shiva 2016: 102). There is little thought given to biodiversity loss and its impact on climate change (Lang 2021). Instead, owning life is important for the 'Big Four' companies. By owning life, gene edited or genetically modified seeds are turned from renewable to non-renewable resources through the use of technology, and can only thrive through the use of chemical inputs (Shiva 2016).

Protecting ownership is undertaken through patents and intellectual property rights. However, intellectual property rights of gene edited or genetically modified crops and animals, mean life itself is patented. For companies such as the 'Big Four', intellectual property rights provide a 'legal lock and key' (Lang 2021: 410). Companies argue there is a need for patents in order to protect their innovations and recoup their costs after investing huge amounts of capital and time (Lang 2016). The cost of bringing a gene edited or genetically modified crop to market is US$136 million, and the average length of time it takes to bring the crop to market is 13.1 years (CropLife International 2021). During the long commercialisation process, patents enable investments to be protected (Lang 2016).

Before stating why patents are troubling, Standing (2019) explains that those in favour of patents believe companies will not invest in research, and innovation and economic growth will be slower if patents are not in place. However, patenting life is troubling for a number of reasons. Many patents have no societal benefit and are used to prevent the development and production of a rival innovation (Standing 2019). Ethical questions need to be asked about how far science should proceed in light of the sanctity of life (Jasanoff 2016), and if life should be owned. For Shiva (2016: 23), patenting life is an act of violence and she argues that firstly, 'life-forms are treated as if they are mere machines, thus denying their self-organising capacity. Second, by allowing the patenting of future generations of plants and animals, the self-reproducing capacity of living organisms is denied.' (Shiva 2016: 23) If these are acts of violence, then we should be questioning how these acts are facilitated though the ownership, commodification and commercialisation of life.

Not only is life owned, but it is also being altered. The growth in computational capacity, big data generation, data linking and mapping applications provide scientists with the opportunity to access huge data sets (Clapp and Ruder 2020; Peters 2012). This has assisted the development of gene edited and genetically modified plants and animals. Vast amounts of data relating to genome sequencing can be generated using digital methods (Clapp and Ruder 2020). The greater the amount of data available, the more opportunities there are to create novel crops or animals. Not only are we 'reconstructing a more complex tree of life' (Peters 2012: 105), we are also redesigning the tree of life.

4 Understanding Agriculture 4.0

Having introduced digital agricultural technologies and gene edited and genetically modified crops and animals, attention now turns to how we understand these technologies. All of these can be considered biodigital technologies. Whilst biotechnology and biodigital technologies are different (Peters et al. 2021b), in agriculture, they do need to be thought of as complementary. This is because of how agriculture operates. For example, a farmer could be growing gene edited crops whilst at the same time monitoring and tending those crops with robots such as Tom, Dick, and Harry.

Technological developments such as those in agriculture, are seen as progressive. Progressive is part of what it means to be human. Tsing (2015: 21) describes how we 'learn over and over that humans are different from the rest of the living world because we look forward – while other species, which live day to day, are thus dependent on us'. Agriculture exemplifies how other species are dependent on us. If a farmer does not tend to their crops, they will not grow sufficiently. Farmed animals will not be fit and healthy if they are not looked after. However, humans only carry out these tasks because crops or farmed animals are raised for food for human consumption. So whilst crops and farmed animals are dependent on us for survival, we really need them in order for us to survive. Obviously there is an argument to be made about whether there is actually a need to eat farmed animals (see Adams 2015, 2018), but for the purposes of the argument here, I will include them. Whilst digital technologies in agriculture are progressive and can aid farmers in their daily practices, technologies can steer agricultural production towards a particular set of outcomes (Klerkx and Rose 2020).

The current model of intensive farming in developed countries (Lang 2021; Lang and Heasman 2015) may be reinforced by biodigital and biotechnologies. The agricultural sector is already dominated by large, powerful companies, and digital technologies and genetic technologies are likely to be added to their portfolio of new developments. Discussing the European Green Deal, Palahí et al. (2020) explain that the 'quantity-oriented, profit-driven economy should be replaced by an economy focusing on delivering people's needs in a sustainable way. This is not an easy task, and certainly a process which challenges the current balance and distribution of power and interests.'

Whilst this may be true for some sectors of the economy, the challenge to the distribution of power and interests will not be easy in the agricultural sector. In fact, the biodigital may further reinforce the existing power structures. For example, with John Deere, a new tractor can cost hundreds of thousands of pounds because of the vast array of software it contains. The company has been accused of requiring farmers to use them for repairs and servicing, as well as for software fixes (Dauvergne 2020). However, in order to perform 'unauthorised' repairs, farmers are turning to tractor hacking. In the USA, farmers are using firmware purchased from Eastern Europe to break in to their own tractors (Freethink 2021). Farmers pay to purchase a dummy John Deere tractor part, and are then sent a code which is used to access a forum (Vice 2017). Farmers are then able to purchase the firmware they require (Freethink 2021). Twenty states in the USA have introduced a Right to Repair Act in the hope that companies such as John Deere will be prevented from stopping farmers and independent repair shops repairing broken down tractors (Freethink 2021). However, farmers are unlikely to ever consider themselves as hackers. They just need to be able to get on with their work.

Companies such as Bayer-Monsanto, BASF, and DowDuPont have long dominated the global market for seeds, fertilisers and agri-chemicals (Dauvergne 2020; Howard 2016). It is global players such as these which hold the power in the food system. But it is also these global players which are shaping the food system. Whilst food activism is taking place using digital platforms (see Schneider et al. 2018), these global players are themselves using digital platforms to promote their corporate images (Lewis 2018). Jasanoff (2016: 8) argues that technologies function as 'an instrument of governance', shaping the physical, social, ethical and legal settings of the world we live in. Digital and genetic technologies in agriculture are manipulating biology, at the genetic level and more broadly at the environmental level.

The bioeconomy, with its interactions between nature, technology and the economy could help with long term sustainability (Peters et al. 2021c). In 2015, United Nations Member States agreed to the implementation of 17 Sustainable Development Goals (SDGs). The goals 'recognise that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests' (United Nations 2021). Peters et al. (2021c) argue that biotechnology will help achieve many of the SDG goals by reducing the environmental footprint, protecting biodiversity, providing clean drinking water and cleaner and more efficient energy, alleviating disease, and increasing food production. Whilst it will help, biotechnology in the form of genetic technologies can create problems. Genetic technologies are patented, and for many farmers, especially those in developing countries, they are unable to save seeds from their harvest for sowing the following year. Crops such as with the example of GM maize in Mexico, can undermine existing cultures and impose globalisation on countries.

There are also problems with digital technologies. In the UK, the infrastructure is lacking for providing reliable broadband in rural areas. This is problematic as many digital technologies require Internet access. Farmers with little capital are also unable to purchase new technologies, and their skillset may be unsuited to the new ways of working which are required with the introduction of these new technologies (Rose and Chivers 2020). As more data is collected and analysed, farmers become more reliant on technology to make decisions for them. Instead of farming crops, farmers are also farming data. This can lead to a loss of traditional farm knowledge and mental health problems for farmers (Barrett and Rose 2020) because of the change to work patterns.

In making sense of these new agricultural technologies, it is useful to consider the convergence of the two overlapping systems of *bios* and *techne* (Peters et al. 2021a). Biology and technology are converging and combining, and are reinforcing each other (Braidotti 2019). However, convergence is not a new idea. Convergence 1.0 is the union between engineering and physics which enabled the development of technologies which were important to innovation in the twentieth century (Hockfield 2019). These technologies include televisions, radios, nuclear power, aeroplanes, computers and the Internet. The coming together of *bios* and *techne* can be thought of more as Convergence 2.0. Convergence 2.0 is the union between engineering and biology, and this is driving current technological developments such as 'virus-built batteries, protein-based water filters, cancer-detecting nanoparticles, mind-reading bionic limbs, and computer-engineered crops' (Peters et al. 2021a: 372). Developments in Convergence 2.0 have the potential to transform the twenty-first century in the same manner as Convergence 1.0 did in the twentieth century (Hockfield 2019). We have to think of agricultural technologies as Convergence 2.0. As well as gene edited crops, we also need to consider other agricultural technologies as belonging to Convergence 2.0. Interactions occur between the digital, and livestock, soil or water depending on the type of technology being used.

Because of livestock, soil and water being involved in these interactions, the term *zoe* also needs to be used alongside *bios*. For Braidotti (2019: 10) *bios* 'refers to the life of humans organised in society, while *zoe* refers to life of all living beings'. Rules and regulations govern *bios*, whilst *zoe* is vulnerable and unprotected. Technologies can impact *zoe* as much as they do *bios*.

5 Postdigital Hybrid Assemblage

In the agricultural sector, biodigital technologies and genomics (biotechnology) need to be considered as a postdigital hybrid assemblage (Price 2020). The interactions which occur between the farmer, the technology in question and the more-than-human world cannot be ignored. These interactions involve humans, 'non-human agents, technologically mediated elements, Earth-others (land, waters, plants, animals) and non-human inorganic agents (plastic buckets, wires, software, algorithms, etc.)' (Braidotti 2019: 164). The postdigital hybrid assemblage in agriculture enables us to see how digital and genetic technologies can be full of promise, yet at the same time provide dystopian futures. The postdigital hybrid assemblage is characterised by entanglements between human, the biological more-than-human world and technology. By considering how interactions are taking place within and through these entanglements, we can see how the postdigital hybrid assemblage is operating in agricultural settings and what some of the potential futures may be. Before turning to these potential futures, it is worth pausing for a moment to consider our current position.

Rosi Braidotti uses the concept of the 'Fourth Industrial Revolution' to describe how biotechnology, nanotechnology, artificial intelligence, the Internet of Things, and robotics are increasingly being developed and used to solve problems that humanity faces (Braidotti 2019: 2). Braidotti (2019) goes on to explain how these technologies can create more problems than they solve by depleting the Earth's resources and creating social inequalities, and as a result, we are positioned between the Fourth Industrial Revolution and the Sixth Extinction. The Fourth Industrial Revolution is characterised by the 'bio-genetic capitalisation of all living systems, and a pervasive use of self-correcting technologies, driven by artificial intelligence' (Braidotti 2019: 32). The Sixth Extinction, the dying out of species as a result of human activity, is forecast to be more devastating than the previous other five (Kolbert 2014).

By being positioned between the Fourth Industrial Revolution and the Sixth Extinction, we are subjected to the 'systemic accelerations of advanced capitalism and the great acceleration of climate change' (Braidotti 2019: 2). Disasters resulting from this positioning are already occurring (Tsing 2015). In agriculture, the quest for high yields and quick profits result in the use of excessive fertiliser and pesticide applications which can lead to super-weeds and barren soil. Industrialised agriculture is a threat to the natural commons (soil, rivers, wildlife, forests) (Standing 2019), and contributes to climate change (Lang 2021). Having discussed the current position, attention now turns to potential futures and how these can be imagined through the concept of the postdigital hybrid assemblage.

In their article, 'Posthumanism, open ontologies and bio-digital becoming: Response to Luciano Floridi's Onlife Manifesto', Peters and Jandrić (2019) discuss the blurring of human, machine, and nature and ask how is this blurring occurring, and how quickly is it occurring? Agriculture is particularly complex but it does allow us to examine the blurring of human, machine and nature. The effects of encounters in assemblages are the results of entanglements. Multispecies worlds are created by humans and the biological more-than-human world. Technology is now also part of these encounters, either through technologies such as drones monitoring fields or through crops being genetically engineered using computer programmes.

In agriculture, the entanglements between the biological more-than-human world and humans are essential if food is to be successfully grown or reared. Anna Lowenhaupt Tsing (2015) in the book, *The Mushroom at the End of the World*, describes how agriculture consists of polyphonic assemblages with rhythms between plants, animals and humans. Once you start to look at agriculture as a whole such as with relationships between pollinators and plants, sowing and harvesting, these rhythms multiply. In order to be successful in agriculture, farmers need to work with these rhythms. However, what happens when these rhythms are interrupted by digital and genetic technologies? Who has power over nature?

6 The Many Faces of Technobiopower

Power is a really important issue in how encounters and rhythms in assemblages may be disrupted by digital and genetic technologies. In her book, *Modest_Witness@,Second_Millennium.FemaleMan©_Meets_OncoMouse*™, Donna Haraway explains the novel, *He, She and It*, written by Marge Piercy, and describes how the characters live 'in the regime of technobiopower, where literacy is about the joining of informatics, biologics, and economics – about the kinship of the chip, gene, seed, bomb, lineage, ecosystem and database' (Haraway 2018: 2). These cyborg figures are the 'offspring of implosions of subjects and objects and of the natural and artificial' (Haraway 2018: 12). Cyborgs are a multiplicity of 'things'. They are the machines with connections to information and systems, organisms when implicated with the terms of labour and communication, and humans when involved with the objects and practices of technoscience (Haraway 2016).

Whilst the idea of the cyborg is important, it is also necessary to consider how digital technologies are affecting humans. In the 1990s and 2000s, the term postdigital humans referred to those that had been enhanced, but the term now refers 'more often to the ways in which humans are seen in relationship, mutually shaping one another, whilst recognising both what is new as well as what is already embedded in our cultures, institutions, political systems, and relationships' (Savin-Baden 2021: 6). The digital is embedded within everyday human activity (Reader 2021). Being tethered to technology means humans are becoming entangled in the digital world. This means that humans are becoming intimately involved with digital technologies, leading to an increasingly data-driven world (Hayes 2021). In agriculture, the postdigital farmer is becoming more prevalent as digital technologies are adopted. The postdigital farmer is growing postdigital crops and could eventually be rearing postdigital animals.

Postdigital farmers are becoming increasingly reliant on the technologies developed by companies such as the 'Big Four'. This has implications for the encounters and entanglements which can be found in the assemblages in agriculture. Genes which are the sources of biological diversity in technobiopower, are causing policymakers, venture capitalists, scientists and activists to scrabble and challenge for their control (Haraway 2018). Controlling genes means not only controlling the natural genetic diversity, but also the technology to create new beings. For Donna Haraway (2018: 58), we should be asking what 'new beings, for whom, and out of whom' are being produced with genetic technologies. We should be concerned because the 'Big Four' now control 60% of global seed sales (Civil Eats 2021). Gene edited or genetically modified seeds are increasingly becoming patented and subjected to intellectual property rights.

Technobiopower is concentrated in the 'Big Four' with genetic technologies. But this is not the only way in which power is concentrated. Data collected by digital technologies allows power to filter rapidly throughout the food system (Lang 2021). For example, the data collected by a sensor on a John Deere tractor, is transferred from the farm, to John Deere's software. Due to the business model they operate, the information about the soil and the crop belongs to John Deere, not the farmer. If the farmer wishes to use that data for decision making, it has to be purchased from John Deere, even though it is about the farmer's own farm. It is software which is the source of power (Lang 2021). Seamless data collection should also be bringing questions about privacy to the fore (Hayes 2021). However, privacy in Agriculture 4.0 is an area that is neglected. Software licences which are embedded in farming equipment such as tractors, sensors, and drones are often not discussed with farmers at the point of sale, nor are they told that turning on farm equipment or downloading updates means they are agreeing to a range of terms and conditions (Wiseman et al. 2019). This lack of transparency means farmers are unaware of the extent their data is being shared or traded, and how much control they actually have over their own data.

There are other implications for digital technologies along with power. It is important to note that digital technologies in agriculture are always portrayed as being smart, they are never not smart (Lang 2021). As digital technologies are smart, they can conduct the job of the farmer. There are calls for farmers to be upskilled in order to use new technologies (NFU Mutual 2019). However, the flip-side to upskilling and having the ability to use new technologies, is the loss of traditional forms of knowledge. Instead of carrying out a task in a way that has potentially been passed down through generations of farmers, digital technologies are taking over some of these tasks. Digital technologies in agriculture are transforming the amount of labour required in food production (Lang 2021), with less people required to carry out work.

It is important to consider the impact of digital technologies for farmers and agricultural labourers. Peters et al. (2021b) discuss how humans are open to being different and may evolve into biodigital beings. Farmers are told they need to upskill in order to have the knowledge to use and operate new technologies. By doing so, the farm becomes more automated. However, automation de-skills the farmer and 'power moves to the technologist, marginalising the ousted worker' (Lang 2021: 405). The farmer has to operate the technology in the particular way it has been designed, so traditional knowledge held by the farmer is swept aside.

As well as automation replacing labour, it also speeds up remaining labour (Lang 2021). The technical training and expertise required by farmers to use digital technologies could potentially make them more reliant on technology providers (Dauvergne 2020). It is not only reliance on technology providers which is changing, but also the nature of the entanglements for farmers which are altering. Ongoing configurations are alluded to by Barad who suggests:

> Machinic agency is part of the ongoing contestation and reconfiguring of relations of production. The point is not that management and workers become cyborgs in their relationship to machines, but rather the point is that machines and humans differentially emerge

> and are iteratively reworked through specific entanglements of agencies that trouble the notion that there are determinate distinctions between humans and nonhumans. (Barad 2007: 239)

Farmers, and the machines and equipment they use are entangled together. This is not a new phenomenon. In the eighteenth century, farmers were working with more sophisticated equipment such as ploughs, they were using crop rotation, and were breeding better farm animals, whilst in the twentieth century, they were using chemical fertilisers and pesticides on their crops, and accessing seeds produced through improved plant breeding techniques (Lang 2021). However, digital technologies are reworking the entanglements which are already found in the assemblages of the human, the biological more-than-human world, and machines in agriculture. Rather than physically being out in the field looking at crops or checking farm animals, farmers can obtain all the information they need about their crops and farm animals from tablets and smartphones (Farm Futures 2018). Farmers do not have to be physically present on their farm, they can be at home or out shopping.

It is not only human labour affected by digital technologies. Declining numbers of bees and other insect pollinators has led to the development of robotic pollinators (Nimmo 2021). RoboBees are being developed by the Wyss Institute at Harvard University. These miniature robots can be used for crop pollination along with weather, climate and environmental monitoring. The RoboBee consists of three components which are the body, brain and colony. The construction is described by the Wyss Institute (2021) as follows:

> Body development consists of constructing robotic insects able to fly on their own with the help of a compact and seamlessly integrated power source; brain development is concerned with "smart" sensors and control electronics that mimic the eyes and antennae of a bee, and can sense and respond dynamically to the environment; the Colony's focus is about coordinating the behaviour of many independent robots so they act as an effective unit. (Wyss Institute 2021)

This postdigital bee is designed to carry out the work of wild pollinators. RoboBee is best thought of as a biodigital technology. With biodigital technologies there can be catastrophic consequences for ecosystems should they fail (Peters et al. 2021b).The irony here should not be overlooked. Natural ecosystems are already failing. The demise of bees and other pollinators are linked to the overuse of agrichemicals (Lang 2021; Lang and Heasman 2015). The agricultural industry could be looking at approaches to reduce these agrochemical inputs. This could be different farming approaches or technologies such as the weeding robot developed by the Small Robot Company. Instead, RoboBee has been designed to replace natural populations of bees and other pollinating insects. If biodigital technologies are to be synchronised with sustainability principles (Peters et al. 2021b), then RoboBee is not an effective solution. RoboBee is an example of using a biodigital technology to address an environmental problem of humans own making. A technology such as RoboBee enables crops to continue to be pollinated, and is engineered to overcome the collapse of natural systems. However, instead of addressing the fundamental and underlying issue of pollinator loss, RoboBee is just a sticking plaster. It is also worth remembering that robotic pollinators are not designed to replace insects, but to replace human labour once the insects become extinct (Nimmo 2021). If insects become extinct, humans will be required to hand pollinate crops. Hand pollination is not a new phenomenon. In Sichuan Province, China, apples have been hand pollinated since the 1980s due to declining pollinator numbers caused by habitat loss and the overuse of pesticides (Partap and Tang 2012).

The postdigital hybrid assemblage enables us to see the many entanglements present with agricultural technologies, be these digital or genetic technologies. But what do these entanglements mean for the agricultural industry? As Tsing (2015: 19) argues, imagining 'the human since the rise of capitalism entangles us with ideas of progress and with the spread of techniques of alienation that turn both humans and other beings into resources'. Humans, the biological more-than-human world, digital and genetic technologies are all resources in agriculture. This can be illustrated with an example of strawberries pollinated by RoboBee. The resources required are human labour, RoboBee, strawberry plants, soil, water, and data. Whilst these are resources, they are also entanglements.

Although digital technologies and genetic technologies are full of promise for agriculture, we do need to be aware of the challenges they bring. As Braidotti (2019: 112) argues, we need 'to embrace the opportunities offered by the new technologies and steer them towards new forms of solidarity and democratic debate and dissent'. It is important that this happens because currently companies are trying to protect the innovations they have created through patents, whilst farmers are turning to hacking so they can keep their tractors operating. We need to understand how the transfer of power is operating throughout the food system, as data is collected and shared. We need to know about changes to human, biological more-than human and machinic labour. It is these biodigital connections that need to be understood.

7 Conclusion

This chapter sought to answer two questions. Firstly, how can we understand new agricultural technologies from a postdigital hybrid assemblage perspective? Secondly, can the concept of postdigital hybrid assemblages help us understand the impact of the biodigital in the agricultural sector?

I have shown that whilst biotechnology and biodigital technologies are different (Peters et al. 2021b), they do have to be thought of as complementary in agriculture. Biotechnology is allowing gene edited and genetically modified crops and animals to be developed, whilst digital technologies can be used to monitor these crops and animals. These new agricultural technologies are characterised by confident expectations of progress, invoking ideas of sustainability and increased food security. Whilst these new technologies will no doubt achieve these goals, there are implications which are revealed when examining these technologies through the lens of postdigital hybrid assemblages.

The postdigital farmer is becoming more prevalent with the adoption of digital technologies, and is growing and monitoring postdigital crops. In the future, there may be commercially available postdigital livestock. However, postdigital farmers are becoming increasingly reliant on the technologies developed by companies such as the ‘Big Four’. This has implications for the encounters and entanglements which can be found in the assemblages in agriculture. There is a concentration of techno-biopower in the ‘Big Four’ companies with the development of genetic technologies, but also with filtering of power throughout the food system by the collection of data by digital technologies. This data is being used for top-down control as opposed to benefiting those at the bottom (Lang 2021). The large agricultural companies are benefiting from data collection through greater financial returns, whilst farmers are losing control of the data about their own farms (Jakku et al. 2019). There is an alternative to this concentration of power. Data could be open source enabling farmers to experiment and innovate (Carbonell 2016), with the benefits of these innovations reaching a larger number of farmers.

Digital technologies also mean the job role of the postdigital farmer is altering. Farmers no longer have to be in the field looking at crops or checking livestock. Instead, sensors and wearable devices are sending data to the farmer’s smartphone or tablet. It is not only the labour of humans which need to be considered in the biodigital world of agriculture. Postdigital bees such as RoboBee are being developed to take over the role of wild pollinators. Should wild pollinator numbers fall so dramatically, there will be a need for interventions in the pollination of certain food crops. RoboBee not only replaces the labour of wild pollinators but also the need for human labour to hand pollinate crops.

Agriculture needs to move to sustainable farming practices. Digital and genetic technologies are approaches that can be used to help achieve the aim of sustainable farming. Whilst the world may not be in the age of bioeconomy (Peters et al. 2021c), the agricultural sector is an area where the bioeconomy is beginning to emerge. However, we do have to be careful with technologies in the bioeconomy. A sustainable and resilient bioeconomy is powered by biodiversity. Whilst RoboBee could present a solution to pollinating food crops due to declining wild pollinator numbers, we should not overlook why this problem is arising. Looking to the problem of the overuse of pesticides and insecticides in agriculture could help us save our wild pollinators. We should be trying to solve this problem first. RoboBee should be a technology of last resort.

Finally, the ‘earth, animate and inanimate beings and objects, algorithms and postdigital platforms, and the political and social restrictions’ (Jandrić and Ford 2020: 5) are all becoming tied up in agriculture. Questions are being raised about the implications for digital and genetic technologies in agriculture and what the future may hold (Bronson and Knezevic 2016; Dauvergne 2020; Klerkx and Rose 2020; Rose and Chilvers 2018). Does power become even more concentrated with the ‘Big Four’ controlling an ever greater percentage of global seed sales? Will all decisions about a farm ultimately be made by technology? Will postdigital farmers be needed? What impact will digital technologies have on the biological more-than-human world? Will there be more incidents of farmers hacking technologies? These are questions that will need to be addressed. The use of digital and genetic technologies in agriculture may not be the silver bullet for sustainable agriculture. Instead, unsustainable agricultural production practices may be further intensified. Looking at agriculture through the lens of the postdigital hybrid assemblage, enables us to see how digital and genetic technologies can be full of promise, yet at the same time provide dystopian futures in agriculture.

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Maps of Medical Reason: Applying Knowledge Graphs and Artificial Intelligence in Medical Education and Practice

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1 Addressing Biodigital Convergence in Theory and Practice

'Biodigital convergence and its various implications, from biotechnology to bioeconomy, seem to promise a Copernican shift in our current way of life,' say the editors of this volume (Peters et al. 2021a: 6). The biodigital is 'an emerging configuration' (Peters et al. 2021b). The editors also speak to the notion of a 'postdigital' age, taking up an idea first contemplated by Nicholas Negroponte (1998): 'Its literal form, [digital] technology, is already beginning to be taken for granted'. Soon, 'like air and

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drinking water, being digital will be noticed only by its absence, not its presence… Computers will be a sweeping yet invisible part of our everyday lives: We'll live in them, wear them, even eat them. A computer a day will keep the doctor away.'

If we are to take 'postdigital' at its word, we have become so thoroughly 'in' the digital that we have become 'post' by virtue of its barely noticeable ubiquity. However, like other 'posts', we need to suspect sweeping assertions of rupture, as if for instance the 'postmodern' were not a variant of the modern, and the 'posthuman' not a variant of the human. The digital, after all, is not so new, beginning perhaps with Claude Shannon's insight that electrical switches could represent two numbers—on and off; zero and one; which in turn could represent Boolean logic (Shannon 1938). In any event, underlying algorithmic processes are binary, and at most only partly and secondarily digital. And we can never be 'post' to the extent that the meanings can only be partially represented and calculated with quantifying media—bodily meanings and medical conditions, for instance. Our Fitbits do not erase the difference between body and its calculability. The bio and the digital do not become each other. The digital and the bio are fundamentally and irreducibly different from each other. The digital is no more than a quantitative, conceptual representation of limited features of the bio. Hence, Jandrić et al. (2018: 895) conclude: 'The postdigital is hard to define; messy; unpredictable; digital and analog; technological and non-technological; biological and informational. The postdigital is both a rupture in our existing theories and their continuation.'

Inspired by the themes of this volume, the chapter that follows speaks both philosophically and technically, and theoretically as well as practically. Philosophically, we want to speak to theoretical limits as well as the enormous potentials of algorithmic reason. Practically and technically, we want to describe a project in which we have been developing knowledge graph software to support medical education and electronic health records. This project has been supported by a series of three grants from Jump Applied Research through Community Health through Engineering and Simulation (ARCHES) program, a partnership between Jump Simulation and Education Center at OSF HealthCare and the Health Care Engineering Systems Center in the Grainger College of Engineering at the University of Illinois.

Our thesis is as follows: the biodigital is today both ubiquitous, as evidenced in rapidly expanding use of computable information in modern medicine, and an oxymoron, because the bio and the digital are irreducibly different things. As a consequence, our focus is the relation between these two.

Elsewhere, two of the research team have developed a metaontology centered around the idea of 'transposition' or movements in meaning appliable to digitally-mediated representation and communication (Cope and Kalantzis 2020; Kalantzis and Cope 2020). Here we have identified four transpositions between the qualities of biolife and the quantities in which they may be calculable (Cope et al. 2020). These are as follows.

Namability: the character collocations of medical labels can be tracked for similarity by search and other forms of text mining—the terms in a medical ontology, for instance—but computers can have no conception of what these labels mean.

Countability: instances of labelled things can be counted, but counting is always limited by the criterial features of a label, losing in the process irreducible materiality of the singular referrent and the subtleties of its context. This is an intrinsic limitation if population-based medical science, whatever its undoubted benefits.

Measurability: clines of progression can be measured, often now with automated sensors (temperatures, heart rates, pharmacology etc.), but such numbers are mostly limited to linear vectors.

Renderability: digital capture tools can render medical images on a two-dimensional plane, and 3D printing can construct three-dimensional medical models and even prosthetic body parts, but the materiality of rendered image and object is always fundamentally different from its referent.

These four things, and no more, can be performed by the mechanics of the digital. These are what the digital offers us, sometimes a miraculous servant for the cure of our bodies, but these transpositions also set its absolute limits. The limits of the digital are the limits of the transposability of qualitative biomeanings into quantity.

2 Ontologies, in Philosophy and Medical Practice

Theoretically, this chapter works at two levels, applying the concept 'ontology' philosophically at one level, and technically at another. Philosophically, the term 'ontology' connects material being with the immaterial of its understanding, our viscerally experienced lives and bodies connected with models or schemas of specialized medical understanding. In traditional philosophical terms, ontology is a relation between the material (bodies) and the ideal (medical reason). Technically, in the digital era ontologies perform the same function, as schemas that represent and model the material world. In our case, medical ontologies to describe bodies and their ailments. They transpose the ideal and the material through a backwards-and-forwards play between conceptualization and practice**.** In our case, the medical understandings captured in medical ontologies are connected in medical practice with the biomedical materiality of bodies. One of many such connections is that between bodies in a qualitative experiential sense and their quantitative calculability. This is the extent of 'biodigital convergence'.

On the question of calculability, the relation of the ideal of the calculability with the material of the world to which it refers, Gottfried Leibniz led the modern charge. Here he is, writing in 1666:

> I have found an astonishing thing, which is, that we can represent all sorts of truths and consequences by Numbers … [T]here are certain primitive Terms which can be posited if not absolutely, at least relatively to us, and then all the results of reasoning can be determined in numerical fashion, and even with respect to those forms of reasoning in which the given data do not suffice for an absolute answer to the question, we could still determine mathematically the degree of probability… and where there are disputes among persons, we can simply say, Let us calculate, without further ado, in order to see who is right. (Leibniz 1951: 50–51)

Chris Anderson, editor of Wired magazine, was still saying a version of this in 2008.

> Out with every theory of human behavior, from linguistics to sociology. Forget taxonomy, ontology, and psychology … This is a world where massive amounts of data and applied mathematics replace every other tool that might be brought to bear … With enough data, the numbers speak for themselves. (Anderson 2008)

We disagree, for the reasons that we lay out in this chapter. Of course, we live in an era of 'big data', of massively networked and integrated information. But purely algorithmic reason only works by leveraging human reason. One such leveraging is the process of inference in statistical text mining (Zhai and Massung 2016). Text consists of stings of characters which in combination reference things and ideas. Computers can never be intelligent in the sense of understanding ideas, but they can point to repetitions in strings of characters that come together into words that may make sense to humans. Statistical work with text can only point to latent semantics (Landauer et al. 2007). After the patterns of textual characters are counted, the limits of this process are the limits of natural language with its baffling ambiguities, infinitely variable context dependencies, and polysemy that even the best of dictionaries find hard to disentangle. Supervised machine learning helps, where humans supplement numerical or textual meaning with labels that are meaningful to them. This helps the machine detect future such patterns; and unsupervised machine learning where the machine finds statistical clusters or outliers that may warrant labelling. In both cases, the thinking can never be smarter than the labels that humans apply.

So, on top of the laborious but otherwise dumb calculation of frequencies of alphanumeric characters, the textual labels are crucial. Folksonomy is commonsense, ad hoc and frequently spontaneous labelling, of which hashtags have become a prominent example in the era of social media (Guy and Tonkin 2006). Taxonomy (hierarchical) and ontology (multidimensional) have become crucial tools for representation of meaning in the digital era.

In their basic functions, taxonomy and ontology are as old as the human mind—beginning with the extraordinarily complex totemic, kinship, and natural classification systems of First Peoples (Kalantzis and Cope 2020: 42–47). For modernity, Immanuel Kant proposed a 'categorical imperative', or the process by which mind applies its categories of meaning to the material world encountered by the human body. In our utilitarian twenty-first century, digitized ontologies are pervasive. Kant could be proud of the rigorous intent of the categorical systems insisted upon by the medical insurance companies in order to argue the cost of medical interventions.

An example: Intelligent Medical Objects (IMO) is a company in the Research Park at the University of Illinois that teases out the nuances of how human bodies work, or don't so well in the case of illness and death. 'Object' is a revealing word, because the manner of relating of concepts is digital ontologies are not merely conceptual; they purport reference objects of the material world, in this case manifest physiological conditions. These are not mere ideas or figures of cognition. They are 'objects', arranged in some sort of order, and this order is a series of determinate relations. Though not a commercial concern for the IMO company, this is where the philosophical notion of ontology meets the technical one. The medical labels dwell in the realm of the ideal, but they oriented to the realm of the material, people's bodies.

'Clinicians are asked to see 6–10 patients per hour & do all the documentation', says the PowerPoint presentation that is used to sell the IMO software product. 'The most expensive resource in the healthcare ecosystem is currently being used to do the bulk of documentation via the Electronic Health Record (EHR). How do you extract maximal value for your investment?'

IMO offers a standardized classification scheme by means of which medical vendors can share electronic records about a patient's medical condition, preserving 'the truth of clinical intent'. Not only is there a problem of accurate coding. There are two main classification schemes, ICD (the International Statistical Classification of Diseases and Related Health Problems[1]) and SNOMED (Systematized Nomenclature of Medicine[2]). ICD exists in a succession of versions, older records in ICD-9, and newer records in ICD-10 and after that, ICD-11. IMO provides apps, accessible on computers and phones, for looking up the terminology associated with different medical conditions across ICD-9, ICD-10, ICD-11, SNOMED, and other specialized medical ontologies.

IMO also analyzes synonyms that emerge in medical practice and maps these to the standard ontologies. For instance, IMO has a term 'abnormal excitement', which maps to ICD version 9 code 799.29, 'other symptoms involving emotional state'. Version 10 of ICD codes this R45.0, 'nervousness'. SNOMED codes it 247006004, 'Over-excitement', or 'Uncontrollable excitement'. At this point, medical classifications begin to run into another life-defining ontology, the Diagnostic and Statistical Manual of Mental Disorders.[3]

The historians of ICD trace the origins of formal classification of medical conditions to registrations of the causes of death from Italy in the mid-fifteenth century and England in the mid-sixteenth. ICD had its beginnings in the International Statistical Congress, which first met in Brussels in 1853, when the 'CD' part of the acronym stood for 'causes of death'. At the 1860 meeting in Paris, Florence Nightingale used death classification statistics to show the causes of hospital deaths and how they could be reduced (Bostridge 2008: 11–12).

The first version of the International List of Causes of Death was adopted at the Chicago congress of 1893 (Moriyama et al. 2011: 11–12). Since then, ICD has gone through eleven major versions, including digitization in the third quarter of the twentieth century. The title 'Causes of Death' was changed to 'Classification of Diseases' in 1949 when the World Health Organization took responsibility for it. WHO now hosts periodical revision conferences and manages the revision process. ICD-10 was released in 1994, ICD-11 in 2018. ICD-11 expands the number of

[1] See https://www.who.int/standards/classifications/classification-of-diseases. Accessed 1 October 2021.

[2] See https://www.snomed.org/. Accessed 1 October 2021.

[3] See https://www.psychiatry.org/psychiatrists/practice/dsm. Accessed 1 October 2021.

codes available to 55,000, up from the 14,400 in ICD-10. Meanwhile, SNOMED, in development since 1965 and now controlled by a London-based not-for-profit, was created to describe a range of pathologies and clinical processes—311,000 in total—not all of which are adequately captured in ICD.

Nobody could conceivably remember or be able to speak more than a few of 55,000 or 311,000 things, which is why IMO created the look-up app as a textual prosthesis for medical professionals. ICD-10 is a carefully ordered classification scheme, divided into in sections that are marked auspiciously with roman numerals. It has sections on various bodily systems: IX 'circulatory', X 'respiratory', XI 'digestive', IV 'endocrine'. Then there are some strange system conjunctions: XIII the 'musculoskeletal system', and XIV 'genitourinary system'—muscles are very different from bones and reproduction very different from urinating, but in the body, these things work together or are near each other.

Ontologies connect the objects of their reference in a number of kinds of relation. For instance, one thing may be a kind of another, or it may be an instance of another. 'Malignant neoplasm of the breast' is a kind of 'neoplasm'. This is type of coherence can be visualized taxonomically: one thing is an instance of concept that happens more than once, such as a single case of breast cancer. More broadly encompassing concepts can group subsets of narrower concepts. Ontologies can also represent things that are parts of another. For example, 'Sprain and strain of ankle' involves joints and ligaments, constituent parts of ankles. They can represent patterns of action in chains of cause and effect. 'Whooping cough due to Bordetella pertussis' is different by dint of its cause from 'Whooping cough due to Bordetella parapertussis'.

The coherence of ontologies is also just as much a matter of relations of difference, where as much importance is afforded to: not-a-kind of; not-a-part-of; does not have certain properties; or does not cause. In medicine, differential diagnosis is the process of distinguishing the 'is' from the 'is-not', even though the symptoms may have created initial uncertainty. Medicine then becomes a practice of weighing evidence in order to make categorical judgment. Differentials in medicine are close but nevertheless important differences. And there are differences that are just irrelevancies, or informational 'noise'.

No two relations are the same. We can use 'kind of', 'part of', 'property of', and 'cause of' as rough heuristics for relations. But muscles do not connect with bones in the same way that the environmental conditions of bodies and brains connect to emotional states.

This irreducible specificity of relations is also the reason we need big lists of things, codified and the subject of general agreement in the digital era. As well as describing the body and its ailments, GeoNames[4] is for places, Ethnologue[5] for languages, Chemical Markup Language[6] for chemistry, product numbering and

[4] See http://www.geonames.org/. Accessed 1 October 2021.

[5] See https://www.ethnologue.com/. Accessed 1 October 2021.

[6] See https://www.xml-cml.org/. Accessed 1 October 2021.

classification systems for purchasable things.[7] The list of lists in digital modernity is long, covering billions of the most useful and important things that can be meant, many of which, as it happens, may impact medical conditions. More meaning is to be found in the unique configurations of relations in these lists than can be found in purely algorithmic or logical work of so-called 'artificial intelligence'.

Of course, even the most fastidiously organized ontologies are rough and indeterminate in places. In the case of ICD, some are internal to bodies, some external, but nevertheless objects of very different orders: organs or parts of the anatomy such as VIII 'eyes', VII 'ears', XII 'skin'; acquired conditions such as I 'infectious diseases' and II 'neoplasms' (cancers); external effects such as XIX 'injuries'; conditions that may have been inherited in the form of XVII 'congenital malformations'; conditions that may not even be medical, at least in their origins, but which might now be classified as V 'mental or behavioral disorders'; and stuff that happens in XXI 'contact with health systems'. Cross-classification clarifications are offered in the form of inclusions and exclusions. XVI 'perinatal conditions', we are told, includes conditions whose origins are in pregnancy even though the baby dies later, but they exclude congenital malformations.

For all its agonizing order, and after a century and a half of institutional agonizing about its ordering, ICD still has the appearance of a ramshackle list. This is not because our medical thinking is flawed, but because the material world is endlessly varied and complex. The list is as ramshackle as the particularities and relations of biolife itself. And it is as fallible as the politics of the construction of the medical self, where old maladies such as homosexuality are no longer that, and new conditions appear, such as post-traumatic stress disorder. 'Classification systems', say Bowker and Star (2000: 61), 'simultaneously represent the world "out there," the organizational context of their application and the political and social roots of that context. Many of these concepts are matters of judgment and thus contention. 'Excitement', 'nervousness', and 'emotional states' traverse vast territories of human experience, and the point at which these become a medical condition as distinct from healthy life may at times become a contentious matter between patients, doctors, and insurance companies.

Then there is the frequently-appearing but nevertheless disquieting notion of 'other'—'other infectious diseases', 'unspecified mental disorder', 'neoplasms of uncertain or unknown behavior', 'other ill-defined and unspecified causes of mortality', 'provisional assignment of new diseases of uncertain etiology or emergency use', to mention just a few labels for uncertainty in ICD-10. If an ontology is to encompass all possibilities in a domain, it has to countenance as-yet or in-the-moment unknown possibilities.

In the professional domain of medicine, the historically evolved ontology of ICD speaks an un-natural language. For all the open-ended possibilities of medical science, the aim of an ontology is to reference the world—in this case, the human body

[7] See https://www.gs1.org/standards/barcodes/ean-upc. Accessed 1 October 2021.

and its maladies—in ways that are more precise than the natural language of everyday or vernacular experience of sickness and health.

How, then, do digitally represented labels arrayed in conceptual schemas connect with the bodies they are labelling? At this point, we come to rely on the philosophical notion of ontology. This is our twenty-first century replacement for metaphysics, tracing the relations between the material and the ideal. The material of ontology is the immanent if complex order in the world, in nature, society and history. The ideal of ontology is the conceptualization of these meanings, not only by means of the artifact of language, but with other tools of representation including image, space and embodied feeling. The ideal is integrally connected with the material, but the one is never a straightforward reflection of the other. The ideal can exceed the material, in conjecture and imagination, in the service of a medical diagnosis or scientific hypothesis, for instance. And the material exceed the ideal, for example in the as-yet undiscovered but eventually knowable (Cope and Kalantzis 2020: 280–303).

Returning now to the specifics of medical ontologies. The labels are ideal in the sense that they are ideational constructs, and the bodies to which they refer are material. The two are of course connected. There is no label in a medical ontology without a material reference to which it can point in the body, brain, or behavioral manifestations of mind—either retrospectively or potentially. There is no meaningful material body without our making sense of it. But the ideal and the material are not mirror reflections of each other. The material can exceed the ideal—things that are as yet unexplained, for instance, in a particular case or in medical science. And the ideal can exceed the material—diagnoses about the causes of illness, or prognoses about progression and the effects of treatment. Ontology is a complex dialectic, a play between the ideal and the material (Cope and Kalantzis 2020: 302–10).

3 Knowledge Graphs, in Theory and Practice

Digital ontologies can be represented visually as concept maps or knowledge graphs. The concepts of an ontology can be represented as labelled containers, joined by lines to indicate one kind of relation or another: something that is a part of something else; something that is a kind of something else; something that has a namable property; or something that is a cause of something else. Medical ontologies can be represented taxonomically, as tree diagrams showing parent/child and sibling relations. Knowledge graphs, however, allow endless complexity where each node can be represented in multiple relations with other nodes, and different kinds of relations between nodes can be specified as labels for the arrows that connect them. To agree on labels and relations for a domain like medicine, as we have seen in the case of the history of ICD, is a long historical and open-ended social process.

The emergence of the social web has led to a shift in meaning making in the direction of more collective endeavors, of which ICD online is an example. This process can be found in present-day representation of large-scale collections of knowledge with emphasis on aggregation and integration, utilizing standardized schemes for scalability, structure, identity, relationship, and provenance. This phenomenon is clearly evidenced by the rise of large-scale knowledge graphs and their growing importance to sense making at scale.

The knowledge graph is not a novel development in knowledge representation or automated reasoning. In early AI research expert systems employed various mathematical logics and rule-based reasoners to represent knowledge and perform inference—with emphasis on capturing human expertise to approximate human level reasoning. Knowledge was thought of as 'descriptions, relationships, and procedures' (Hayes-Roth 1983). Semantic networks were used as visual representations of first order predicate logic (FOPL) where nodes represented entities and links were thought of as predicate relationships (Dietterich and Michalski 1983). Reasoning was performed by applying logic rules over typed entities to generate new entity relationships and attributes.

The current day graph database systems evolved gradually, in response to improvements in hardware performance and storage of ever-increasing amounts of data—including curated stores, and evolution of mature standards of data identity, semantics, and federation. Outside of academia, prior to the 1980s, data was stored in customized hierarchical structures largely influenced by hardware limitations and with a premium placed on efficiency of insertion and retrieval.

The 1980s through the end of the century saw the development of relational database technologies, based on the relational algebra. These technologies also emphasized data operational efficiencies over the leveraging the power of the data itself (i.e., relations between data elements were limited), with tables of columnar data types joined to other tables via key fields and queried using the Structured Query Language (SQL). Triple stores (RDF) and No-SQL technologies developed soon after which allowed data of any shape to be stored in key value systems, and relational knowledge of data entities could be represented at a finer grain. Graph database technologies in general use began to emerge around 2010 and have been improving over the last decade. The graph database systems of today allow relations as first-class objects with reasoning engines that fully realize the knowledge graph at scale. In general terms, Gosnell and Broecheler characterize the historical evolution as database from hierarchical models, to relational, to NoSQL, and in the 2020s, graph thinking (Fig. 1).

The widespread currency of the contemporary knowledge graph can in large part be traced Google's application of the technology to its search. Launched in 2012, Knowledge Graph presents summary text and images about a search topic in a panel on the right side of the screen. A search on the musician 'Taj Mahal' works because Knowledge Graph knows the difference between the singer, the tomb in Agra, and Donald Trump's failed casino in Atlantic City. Google knows enough about you from your search history and the history of searchers like you to decide which Taj Mahal you are most likely to be interested in. This is because the string of characters 'Taj Mahal' has been classified into a number of different meanings across multiple ontologies.

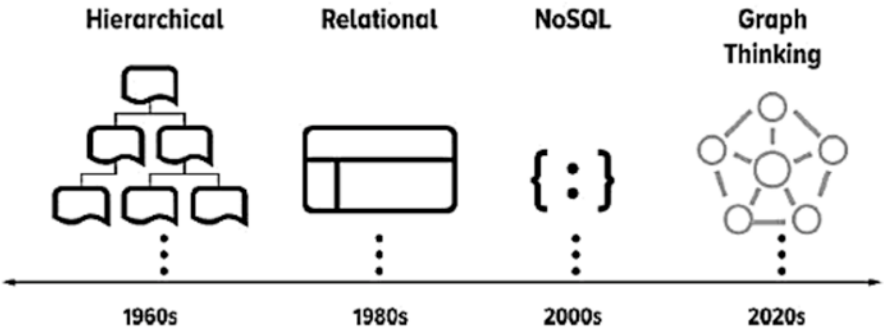

Fig. 1 Evolution of database technologies (Gosnell and Broecheler 2020: 3)

'Things, not strings', has become the Google Knowledge Graph mantra (Singhal 2012). Behind Knowledge Graph is a repository, Knowledge Vault. Unlike previous, text-based extraction, which can be very noisy, Knowledge Vault 'combines extractions from Web content… with prior knowledge derived from existing knowledge repositories' (Dong et al. 2014). Such knowledge repositories have been hand-curated and over a long period of time—medical ontologies, for instance. Google is secretive about its Knowledge Graph technology (Paulheim 2017: 2), but one suspects that its power lies in Knowledge Vault, where the copying of a huge amount of web content, including previously hand-curated ontologies, is at least as powerful and probably more powerful than data mining of unstructured text.

'Defined abstractly', says Kerjriwal (2019), 'a knowledge graph is a graph-theoretic representation of human knowledge such that it can be ingested with semantics by a machine'. However, graph conceptualizations of the world are infinite, capable of generating too much information to the point where they are practically unreadable. Each graph needs to be selective, a small and germane collocation of nodes and specified relations—whether these are machine suggestions, or machine-readable human suggestions (Cañas et al. 2015). These may function pedagogically or to support thinking, as advance concept organizers (Ausubel 2000), concept maps (Novak 2010), or learning progressions (Shi et al. 2020).

Gutiérrez and Sequeda argue that today, data represents a commodity, tied to bits and formats, devoid of any meaning in and of itself. Knowledge, on the other hand, has been thought of as a 'paradigmatic immaterial' object living only in people's minds and language. Over the decades computer scientists have gradually developed the techniques and systems to 'materially support knowledge'. The fusion of knowledge and data thus creates meaning, and knowledge graphs are a manifestation of this vision at scale (Gutiérrez and Sequeda 2021: 104).

The life sciences have been early adopters of semantic web technologies (Chen et al. 2013), and as such they are also heavily involved in advancing knowledge graph research and application. One challenge of knowledge graphs in the life sciences is the integration of disparate knowledge and data sources into one cohesive graph. The Covid-19 Community is a project funded by National Science Foundation

(NSF) to integrate 'environmental datasets to help researchers analyze the interplay between host, pathogen, the environment, and COVID 19' (Rose et al. 2020). The project is using the Neo4j graph database software to integrate disparate data sources to enable reasoning and search in the domain of Covid-19. Over eighteen such datasets are utilized spanning diverse domains such as geography (GeoNames),[4] Covid-19 data resources like the Covid-19 Data Repository by the Center for Systems Science and Engineering at Johns Hopkins University (Covid-19 Data Repository),[8] and general medical resources like the Disease Ontology (Disease Ontology[11]). The graph contains over ten million nodes and thirty-three million relationships. At a high level, these knowledge sources can be broken down into the following categories: metadata; biological data and literature; locations, epidemiological data; and population characteristics.

The network is updated nightly via a staged workflow. Public data sources are ingested (caching reduces redundant processing), and analytics process the data to produce node and relationship data which is integrated into the knowledge graph. To facilitate better integration, the project added their own metadata in the form of nodes and relationships. This is type information used to label data elements. For example, node types like 'strain', 'gene', and 'city' are used to provide type information and to link types via relationships in a graph wide manner. Data provenance was also added by including data source nodes that identify the origin of various data elements.

Another important feature for interoperability across various resources is the use of unique identifiers. The European Union has developed a resolution service called identifiers.org which maintains unique identifiers in the form of compact URIs for over 700 life science resources. This is of critical importance to integrate and link concepts from the various data sources. In other instances where no such service is available, custom identifiers were constructed using attributes of the data elements. Challenges that were encountered in constructing this resource included the sheer variety of file formats, data types, and modalities of data access. Additionally, the sheer volume of the data to be processed while it is changing in real-time was a challenge for synchronization and machine resources. Data inconsistencies also require strategies for bridging gaps, detecting file format errors and the like. There was also a need for domain knowledge to bridge gaps in knowledge representations across domains and at differing scales.

In the following sections we describe the work we have been doing to apply medical ontologies to medical education and health records.

[8] See https://www.openicpsr.org/openicpsr/covid19. Accessed 1 October 2021.

4 Medical Informatics: Where Algorithmic Reason Meets the Semantics of the Body

The research and development we have been undertaking addresses some methodological questions for evidence-based medical science that go to the very heart of its information systems. Leading computer scientist, Judea Pearl, questions the limits of purely statistical and correlational approaches to data, recommending they should be supplemented by 'causal models [that] facilitate the evaluation of the effect of novel actions… that were unanticipated during the construction of the model' (Pearl 2009: 307). He makes a distinction between an actual cause (in a single event) and general cause in populations (type-level) (309–310). His conclusion is that 'to achieve human level intelligence, learning machines need the guidance of a model of reality' (Pearl 2018). In the medical domain, ontologies offer such models of reality. The statistical processes of artificial intelligence depend on the precision of the labels applied to data and used to model reality.

In a single medical case, millions, even potentially billions of highly specified concepts might be available to model causal reality. In the specialized medical domain, there are a number of widely used models, some with long and storied histories. Some we have already mentioned in this chapter, others we mention now to expand this picture: The International Statistical Classification of Diseases and Related Health Problems (ICD);[1] the International Classification of Functioning, Disability and Health (ICF);[9] the Systematized Nomenclature of Medicine (SNOMED);[2] Logical Observation Identifiers Names and Codes (LOINC);[10] and The Drug Ontology (DRON).[11] Then there are ontologies of everyday non-medical things capable of identifying, with a high degree of precision, contextual variables that may be highly relevant to a clinical case, including place (GeoNames),[4] time and event (iCal),[12] demographic profile (age, gender, race/ethnicity etc.), occupational classification (SIC: Standard Occupational Classification),[13] or objects in the form of identifiable products (IAN: International Article Number).[7] Transmission of an infectious disease, for instance, might be identified at the conjunction of a precisely specified place, event, occupation, demographic, or product.

The key characteristic of these ontologies—their millions of classifiers and the billions of data points classified in standardized schemas with unique identifiers—is their semantic precision. Their model of reality is much more finely specified than natural language, with far less potential ambiguity. They can also be arrayed in taxonomic or knowledge graph structures where term-to-term relations (e.g. parent/

[9] See https://www.who.int/standards/classifications/international-classification-of-functioning-disability-and-health. Accessed 1 October 2021.

[10] See https://loinc.org/. Accessed 1 October 2021.

[11] See https://www.ebi.ac.uk/ols/ontologies/dron. Accessed 1 October 2021.

[12] See https://icalendar.org/. Accessed 1 October 2021.

[13] See https://www.bls.gov/soc/. Accessed 1 October 2021.

child, sibling, and other relations) offer insights into the basic components and relationships of a given model of reality (Cope et al. 2011; Sowa 2000).

Purely algorithmic, text mining approaches to artificial intelligence rely to a large degree on statistical analysis of natural language where meaning is principally limited to character collocations in 'stemmed' words (Brown et al. 1991; Kalantzis and Cope 2020). Meanings are subsequently inferred in processes of 'latent semantic analysis' (Landauer et al. 2007). As powerful as these analyses have become, they can be all-the-more powerful when AI is applied to processes of semantic modeling.

The main questions for our project are, how can ontologies deepen processes of artificial intelligence, and how can machine learning generated from human interaction with knowledge graphs add detail and depth to those graphs? In prior research, Zhai and colleagues have used the ConceptNet knowledge base to add supplementary semantics to text mining (Kotov and Zhai 2012). They have leveraged public domain knowledge graphs to improve text-based prediction (Jiang et al. 2018). In the broad area of bioinformatics, they have developed a schema of entity relation semantics for insects for a project researching the genetics of bees (He et al. 2010). The lessons that we have learned from these previous studies are that ontologies can enhance artificial intelligence in multiple ways including facilitating human-in-the-loop collaboration with AI, improving explainability, and addressing the challenge of data sparseness in supervised machine learning. All these benefits are especially important in medical informatics and can be realized via developing innovative technologies for creating, updating, and maintaining comprehensive domain-specific ontologies.

The final two sections of this chapter address the specific development objectives and application testing processes in our current projects.

5 Application Project 1: Medical Education

In a first phase of our current research, we have web-based developed knowledge graph software called CGMap (Common Ground Map), applicable across a number of domains.[14] The medical application of this software we have called MedMap. In the current phase, we are applying and testing this software in two domains: mapping of clinical cases in medical education (MedMap Application 1), and electronic health records (MedMap Application 2).

In the MedMap clinical case application, the web-based environment that we have been developing has been designed to contribute to medical education by supporting holistic, critical, and problem-based learning. In a review of the literature on critical clinical thinking, Benner, Hughes and Sutphen adopt a definition of critical thinking as 'purposeful, self-regulatory judgment that uses cognitive tools such as

[14] See https://newlearningonline.com/cgscholar/projects/medlang. Accessed 1 October 2021.

interpretation, analysis, evaluation, inference, and explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations on which judgment is based'. Applying this to the context of medical practice, they point out that 'the growing body of research, patient acuity, and complexity of care demand higher-order thinking skills. Critical thinking involves the application of knowledge and experience to identify patient problems and to direct clinical judgments and actions that result in positive patient outcomes.' As they argue,

> clinicians and medical scientists alike need multiple thinking strategies, such as critical thinking, clinical judgment, diagnostic reasoning, deliberative rationality, scientific reasoning, dialogue, argument, and creative thinking, and so on. In particular, clinicians need forethought and an ongoing grasp of a patients health status and care needs trajectory, which requires an assessment of their own clarity and understanding of the situation at hand, critical reflection, critical reasoning, and clinical judgment. (Benner et al. 2008)

Mukherjee (2015) describes his training as a physician in these terms: 'The profusion of facts obscured a deeper and more significant problem: the reconciliation between knowledge (certain, fixed, perfect, concrete) and clinical wisdom (uncertain, fluid, imperfect, abstract)'. Gambrill (2012) notes that evidence-based clinical practice is rooted in a willingness to recognize the intrinsic uncertainty of clinical decision-making. Research by Bordage and colleagues demonstrate that critical clinical thinking requires the analysis of systematic semantic patterns (Bordage and Lemieux 1991; Bordage 2007). Failing to teach clinicians about clinical uncertainty has been referred to as 'the greatest deficiency of medical education' (Djulbegovic 2004). Evidence-based medicine (EBM) requires the skillset to develop answerable questions relevant to a case, and to answer these questions with an honest and open appraisal of research findings (Braddock et al. 1999). Learning by doing is emphasized in EBM and evaluation of clinical cases provides such practice.

Individual or exemplary case analysis is a key aspect of clinical problem-solving and medical learning. If used early and with appropriate scaffolding, it has the potential to demonstrate the relevance of the 'pre-clinical' subjects within a medical curriculum. Clinical case study can serve as an important supplement to the acquisition of medical content knowledge by learners. The societal need we are attempting to address is the education of medical professionals who make sound judgments based on clinical evidence, using a variety of human and data sources to make these judgments. Such habits should be encouraged as early as possible and not left to less structured fast-paced clinical training periods.

For the purposes of medical education and training, the individual cases analyzed by students may be hypothetical, created by an instructor or instructional designer, or real cases found in the literature of medical science. The disciplinary challenge is differential diagnosis, or to develop the capacity to distinguish a particular medical condition from others that may have similar features, and to apply and monitor appropriate therapy.

The challenge for evidence-based medicine is that symptomatic and contextual information is necessarily limited, and incomplete and multiple conditions may be present. As a consequence, diagnosis is a matter of professional judgment. Furthermore, paradigms of medical knowledge are changing, where the focus is not only the generic individual whose physiology is assumed to be universally replicable, but where enormous variation is also recognized based on finely determined environmental context, genetic profile, and demographic variables (Wilson and Cleary 1995). Greenhalgh et al. (2014) address what they consider to be a crisis of evidence-based medicine where 'contemporary healthcare's complex economic, political, technological and commercial context has tended to steer the evidence-based agenda towards populations, statistics, risk, and spurious certainty'. As a counterbalance they recommend the exercise of 'judgment not rules' in relation to individual patients, and, in medical education, the development of 'clinical skills, understanding and applying research evidence, and reflecting and deliberating about complex cases'.

This occurs through a process that can formally be characterized as argumentation, involving hypothesis, claims supported by evidence, rebuttal of potential counter-claims, and preliminary professional judgment (Cope et al. 2013; Gillies and Khan 2009; Toulmin 2003; van Eemeren et al. 2002). Typical media for clinical case analysis are case textbooks (Geha and Notarangelo 2016), project-based learning (Greeno 1998), team-based learning (Michaelsen and Sweet 2008), and oral-discussion of cases in situ in medical contexts. Each of these media has its limitations: textbooks tend to transmit knowledge more than encourage active problem solving and professional collaboration (Boulos et al. 2006); project-based learning is difficult and expensive to assess given the complexity of the artifacts created, and often the lack of explicit clarity in their documentation (Kreijns et al. 2003); and in-situ oral engagements are ephemeral where most interactions are invisible to the instructor, and leaving few analyzable traces of the participants' thinking processes (Artino et al. 2014).

MedMap, is a web-browser ontology-suggestion, diagramming, and visualization tool that offers a way to document the features of a medical case using tags from widely used medical ontologies. It supports students as they determine the connections between these features such as possible causal relations or to create a decision tree to plan treatment. MedMap leverages medical and other contextually relevant ontologies, suggesting labels with a high degree of semantic precision. It adds semantic awareness to the electronic text of a case analysis, by: (1) making *coding suggestions* that add a layer of formal semantics to the clinical case analysis; (2) offering a *concept visualization* or mapping tool for deeper analysis of the underlying medical logic of a clinical case; (3) providing opportunities for peers, self, and instructors to code annotations with formalized medical vocabulary, thereby also training the system using machine learning methods.

User mappings are automatically analyzed, contributing to the knowledge embodied in the system via mechanisms of supervised machine learning. The system also offers conjectures about possible labels, in processes of unsupervised or semi-supervised machine learning. In computer science, this project supplements the algorithmic power of machine and deep learning with under-exploited areas of data modelling, formalized ontologies, and rigorously defined and structured semantics. MedMap's user interface takes the form of a concept map visualization (Novak 2010; Olmanson et al. 2016; Schroeder et al. 2018; Tergan 2005; Villalon and Calvo 2011). In Fig. 2, the left side of the case creator's screen is a multimodal documentation space. When the user highlights elements of text or media on the left, the system suggests possible matches for terms specified in one or more ontologies in a smart suggestion system. If selected by the creator, a node will appear in the right panel of the screen. The creator can then begin a concept map connecting nodes according to standard medical relations. This builds a second, semantically formalized, diagrammatic layer of meaning into the case documentation, or what we have called 'explain protocols', an extension of the 'think-aloud' protocols (Ericsson and Simon 1993).

Machine learning and artificial intelligence processes are validated in a collaborative peer review process by: (1) peer reviewers, and (2) by the case creator when they accept a peer reviewer's recommendation. Once validated, the ontology will have been trained to a higher level of machine intelligence to make suggestions for subsequent cases. By these means, users add a rich multidimensionality to the essentially two-dimensional taxonomic structures of legacy ontologies.

The project emphasizes problem-based learning and critical clinical thinking, supporting the documentation of hypothetical or actual clinical cases with tagging

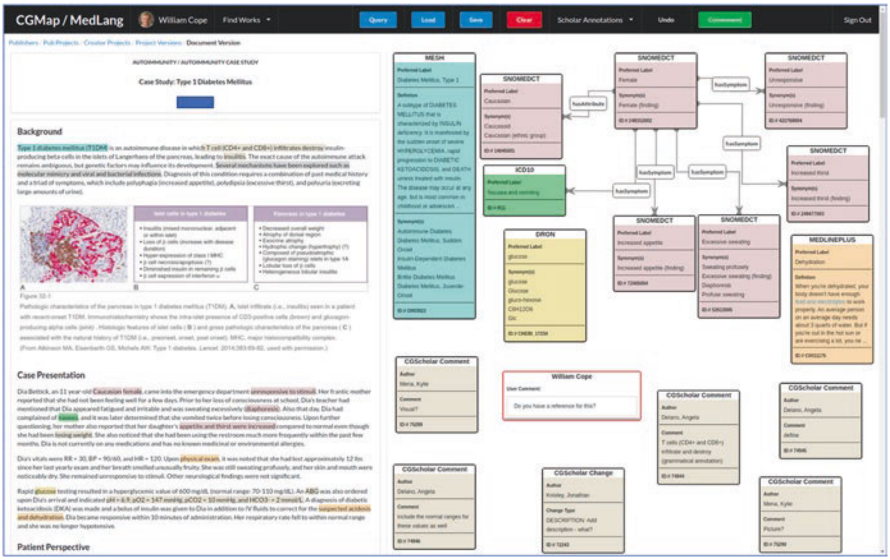

Fig. 2 Clinical case study report, written up on the left side of the screen by the student, and on the right side, a knowledge graph created to explain the condition and provide diagnosis. Left side: Multimodal case documentation with color-coded annotations according to ontology items in the visualization. Each color represents a different ontology. Right side: A medical logic model visualization, where each node and relation is linked to standard medical ontologies: e.g. International Statistical Classification of Diseases (ICD); the International Classification of Functioning, Disability and Health (ICF); the Systematized Nomenclature of Medicine (SNOMED); Logical Observation Identifiers Names and Codes (LOINC); and The Drug Ontology (DRON). Nodes are identified in an easy look-up and suggestion tool—highlighting a part of the data on the left, generates node suggestions for the visualization on the right

from structured medical vocabularies. The objective of this project is to develop in medical students critical, holistic and evidence-based thinking. In support of these objectives, MedMap makes suggestions based on standard medical and other ontologies. MedMap calls for explicit clinical reasoning mapped in a standards, ontology-based case visualization. By leveraging user interactions and inputs, the system captures new knowledge and improve system performance in a synergistic machine-user relationship. For instance: when users connect terms to be found in multiple ontologies or synonyms; when they annotate a patient-friendly vernacular term with a concept from an ontology; or when a user connects a related term not immediately suggested by the taxonomic relationships already present within the ontology. In other words, users by their concept selection and medical logic mappings become involved in training the system, validating its semantics, and thereby, progressively develop its semantic intelligence and the value of its suggestions to subsequent student or researcher users.

In supervised machine learning, users identify semantically precise nodes and draw visualizations of clinical logic models. In unsupervised machine learning, the system offers label suggestions and node connections based on the semantic structure of the supporting ontologies and the previous actions of users. Suggestions vary depending upon the focus of case analysis (e.g. establishing diagnosis), its reasoning (e.g. hypotheses, pathophysiology, evidence, etc.) or its treatment (e.g. linkage between clinical problems and therapeutic choices).

We have been testing the online, cloud-based software module with students and faculty at the University of Illinois College of Medicine, Peoria, and graduate students at Washington University School of Medicine in St. Louis. Students are being presented with cases framed in a clinical case documentation. An online peer review process applies and extends medical knowledge through collaborative clinical analysis: case documentation > peer review > revision based on feedback > publication to the student's e-portfolio. Key aspects of this innovation and testing include:

1. A web-based *multimodal clinical case documentation space*, where data, image, video, 3D imaging, ambiently collected case data, and other media offering supporting empirical evidence, are embedded within the case narrative.
2. A *lookup system* where, in support of the process of documentation, the medical case creator can identify concepts from standardized medical and other ontologies. The case creator highlights the media item or text and connects with the concept.
3. A *suggestion system that* 'reads' the case during the process of documentation, suggesting on-the-fly annotations from medical and other ontologies, as well as connections that the machine has gleaned from other users' case documentation via machine learning processes.
4. The creator then maps a *case logic model* in the form of a *concept visualization*. They can also write unstructured comments to support their thinking processes, or leave open questions for consideration during later stages in the documentation process or by peers during the review process. (The white boxes in Fig. 2 are self-annotations by the case creator.)

5. The case is then submitted to *multiple peers for review*, who in a new version suggest changes including different or additional markup and a revised visualization based on a different extended logic models. (The brown boxes in Fig. 2 are comment annotations by peer reviewers.)
6. Synthesizing feedback from peers, the case creator revises their case and updates their logic model visualization, ready for *publication* by the instructor to the student's e-portfolio and possibly also to the class online community.

6 Application Project 2: Electronic Health Records

It is widely agreed that the health industry is destined to be revolutionized by AI (Reddy et al. 2019). Evidence-based medicine is increasingly data-centric, involving a symbiotic relationship between humans and machines. AI can play an important role in detecting patterns in individual cases, as well as detecting variation across multiple cases. However, Himmelstein et al. (2010) show that while hospital computing increases overall costs, it only modestly improves process measures of quality. A great deal of work still needs to be done to develop user-facing medical informatics systems that attain impacts for patient care promised by AI.

In the era of 'big data' and progressively more comprehensive systems for developing and sharing medical records, variability by case is increasingly visible, and indeed essential for precision medicine. Greenhalgh et al. (2014) address what they consider to be a crisis of evidence-based medicine where 'contemporary healthcare's complex economic, political, technological and commercial context has tended to steer the evidence-based agenda towards populations, statistics, risk, and spurious certainty'. As a counter-balance they recommend the exercise of 'judgment not rules in relation to individual patients, and the development of 'clinical skills, understanding and applying research evidence, and reflecting and deliberating about complex cases'.

Moreover, paradigms of medical knowledge are changing, where the focus is not only the generic individual whose physiology is assumed to be universally replicable, but where enormous variation is also recognized based on finely determined life history, genetic profile, environmental context, and demographic variables (Wilson and Cleary 1995). The relevance of MedMap solution lies in: (1) the precision of documentation of cases with the support of standards-based and ontology-originated medical and everyday concepts; (2) tying these concepts together into a medical logic model in support of clinical reasoning and tracing the thinking underlying decision pathways.

A key question then for our ongoing research is to create a more precise record of the particularities of case-to-case differences. To address this question, MedMap is a web-browser semantic suggestion, tagging, and visualization tool that documents the features of a medical case with precision. It leverages medical and everyday life ontologies, and the data they contain, suggesting labels with a high degree of semantic precision for supervised machine learning, and offers conjectures about possible labels in the case of unsupervised machine learning. MedMap supports research scientists, students, trainees, practitioners, and data analysts as they make connections between these features such as possible causal relations or the creation of decision trees to plan treatment.

The prototype we have been developing aligns with the Precision Medicine Initiative, a US government effort involving the National Institutes of Health, aimed at leveraging new opportunities in access, aggregation, and analysis of health data. This initiative has two major foci, both of which are addressed in this project: (1) to develop personalized approaches to patient care; (2) to support researchers to make new discoveries. Our particular interest in 'precision' is the detection of semantic configurations in single or small numbers of cases. To give the example of a novel pathogen, this may begin in a localized context and a unique configuration of events. Then, in the first critical stages of transmission, there were only a few cases. Once the pathogen spreads across a wider population, the course of the disease may present differently from patient to patient, depending on a unique configuration in of medical history, genetic propensities, environment, and other factors. While sharing detectable and statistically measurable features, every subsequent case is unique, and every medical outcome causally related to a unique configuration of circumstances. A key question for this work is to put a more precise record of the particularities of case-to-case differences into practice.

Although the focus of this research is single cases or small numbers of cases, and the varied presentation of subsequent cases, the semantic processes we are advocating also enrich big data and AI across populations at any scale by making data points smaller, more precise, and their relations specified with less ambiguity. Cross-mapping between ontologies yields further precision.

This project addresses four specific areas of need in AI-supported medical informatics in medical case documentation:

1. Efficient and effective medical communication and error-free collaboration, where medical records accurately represent case histories and provide useful information to a range of specialist team members. The Intelligent Medical Record tool *offers suggestions* informed by standardized medical and other ontologies as well as AI comparisons with similar, de-identified records.
2. Explicit *clinical reasoning* and decision tree mapped in a standards (ontology)-based case visualization or map.
3. Sharing of deidentified data in the service of public health and precision medicine. The system we are proposing will offer a lightweight yet standards-based *mechanism for interoperability* across different professional and personal health record and data systems.
4. Early *ontology and AI-supported detection of a single case or small numbers* of cases, and variation in the course of a clinical condition across cases.

The focus of this project is the detection of patterns of significance in a single case based on *intelligent suggestions* and the *mapping of clinical reasoning*. For the purposes of development of a prototype in this project, we are using the source

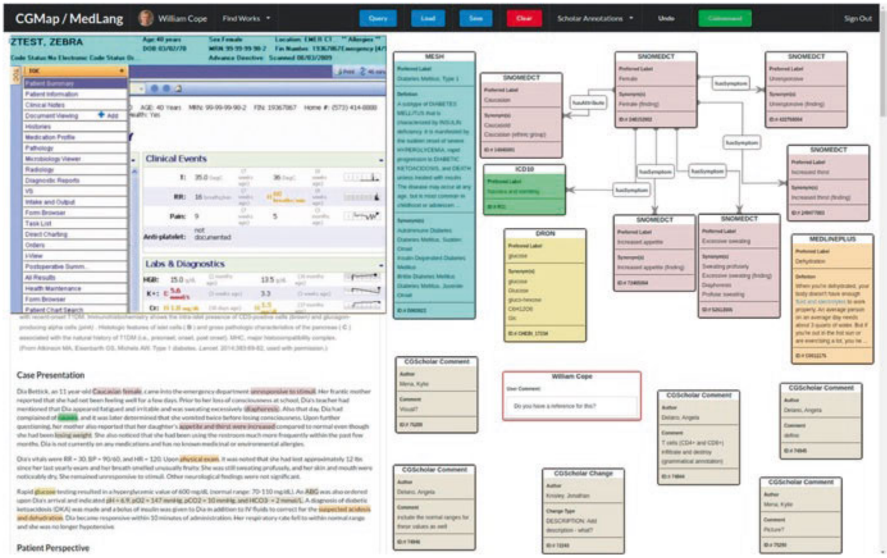

Fig. 3 Case annotation and clinical reasoning tool. The left side of the screen is the case material, for the purposes of illustration here consisting of a screenshot of an EPIC electronic medical record, followed by plain text in our proof-of concept tool. The case documented on the left has annotations color-coded according to ontology items in the visualization. Right side: annotations drawn from medical ontologies, linked by clinical reasoning and decision tree relations. White boxes are unstructured notes to self; brown boxes are unstructured notes from others

OpenEHR.[15] However, we are not suggesting that health providers should change their medical records systems. Rather, we are proposing an intelligent overlay over any medical records system in the form of either:

1. a *'private' web browser window* for data mirroring side-by-side with the existing system, or
2. a *shadow box* browser overlay for secure simultaneous double entry, or
3. *automatic export/import* between the current medical records and the proposed intelligent record.

We have attempted to minimize the effort required to learn and use the system and limit it to a single, browser- based screen with a simple drag-and-drop user interface, as illustrated in Fig. 3.

This particular project uses leverages MedMap to create an intelligent medical record. The left side of the screen features a medical record, illustrated above with a screenshot of an EPIC record and the right side is the case annotation and clinical reasoning tool. In this design, the medical practitioner highlights a term or label on the left, and the annotation tool suggests possible terms from multiple ontologies. The practitioner then builds a logic model or clinical reasoning visualization on the

[15] See https://www.openehr.org/. Accessed 1 October 2021.

right side of the screen. We are currently testing our hypothesis, which is that the proposed tool will improve: (1) diagnosis and decision support; (2) precision identification of clinical conditions; (3) anonymized data sharing across a distributed medical informatics system.

Interoperability and the ownership of medical record data have been identified as a key challenge for the future evolution of medical informatics and personalized medicine. With varying data models and overlapping ontologies, considerable challenges are raised for the exchange of data (Benson and Grieve 2016; Garde et al. 2007; McGuire 2018; Reis et al. 2017). A related challenge is the question of ownership of medical data (Zhu et al. 2012). In our proposed intelligent record, we address these problems by creating a connected but independent layer of data.

Addressing both these challenges, on 9 March 2020, the U.S. Department of Health and Human Services announced a requirement that both public and private organizations in the health industry should establish systems to share information, while positioning the patient so they are in control of that data.[16] This points to new openings and opportunities for the approach we are proposing now. The potential benefits of the Intelligent Medical Record system we are developing are:

1. *Standards-based suggestions*—supporting medical students, trainees, and professionals as they document a case in both classroom and clinic.
2. Case *logic model visualization*—making clinical reasoning and decision trees explicit to self and colleagues.
3. A *highly granular, standards-based markup* of the clinical case—supporting discovery and machine analysis across multiple cases.
4. A widely *distributed medical knowledge system*, where broad range of medical practitioners can contribute the development of medical datasets and scientific knowledge with the support of ontology- based knowledge scaffolds and explanatory logic models.
5. AI applications—Unsupervised machine learning processes will detect associations across multiple cases, identifying *patterns of similarity* which, although uniquely configured, may share features pointing to causality and potential implications across populations, small and large. By these mechanisms, ontologies can be supplemented and become 'smarter' the more they are used.

Together, these benefits offer patients more personalized medical care, with more accurate diagnosis and customized decision support. Through the development of MedMap, we aim to develop of a new generation of medical informatics and learning environments for medical students and practitioners.

In developing MedMap, the team is employing agile development strategies with short, focused release cycles. This approach is a lightweight and highly collaborative process that is well suited to research-based software development and lightly structured for diverse project teams (Stober and Hansmann 2009). This method

[16] See https://www.healthit.gov/topic/health-it-and-health-information-exchange-basics/what-hie. Accessed 1 October 2021.

emphasizes rapid, flexible evolution of software that is put into user hands at an early stage for frequent evaluation and feedback. This is being collected in highly controlled, small-group cognitive labs. At the end of each cycle a new functional evolution of the prototype is released, and the next development cycle build upon that work. In terms of software architecture, the approach of this project has been to develop three system layers:

1. A *metaontology* layer (Cope and Kalantzis 2020) encompassing all widely used medical and related ontologies and capable of creating an overarching framework for patient information the medical domain. For trials, we are applying MedMap to OpenEHR.
2. An *interlanguage* layer, to address schema synonyms, inter-schema overlaps and cross-schema connections (Cope et al. 2011).
3. A *permissions* layer, offering patients a range of options, including for instance: allowing identified data to be shared across medical providers with whom they might need to engage; and sharing de-identified data for the benefit of other patients, including in the case of this proposal, the intelligent record suggestion system. Patients could also grant permission for sharing their data from personal health apps and records, ambient intelligent sensors, and implanted devices (Patterson 2013; Roehrs et al. 2019). Permission to share geolocation data, for instance, might offer insights into the communication of pathogens—not unlike the aggregated data now used to offer traffic density reports in map apps. This would be accompanied by privacy and security guarantees for all users, including those who have not opted into data sharing (Dagher et al. 2018; Staudigel et al. 2017).

We are teaming with the Institute for Informatics at Washington University School of Medicine in St. Louis to test the feasibility of the MedMap overlay with residents and fellows from different specialties and subspecialties. Physicians and informaticians will test and use the software to document clinical cases. For this project, we will overlay Open EHR medical records. Following the trial, participants will fill out surveys and participate in interviews and focus group sessions to determine feasibility of this system. The software will then be revised based on trial performance and user feedback.

As a web application that supports case or project documentation that uses structured vocabularies for semantic parsing, author suggestions, formative and summative assessments, and semantically aware data mining and meta-analysis, we believe MedMap may have the potential to transform the ways in which clinicians and researchers interact with the electronic health record and patient data.

7 Reconciling the Bio and the Digital in Bioinformation

In this chapter we have attempted to explore the connections between the bio and the digital, because nowadays the digital serves our understanding of biolife and supports remedies for our bodily maladies.

Postdigital? The digital may slip from our consciousness as it ubiquitously inveigles itself into our lives, but it seems a perverse use of the Latin word for ‘after’ when the mechanics of the digital impacts our lives more and more.

Biodigital? Yes, to the degree that we increasingly use digital machines to master biolife. But this is hardly a singular reality when the bio and the digital are irreducibly different. The bio is material, where the digital entails a transposition of the meaning of the material into calculable quantity. However, as we have argued in this chapter, there are absolute limits to the transposability of the bio and digital meanings.

The focus of this chapter has been the explore the potentials of the bridge between the material of bodies and the ideal of their understanding by applying the philosophical and technical notion of ‘ontology’.

Philosophically, this is a dialectic where, although the ideal and the material are integrally related, the ideal of conceptualization can sometimes exceed the immediately material (hence, modelling, conjecture, prognosis), and the material can exceed the immediately comprehensible (hence, uncertainty, discoverability, and diagnosis). Ontologies are models of material reality, and although the models are derived from material experience, in their immaterial ideality they are quite different. The ideal side of ontology is the paradigmatic, immaterial representation of reality, with degrees of latitude in the connection between the ideal and the material: hence uncertainty, absence, and the role of imagination in the discovery of the as-yet unknown. Such is the dialectic of knowledge. This ontology in the philosophical sense.

Technically, the ontologies of computer science model the world of experience for the purposes of systemic and scientifically-grounded labelling in digital information systems. Where the tables of databases were two-dimensional, knowledge graphs are multidimensional, and for this reason support complex semantics more effectively. Moreover, the limits of these systems are not merely digital; they are the limits of language, and beyond that the struggle of classification to make sense of the biomaterial world.

In this chapter, we have played out these ideas in the area of medical ontologies, arguing that purely algorithmic AI needs to be supplemented by human reasoning in the form of semantically-grounded data models.

Translating these ideas into practice, we have described two projects in which users represent ontologies visually and conceptually in the form of knowledge graphs. Our research questions are entirely practical. Can medical students’ clinical reasoning be deepened by the use of knowledge graphs representing medical ontologies? And, can knowledge graphs support medical practitioners’ thinking as a supplement to electronic health records? This is a work in progress, and we await empirical evidence.

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Cycling in the Time of the Biodigital: Small Acts Towards a Conscious Uncoupling from Non-regenerative Digitised Economies

Karl Royle

1 Introduction

> The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it. (Weiser 1991)

Biodigital, bioinformational, postdigital, analog, sociotechnical, and Artificial Intelligence. It's a tone poem sounding like a riff from Coltrane's saxophone in a New York bar. But like Coltrane, this poem is more than the sum of its parts and somehow held together by more than the technicalities of musical scales and notation. In 1984 William Gibson wrote *Neuromancer* (Gibson 1984) where protagonists 'jack' into cyberspace through a digital organic interface and in later works such as *Zero History* (Gibson 2010), a text based 'twitter' has become confusing to his main character (see Jones 2011). Gibson's character, rather than a recipient of biodigital technologies, became postdigital and is increasingly situated in the present describing the future from which we hoped so much.So where are we now and how do the postdigital, biodigital, and analog realities come together in daily lives in a bioeconomy? The bioeconomy is a holistic model that integrates the biotechnical with the biodigital but goes further by advocating a paradigm shift towards sustainability across all aspects of human activity within the planet. 'What is needed is a system change, to dematerialize our economic model and upgrade resource efficiency logic to resource sufficiency, based on the decoupling of economic growth, or better well- being, from resource use and environmental impacts.' (Palahi et al. 2020 in Peters et al. 2021a)

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This chapter uses Actor Network Theory to map the existing terrain of an emergent biodigital economy by reference to a predominantly over 60's cycling group in Shropshire, England. Actor Network Theory is about how combine human and non-human actors combine to produce societal effects. Looking at a particular social assembly (the cycling group) and the variety of heterogenous actors that constitute it should reveal both analogue and digital actors, bio varieties of these and the socio-technical. It will argue that the biodigital age and an emergent bioeconomy are already manifest but conversely still integrated with non-sustainable industries. To align fully with a bioeconomic future requires the development of individual digital and data consciousness in order to realise the consequences of personal interactions with supply chains and decouple from resource exploitation and environmental impacts.

The notion of data trespass is also important here which can be aligned with the concept of physical trespass. Trespass is often equated with an unauthorised use of private land as opposed to the use of common goods such as water, air, land etc., where resources, which should not be owned privately, are accessible to all members of society. A part of trespass law is also trespass against the person which alongside physical acts is also used to defend rights and civil liberties. The question in this context is about the rendering of personal activity as data which is then used for other purposes and whether the data subjects are fully aware of this use and have given their permission. Another aspect is the increasing enclosure of the digital commons by technology companies for their own purposes. Zuboff (2019) equates this with the negation of rights by the commodification of information which is occurring apace within the digital economy often by the ubiquitous use of 'click to accept' strategies which obscure the consequences of such actions.

As a point of departure and before going further, a slight unravelling of terms. This chapter focuses predominantly on the postdigital condition, describing the reconfigurations between various technologies and humans (Jandrić et al. 2018), with a departure in more depth towards the biodigital 'convergence between the analog (biological) and the digital (informational)' (Peters et al. 2021b), and finally how this might impact upon a pivot towards green, regenerative, bio-focused economies. Where better place to start than with a predigital technology (ANT) applied to the postdigital context to map how human and non-human, analogue and digital, might converge and hold together in purposeful social assemblies.

Actor Network Theory (ANT) (Callon and Latour 1981; Latour 1987; Law 1992) is a technology insofar as technologies can be seen as broader ontologies (McGinn 1978; Mitcham 1994; Arthur 2009) that 'fulfil a human purpose … as a means, a technology may be a method or process or device' (Arthur 2009: 9). Herschbach (1995) draws attention to dualism in technology by referring to its usage in French, where 'technologie is used to refer to the study of technical processes and objects, and the term "technique" refers to the individual technical means themselves, the actual application processes' (Herschbach 1995: 2). This highlights the distinction between 'technology as knowledge, technology as activity and technology as object'. These definitions open possibilities about how humans create and work with and alongside 'technologies' beyond technology as an object. ANT includes technologies as actors/actants in a network by ascribing to them agencies and ways of acting with others.

> An 'actor' is a semiotic definition -an actant-, that is, something that acts or to which activity is granted by others. It implies no special motivation of human individual actors, nor of humans in general. An actant can literally be anything provided it is granted to be the source of an action. (Latour 1996: 7)

Each actant also brings with it other actors in its own ontological network, the 'unpacking' of which can reveal the design or policy that created it. For example, the World Wide Web would not exist without government funding (Naughton 2016). ANT presents a point of departure and for analysing the sociotechnical systems of the postdigital 'which do not operate in isolation from human labour, language, politics, or morality' (Hayes and Jandrić 2014: 199) and the actors that seek to integrate the biodigital. ANT requires that all 'assemblages of the social' are performed into existence purposefully and that it provides a methodological toolkit for 'inquiring, turning over interesting stones, tracing links, and most of all, of following unexpected leads and connections' (Law 2008: 4). Law (1992) further notes, 'networks are composed not only of people, but also of machines, animals, texts, money, architectures – any material that you care to mention. So, the argument is that the stuff of the social isn't simply human. It is all these other entities too.' The argument here is that using such an analysis on the everyday or the mundane should reveal the biodigital and how it is assembled as part of the social and how it 'manages to hold together – to assemble collectives or "networks" that produce force and other effects: knowledge, identities, routines, behaviours, policies, innovations, oppressions, reforms, illnesses and on and on' (Fenwick and Edwards 2011: 3).

The notion of the biodigital may alter our perceptions of human or non-human in the future as Peters et al. (2021b: 3) note, 'humans are open to becoming something different, to evolving into bio digital beings'. As technologies they present an integration with the human, which is less immediately visible, a more trojan horse style of proposition (fraught with ethical and moral dilemmas). However, this chapter notes that this does not necessarily extend immediately to Gibson's (1984, 2010) vision of augmented digital brain interfaced memory or genetic engineering but somewhere more mundane and arguably already made manifest within our lives. ANT allows us to see the how and the what of the current level of integration and its potential drivers and the manifestations of power that sit behind them so that we might be more prepared for other trespasses upon the person through biological transformations. Power and how it is constructed, embedded, and concealed (Law 1992) within social practices is a key part of analysis using ANT. Even something as innocuous as leisure cycling has a range of vested interests, from the cyclists themselves to the software companies that provide services, in curating people's experience.

2 The Art of Disappearing

Fundamental concepts in an application of ANT are the notions of punctualisation and black boxing. Punctualisation allows actors in networks to be simplified from their own constituent ontologies so that they can be single actors within a particular assemblage (network). For example, a TV in an older person's home is a communication device, a source of companionship and entertainment. It is an actor in their network as much as the health visitor, postal worker and so on. It is never a complex network of components and electrical parts too complex to contemplate or describe. Only if the TV breaks and needs repair and no longer functions in the network might its complexity become visible (to a repair person).

ANT accepts this simplification of the complex to define the actors within a network. Law calls these parts of a network 'resources' and they are stable at the point of use but can become unstable either when an actor no longer subscribes to the purpose of assembly or when an actor changes its form to influence others and form new networks. Such resources, according to Law, can be: 'agents, devices, texts, relatively standardised sets of organizational relations, social technologies, boundary protocols, [and] organisational forms' (Law 1992: 5). Law uses the analogy of the human body, where:

> if a network acts as a single block, then it disappears, to be replaced by the action itself and the seemingly simple author of that action … At the same time, the way in which the effect is generated is also effaced: for the time being it is neither visible, nor relevant. So it is that something much simpler —a working television, a well-managed bank, or a healthy body — comes, for a time, to mask the networks that produce it. (Law 1992: 5)

Actors in a network can also be black boxes (Law 2008), as complex networks themselves are imported into a system and the actant is not reopened or questioned. The actant functions within the network and does what it does. Black boxing allows complex networks to be bundled as actors within another network. A black box can be an actant once it has undergone the process of punctualisation and from this point 'contains that which no longer needs to be considered, those things whose contents have become a matter of indifference' (Callon and Latour 1981: 285). This phenomena of concealment by forgetting or removing from conscious awareness is central to the design of the human digital interface (Norman 1990).

Black boxing and punctualisation are similar to Weiser's (1991: 94) notion of ubiquity in computing where the 'the most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.' This is similar to Pink et al.'s (2017: 2) definition of mundane data where things that are initially extraordinary – the ability to track your bio data on a watch for example 'become familiar, less strange and habituated – in other words, mundane'. They see data as an actor embedded within people's lives that is constantly generated and enacted through using affective technologies. Therefore, to make any changes within this dynamic requires an understanding of how and why people generate data – 'how, in any context, digital data produced through human and environmental everyday processes and activities become active in shaping how life proceeds' (Pink et al. 2017: 10). In contrast, Zuboff in her treatise on surveillance capitalism sees the use of digital data as a means for behaviour modification noting that 'there can be no exit from processes that we cannot detect and upon which we must depend for the effectiveness of daily life' (2019: 23). It is interesting to note that in both cases, the data subjects (people) are either unconsciously generating data or being unknowingly manipulated through other agents. In such situations, the possibilities for digital trespass are manifold.

However, both viewpoints are important as they focus on understanding the mechanisms of human digital interaction so that change might occur. Where Pink et al. (2017) seem to see a constructive contextualised contribution of the human, Zuboff (2019) sees a manipulation. Notions of the postdigital as defined by Cramer (2015: 2) align with these two approaches where postdigital is seen as 'either a contemporary disenchantment with digital information systems and media gadgets, or a period in which our fascination with these systems and gadgets has become historical'. This allows a focus on human relationships with technology within society – a sort of rediscovery of that which is unconsciously taken for granted.

The digital is already ubiquitous within our lives and the biodigital, at least in terms of the logging of human experience (through data and information) is also hitching a ride upon the vagaries of the algorithms, platforms and architectures of the tech giants and their systems of data harvesting for commercial gain (Zuboff 2019: 132). Latour (2005) notes that ANT can be used to question such assumptions or at least, ask for the detail in regard to how it happens, noting that the presence of the social has to be acted into being not just postulated. An examination of how and what does the manipulating and how consciously data is generated in a specific context should clarify whether or not this is the case.

3 Situated Data in Context: The Wednesday Wobble, Shrewsbury, Shropshire, UK

Cycling has quite a radical history in the United Kingdom and from the 1890s through to the early 1930s the relatively 'new' technology of the bicycle transformed people's mobility and became a catalyst of social change. By example, there was a national cycling group called the Clarion Cycling club with affiliated clubs across the country (National Clarion Cycling Club 2021). These groups were established in the 1890s and whilst their purpose was cycling, they were also socialist and designed to assuage the exploitation of working people and the conditions in which they lived derived from the ubiquity of the industrial revolution. Their motto was to 'combine the pleasures of cycling with the propaganda of Socialism' (Pye 2004). Similar worker affiliated clubs were established throughout the 1920s and 1930s which assembled around various causes and actions including acts of trespass for land rights and antifascism (Corkhill and Rawnsley 1981). Coincidentally the Clarion reached its zenith in 1914 in Shrewsbury for its Easter meeting. The participants were increasingly conscious of their position and utility within the industrial economy of the time.

In its own words the Wednesday Wobble is ‘a group of leisure cycling enthusiasts from Shrewsbury UK and the surrounding area that get together to ride on a Wednesday and are definitely apolitical in contrast to their forebears. The rides include a mid-way(ish) tea stop and are generally between 50 to 80 kilometres long.’ Cycling in twenty-first century Shropshire is a moveable feast of perambulation across one of the richest and most varied landscapes of any of the English counties which exhibits a high degree of geodiversity (Shropshire Local Government 2006). It is an ancient landscape crisscrossed by a seemingly impenetrable network of lanes and byways that seem disconnected from the arterial trunk roads that now move across the county in the intent of going somewhere else. In contrast the smaller lanes appear governed by different expediencies, bypassing a hill here or ending in a ford elsewhere, disrupted only by a need to traverse a river or stream.

On the map, these lanes appear rhizomic evoking Deleuze and Guattari’s (1987) notions of mapping and tracing – the rhizome versus the arboreal system. The trunk roads are arboreal, like a tree with its roots and branches and trace a path across the map. Whereas the multiplicity of lanes form a landscape of interconnecting points (a rhizome) that allows the cyclists to be flaneurs randomly tracing their own paths and mapping the rhizomic assembly. As you ride across the landscape you can be forgiven for thinking that you can connect points endlessly just by moving in the direction you want to go, however, in reality we are on a map of fixed points –an arboreal order of tree and roots (Deleuze and Guattari 1987: 7).

A traverse of this map traces a line from A to B to C and yet while you are in it you can still have an illusion of being lost on the map and a degree of choice to choose your path within the time that you have. Riding a cycle around the lanes of Shropshire can be a delightfully analog experience based on intuition and a sense of choice or agency freedom (Sen 1992; Robeyns 2005; Nussbaum 2011) which refers to the freedom people have to choose actions or possibilities that may lead to a life they value. An analysis of the actor network (AN) that is the Wobble (Fig. 1) illustrates how technologies have digitised that experience, capturing it as behaviour (Zuboff 2019) and drawing our data representations across the landscape in digital form.

In Fig. 1 the actors both digital and analog are mapped to show the extent of the network that constitutes the Wednesday Wobble. The items in green and yellow are those that make a direct contribution to the Wobble experience and as noted by Callon (1984) actor networks are always assembled for a purpose or goal in ‘assemblages of the social’ (Latour 2005). This means that an examination of the goals or purposes or contributions to the assembly can uncover motivations and reasons of how things come together and manage to hold together (Fenwick and Edwards 2011). Actors in ANT are also classified as intermediaries and mediators. This describes how actors might operate and has bearing on how a network might be created, sustained, and consolidated. As Fox (2000: 863) notes, ‘the important point is that if an actor wants to grow it must enlist and mobilise all kinds of heterogenous links’

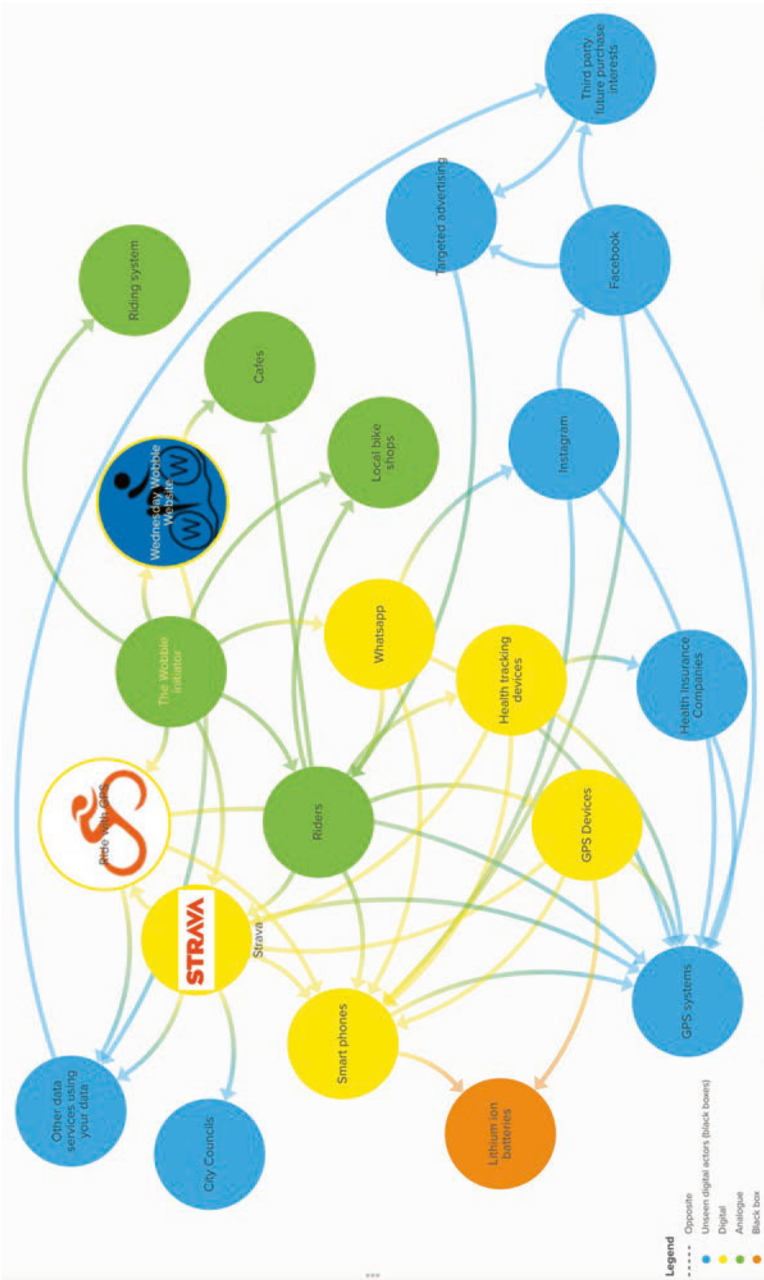

Fig. 1 The Wednesday Wobble actor network

Latour defines intermediaries as actors that ‘transport meaning or force without transformation: defining its inputs is enough to define its outputs. For all practical purposes, an intermediary can be taken not only as a black box, but also as a black box counting for one, even if it is made of many parts.’ Intermediaries hold things together and sustain the activity of the network by not diverging unduly from their function whereas mediators ‘cannot be counted as just one … their input is never a good predicator of their output; their specificity has to be considered every time. Mediators transform, translate, distort and modify the meaning of the elements they are supposed to carry.’ (Latour 2005: 39) In the Wobble network most of the actors are intermediaries. In the network they perform as they are supposed to perform but when one delves a little deeper, they do have the capacity to act as mediators, especially in how they translate experience into other formats in terms of data capture, transmission, and aggregation. For example, Strava, to all intents and purposes, records my individual data, my heartbeat, my route, and speed across the countryside. It performs as it should and shows me what it does for me but at the same time it takes my data and aggregates it with that of thousands of others that may then be used to transform my environment or sell me products. That I am unaware of this effect is about the connection of Strava to other networks with different purposes.

The collective purpose of the Wobble is to enjoy the experience of cycling, the countryside, companionship, and fitness. Each actor will also have its own motivations as will each rider of the 30 plus strong group. For example, the initiator of the group was new to the area and wanted to create a social cycling group and develop new routes across the county. The cafés want to sell their teas, cakes and coffees and provide a destination for the ride and fuel for the riders. The local bike shop wants to nurture local riding groups and offer discounts so it can compete with online cycle stores and sustain the Wobble with spares, repairs, and advice. In terms of the digital actors the Wednesday Wobble website and Ride with GPS were recruited by the initiator to plot rides and connect to wayfinding GPS devices and act as a resource for riders.

This initial recruitment of digital actors changed the analogue experience by augmenting it with some of the qualities of digital environments – such as persistence, searchability, replicability and scalability (Boyd and Ellison 2007). These digital actors solidify the experience making it less likely to fall apart and act as recruitment points to more actors. WhatsApp is recruited to the Wobble for its use as a communicator for the group where each week’s ride is posted, and post-ride pictures are shared. It builds the community adding further cohesion. Almost all the riders carry a smart phone for emergencies and to log their fitness data, track their ride and connect to one or more online social fitness networks (OSFN).

For cycling, Strava is the most popular OSFN and was initially developed to track performance over certain sections of road by using GPS when paired with a suitable device. As noted by Rivers (2020: 2), it allows users to ‘track, record, analyse and share real-world exercise activities with people in other locations and at different times’ and OSFNs have ‘reconfigured the socio-technological practice of exercise participation’ (1). Strava adds different motivations for riding other than the social by providing comparison and logging of data and routes and praise from other Strava participants/connections. Strava effectively extends riders' cycling experience and allows performance comparisons to be made with potentially 40 million other users (Strava Business 2019).

GPS devices are basically sat navs for cycles but also incorporate health related data such as heart rate monitors all of which is recorded in the OSFNs. Strava generates a record and a graphic trace line through the data related to our passing. Strava is often connected to health tracking devices such as a Fitbit or other smart watches which record health related data as a bi product of our experience. Strava according to Rivers (2020: 1) is 'changing the way in which cyclists ride and interact' and because it is designed to motivate and build communities through self-comparisons based on psychological principles has become hard to give up. In this way it supports the aims of the Wobble and enables it to stay together, the physical experience of the 2-to-3-hour ride is no longer just a memory and perishable it is logged, extended, and echoed, to be relived, shared, compared, and represented digitally.

However, whilst the technologies described above are designed to enhance the experience of cycling and do provide an augmentation to that experience through their perceived affordances (Gibson 1977; Norman 1988) they also have their own ontologies and purposes that run alongside their more seductive qualities. First and foremost, they are designed to sustain and build participation and are considered by some (Zuboff 2019) to purposefully obscure their other functions. The language of agile software design talks of end user value, removing customer pains and solving customer problems so that the product will continue to be bought and used through iterative releases and improvement cycles (Sutherland 2014; Rubin 2013) and this focus on useability and experience cleave the apps to supporting and enhancing human experience.

However, Zuboff sees this as the glass beads of early colonisation – that obscure the reality of 'supply-chain operations that begin with the rendition of human experience and end with the delivery of behavioural data to machine intelligence–based production systems' (2019: 13). She notes that

> individual 'users' are not the subjects of value realization. Nor are they, as some have insisted, 'the product' in the sales process. Instead, they are the objects from which raw materials are extracted and expropriated for Google's prediction factories: they are the means to others' ends. (Zuboff 2019: 15)

Rettberg (2020: 2) agrees noting that 'big companies make a lot of money from aggregating personal data. Detailed information about our personal preferences and habits is not only used by the apps and platforms we intentionally use; it is also shared with and sold to AdTech companies and data brokers'. The problem here is that we like the candy of the OFNS functionality and enhanced experience and are somewhat oblivious to the other uses to which our biodigital data is put. In fact, we collaborate as willing yet perhaps unknowing participants in supply chains whose purpose is to develop demand through carefully curating our activities. In the 1930s the effects of those supply chains first-hand could be seen first-hand in the crushing inequalities and pollution of industrial complexes but now they are no longer visible and somehow othered as if the only means of production is the Amazon warehouse and the pristine cardboard packaging in which deliveries arrive.

4 If It Is Free, Are You the Product?

So, are avid users of Strava, WhatsApp, and other apps really being farmed? Some of Zuboff's claims are verifiable through closer investigation of the blue/opaque digital actors/items in the network in Fig. 1. Instagram and Facebook are quite open about the way that they target people through advertising and several health insurance companies offer fitness tracking devices as life insurance incentives where discounts are available for maintaining 'healthy' lifestyles. WhatsApp's ownership by Facebook means that they do access communication activity, location, use habits, contacts etc. if not the content of messages which could undoubtedly enhance their activities involving targeted adverts on Instagram and Facebook (Marks 2021). The secondary use of data, generated by our activities and experiences, commonly known in the industry as data exhaust or digital gold (data gathered from Internet use or other digital activities and used for commercial purposes), we are mostly unaware of and a small act of extending our data consciousness would be to understand how that data is repurposed.

Rettberg (2020) usefully classifies data into different use cases – namely, representations of data – meant for humans [such as visualisations in Strava (Fig. 2)], and secondly, operations with data – where personal or aggregate data is processed by machines. Aggregate data can be for both human and machine audiences and can be situated dependent upon the purpose it is used for. Thus, if your purpose is to sell more cycling jerseys then you probably want to use data individually targeted data towards cyclists with the correct amount of disposable income, hence Zuboff's (2019) treatise on surveillance capitalism. Conversely, Rettberg notes:

> Publicly released, aggregated Strava data is processed algorithmically, by machines, for purposes such as city planning, public health research, data-based activism and developing navigation systems for automated vehicles and human cyclists or pedestrians. In these cases, the data is no longer primarily representational: it is operational. (Rettberg 2020: 2)

Strava made their previously charged data from Strava Metro free to public bodies in 2020 and essentially the argument is not a case of good biodigital versus bad biodigital – it is more about knowing or not knowing and acting upon what one knows accordingly, or not.

5 Privacy, Rights, and Invisibility

The utility offered by digital actors predesigned to augment experience do not overtly inform or advertise how they track, aggregate and package that experience for other use cases. As users of ubiquitous technologies, we click and accept as normal in seconds the transfer of information to corporations and third parties that we would never disclose to strangers were we to meet them in the street. A brief examination of cookies and privacy opt-ins that abound on websites reveals how one sided these are and this gives rise to concerns about rights, privacy, and

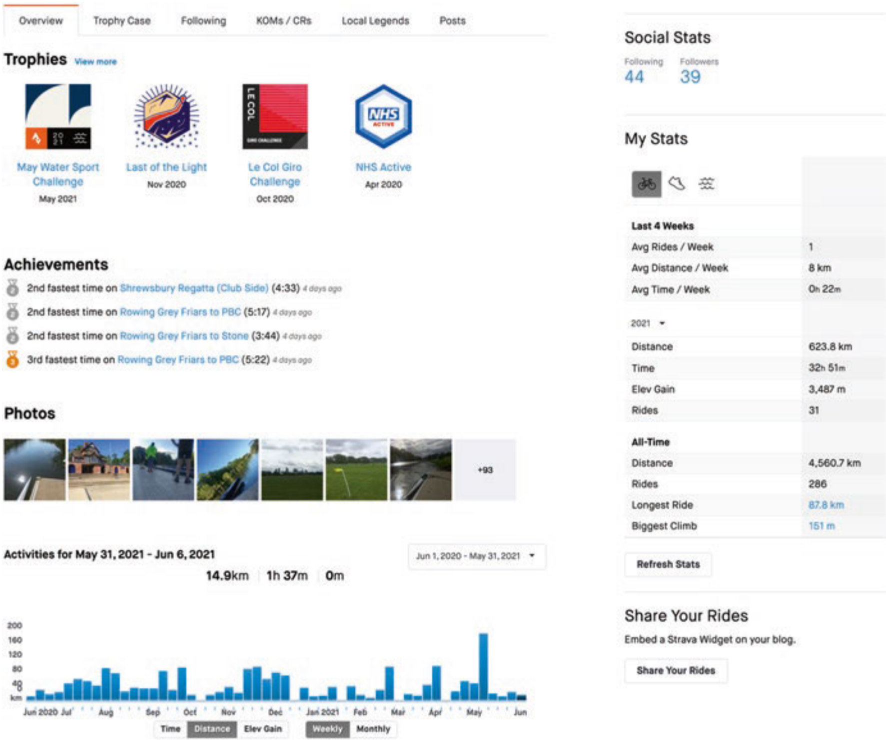

Fig. 2 Strava data visualisation and gamified challenges linked to vendors and charities

awareness of how our data is being used. These privacy policies are actors in our Wobble network but remain hidden and predicated towards acceptance. Figures 3, 4 and 5 show what happens when you start to delve a little deeper. This is in relation to a popular cycling magazine web site.

Figure 5 shows only part of a very long list of partners that your data may be shared with, at no point does it say they are selling your data – it is presented as sharing or passing on whereas the economic model is data is sold. The point being that users predominantly accept a level of trespass against the person without realising their position of connection to the digital economy. Conversely, users may realise and accept the utility of the product as a trade off against that trespass or are simply not conscious of how their data might be used.

Zuboff (2019) sees this as a negation of choice where participants in postdigital contexts have been led to give up their rights as to what to disclose to others (clearly there is choice, but it isn't an informed choice). Rettberg (2020: 3) supports this noting 'people who use these apps are usually neither aware of who their data is being shared with or what it is being used for'. She makes a distinction where individuals know what data they are sharing with other individuals (in Strava) but also talks about the purpose of Strava in establishing a behavioural norm of self-improvement where we realise that others may be watching. The use of data appears

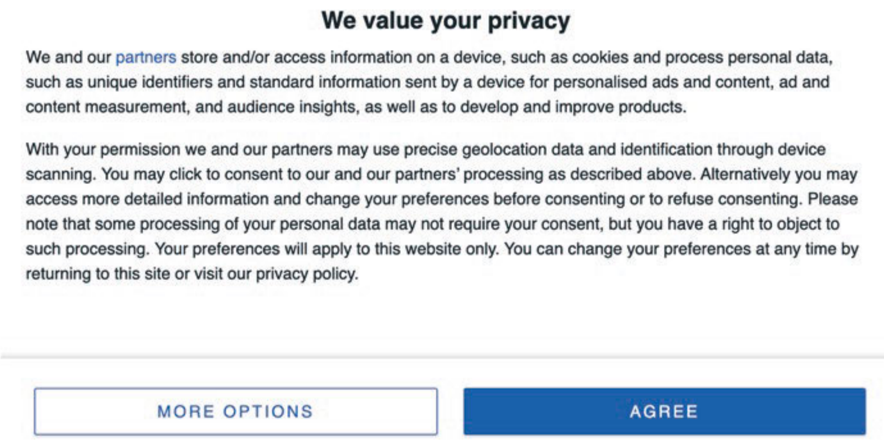

Fig. 3 First line 'click agree to accept'

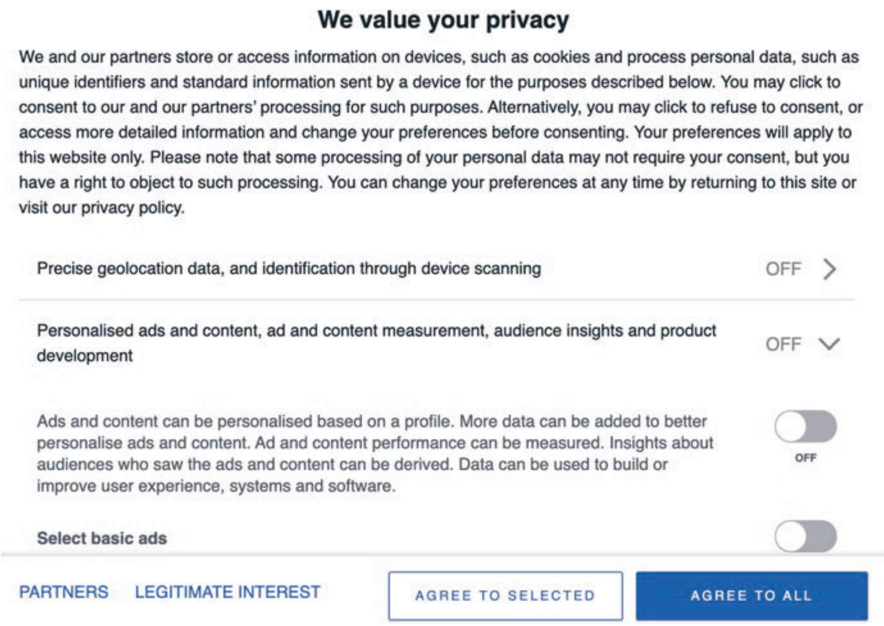

Fig. 4 Clicking more options still prompts you to agree to all. Notice how the affordance click agree to all is highlighted. Clicking on partners leads to a list of 435 entities which may have access to your data. Part of the list is illustrated in Fig. 5

to have shifted from aggregation for an individual benefit or purpose towards also being used to monitor and influence human behaviours. Rettberg makes this clear regarding aggregated data from Strava (2019) where users become data points – used at environmental levels to control the ways in which citizens traverse their

1. 1Agency
2. 360e-com Sp. z o.o.
3. 42 Ads GmbH
4. A Million Ads Ltd
5. A Mob
6. Aarki, Inc.
7. AAX LLC
8. Accorp Sp. z o.o.
9. Active Agent (ADITION technologies AG)
10. AcuityAds Inc.
11. Ad Alliance GmbH
12. Adacado Technologies Inc. (DBA Adacado)
13. adality GmbH
14. ADARA MEDIA UNLIMITED
15. adbility media GmbH
16. AdColony, Inc.
17. AddApptr GmbH
18. Addrelevance
19. AdElement Media Solutions Pvt Ltd
20. Adevinta Spain S.L.U.
21. Adform
22. AdGear Technologies, Inc.
23. Adhese
24. adhood.com
25. Adikteev
26. ADITION technologies AG
27. Adkernel LLC
28. Adludio Ltd.
29. ADman Interactive SLU
30. adMarketplace, Inc.
31. AdMaxim Inc.
32. Admedo Technology Ltd
33. Admixer EU GmbH
34. adnanny.com SLU
35. Adnuntius AS
36. Adobe Advertising Cloud
37. adQuery
38. AdQuiver Media SL
39. adrule mobile GmbH
40. ADSOCY
41. AdSpirit GmbH
42. adsquare GmbH
43. Adssets AB
44. ADSTOURS SAS
45. AdsWizz Inc.
46. AdTheorent, Inc
47. ADUX
48. advanced store GmbH
49. Adverticum cPlc.
50. Adverty AB (publ)
51. Advisible AB
52. ADWAYS SAS
53. ADYOULIKE SA
54. Adzymic Pte Ltd
55. AerServ LLC
56. Affle International
57. AirGrid LTD
58. Alliance Gravity Data Media
59. Amazon Advertising
60. Amnet GmbH
61. Amobee Inc.
62. ANINPRO-CREATIVE, S.L.
63. Aniview LTD
64. AntVoice
65. Appier PTE Ltd
66. Arcspire Limited
67. Arkeero
68. ARKHEUS
69. Audience Network
70. Audience Solutions S.A.
71. AudienceProject Aps
72. Audiencerate LTD
73. AudienceRun corp
74. AuDigent
75. AUDIOMOB LTD
76. Avocet Systems Limited
77. Axel Springer Teaser Ad GmbH
78. Axiom Media Connect
79. Azerion Holding B.V.
80. B2B Media Group EMEA
81. Bandsintown Amplified LLC
82. Beaconspark Ltd
83. BeeswaxIO Corporation
84. Bertelsmann Data Service GmbH
85. Betgenius Ltd
86. BidBerry SRL
87. BidMachine Inc.
88. Bidstack Limited

Fig. 5 Partners engaged in data sharing with the original website (total 435)

city, ultimately changing behaviours. Similarly, the Covid-19 app-based track and trace systems (NHS 2020) attempt to control behaviours albeit overtly rather than covertly.

To return to an ANT analysis this requires only an examination of the what and the how of the assembled network. Each actor within the Wobble network has its own punctualised network which could bear further scrutiny, but this would require more space than is available here. The point to make is that with scrutiny it is possible to see the motivations behind the digital actors such as Facebook, Instagram and the like and their variety of functions, policies and technologies that constitute them. One place to start might be the way in which privacy policies are developed and the range of motivations that enable such documents to accumulate power through their presentation to the end user. Dismantling some of these mechanisms of influence by making their purpose and provenance transparent might be a route towards data consciousness. Zuboff (2019), on the other hand, sees no escape from the hegemony of the digital architectures that we have willingly joined as social participants, using processes we cannot detect and upon which we have come to depend.

However, according to ANT, the idea that nothing can change because it is too difficult or complex, or because we lack power, or social factors are against us, is a fallacy of our own making. Law (1992) notes that a core assumption of ANT is 'the mechanics of power'. For example: 'How it is that we never saw before that the Gorbachevs of this world really had feet of clay all along?' (Law 1992: 6) Meaning that no matter how powerful and entrenched things seem they can always change.

Equally, ANT recognises that all actors have network effects beyond their perceived power and size and that ‘Napoleons are no different in kind to small-time hustlers, and IBMs to whelk stalls’ (Law 1992: 380). The Wobble members already prefer to support their local bike shop (LBS) over online retailers and are environmentally oriented. A consideration of how their data is also used through an emerging data consciousness may also affect change within the digital product business models that they are part of.

6 Biodigital Data as an Influencer and a Two-Way Street

It is tempting to think in this time of the postdigital/biodigital that humans and technologies are already enmeshed in a symbiotic relationship that is hard to perceive and difficult to be without. This may be a reason why people accept a position in digital architectures that want not only your digital life but your embodied human experience (Zuboff 2019). However, Pink et al. (2017: 10), offer an alternative discourse arguing that it is necessary to ‘depart from the idea of the mundane (where socio technic networks are established) as a landing place for new technologies, power politics and other affordances of the spectacular: to reconceptualise it as a generative site’. This reinforces the idea that the social is an assembly that is constantly being formed and reformed and that if data, is generated by activities, then activity has influence in shaping how we experience not only the analogue and the digital but also the products and services that our data is used to develop.

The generation and use of data for different purposes becomes a causal loop or powerful two-way street which is reflected somewhat in the nature of the Janus-like qualities of the digital technologies that adorn our networks and activities, and it is perhaps this ‘fluidity’ that makes them attractive. If we recognise that big tech is using our data to influence what is produced then collectively, networks of the social can change what is produced. Laet and Mol (2000) suggest that an object can have several fluid identities, depending upon the agencies it creates with others, which may lead it to be employed for different purposes. As such it can be repurposed towards the goals of the network whether they be more efficient online shopping or the avoidance of conflict minerals. Laet and Mol (2000: 225) describe the quality of fluidity as – ‘not too rigorously bounded, that doesn’t impose itself but tries to serve, that is adaptable, flexible and responsive’. All of these are arguably qualities of the OFSNs that the Wobble uses.

Equally, ANT describes its networks, as constantly forming, breaking down, contracting, and expanding, like Deleuze and Guattari’s (1987) smooth and striated spaces they are generative and regenerative, able to change and reconfigure themselves depending upon their purposes for coming together, nothing is fixed. Actors can also be recruited, changed, and modified by their interaction with others which means that action can be taken to affect change.

One powerful practice that allows experimentation and the creation of ‘what if’ scenarios is Foley and Lockton’s (2018) notion of actant switching where ANT is used to map out a heterogenous network of actors and then engage the idea of actant switching and speculative design through service fictions.

> Actant Switching (AS) is a method for speculative scenario creation that interchanges human and nonhuman actors to create counterfactual scenarios, exposing tension with the context and technology. Service Fictions (SF) is a method for engaging participants in a co-created speculative design around the created Actant Switching scenarios. (Foley and Lockton 2018: 1)

Yaneva (in Foley and Lockton 2018: 203) notes, 'a thing or a design project can modify all the elements that try to contextualize it, triggering contextual mutations'. This means that actors can be exchanged, intermediaries for mediators and vice versa to see how contexts might be redesigned for other purposes, Strava Metro being a case in point. Making Strava Metro free rather than continuing to charge for what was conceivably a contribution to a human good was a sensible move for a company which did not want to alienate their customer base of pro-cycling pro-environment participants.

7 The Myth of Digital Cleanliness

Returning to the original Wobble actor network (Fig. 1), the lithium ion (L-I) battery which powers most of our digital devices will have its own actor network which is mapped in a simplified form (Fig. 6). The actors on the map are designated as mediators, intermediaries or acting with the potential to be both, reflecting the dynamic and impermanent nature of the assembly. The (L-I) battery network includes so called artisan miners of the Democratic Republic of the Congo where some 35,000 child labourers work alongside conventional mining operations to extract cobalt (UNCTAD 2020). They may act as potential mediators indirectly as the use of child labour is now widely held as an unacceptable part of any product development supply chain. Even the word artisan has different connotations across continents where artisan in Europe may mean high quality, small batch products such as the 'artisan beer' the Wobblers might drink after a ride as opposed to the squalid conditions of freelance unprotected, unsafe mining enterprises.

Equally, whilst (L-I) centres of battery cell and pack production are distributed amongst China, the USA, Japan, Korea and Europe, value added is highest in China, probably due to their lower wage rates, worker benefits and protections (Coffin and Horowitz 2018). Further, only 5% of (L-I) batteries are recycled in the USA, and neither are the current recycling methods environmentally friendly (Oberhaus 2020). As Fig. 6 illustrates, scientists and rival battery tech developers may act as mediators by developing alternative technologies to the raw material based (L-I), causing the network to reconfigure itself towards a more sustainable bioeconomy.

Other mediators, somewhat less spectacular and more mundane actors (Pink et al. 2017), such as the Wobble members and *inter alia* the consumer electrics companies, may be just as powerful mediators through using the two-way effects of

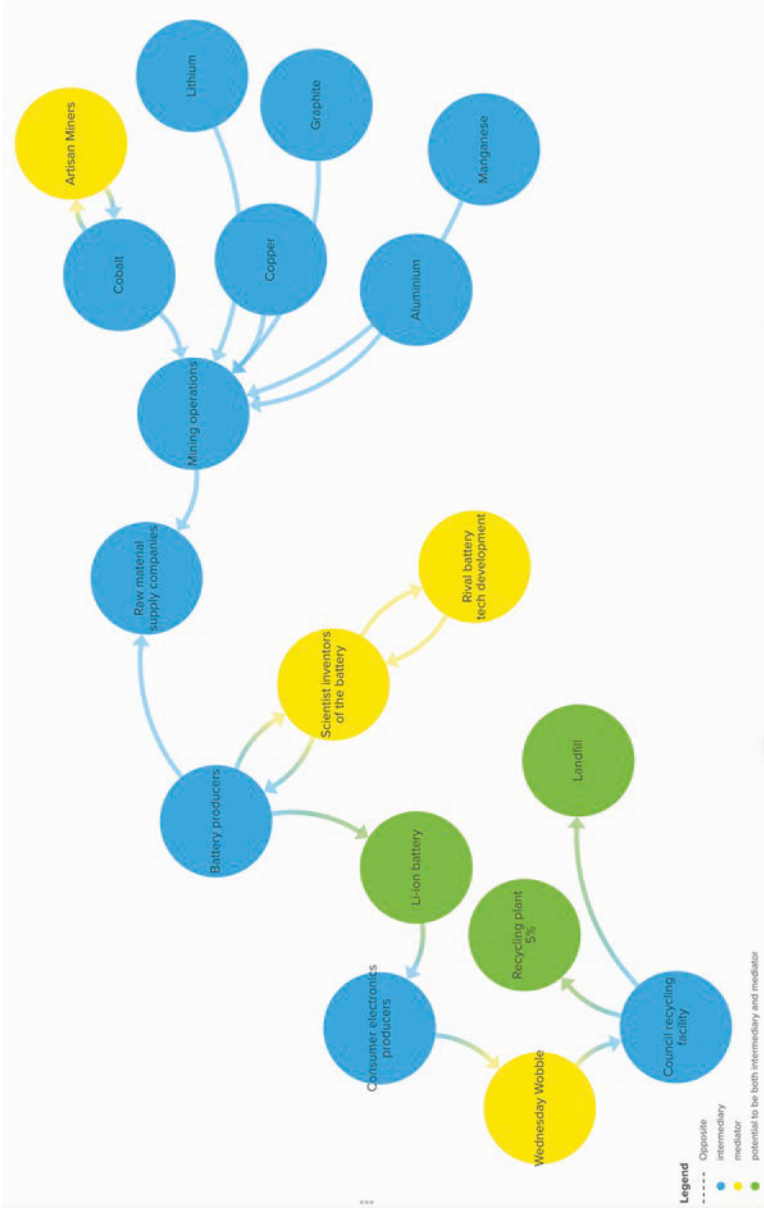

Fig. 6 How the Shropshire cyclists are connected to the Democratic Republic of the Congo and artisan miners

the digital architectures they inhabit by propagating opinions of regenerative environmental sustainability and ethical purchasing back into the system of 'surveillance capital'. Whelk stalls versus IBMs… works both ways. Indeed, in response to consumer awareness of the waste involved in (L-I) battery obsolescence recyclers are already developing 90% efficient plants that can make battery production cyclical and reduce the need for extraction (Oberhaus 2020). Clearly this also has a financial imperative but at least it may reduce raw material exploitation.

8 Conclusions

What Fig. 6 reinforces is the invisibility and 'black boxing' of actors both human and non-human in actor networks which has parallels to designed in ubiquity where both designers and users want digital technologies to disappear and be part of life. The supply chain for clean digital products is often opaque and masks the dirty aspects of production processes which are out of sight. (UNCTAD 2020). In the 1930s the ubiquity of the industrial complex was self-evident and the contrast with other lives and cleaner air was only a short bike ride away from the towns. In current postdigital contexts our lives and technologies are not so transparently connected to secondary manufacturing and primary extractive industries. Better perhaps to consider the wider map, nature, and extent of 'the digital integrations of heterogenous actor networks' within which human experience can be located and how the relationships of power and actions can make them hold, fall apart or be reengineered towards the regenerative bioeconomy.

To achieve this wider view requires a mapping of actors and a tracing of connections detailing how things come together and hold together. Within the discussion of postdigital and biodigital there is a propensity to adjudicate about good and bad actors but ANT, to quote Law is

> a ruthless application of semiotics. It tells that entities take their form and acquire their attributes as a result of their relations with other entities. In this scheme of things, entities have no inherent qualities: essentialist divisions are thrown on the bonfire of the dualisms. (Law 1999: 3)

Equally, if one thing, actor or design is changed there is always the potential for that change to reconfigure the network and its goals or equally lead to its demise.So, there is a warning that mappers and tracers of the social should not approach this act with a vision of the good or the bad. 'Good and bad are only the products of an active and temporary selection, which must be renewed.' (Deleuze and Guattari 1987: 31) By example, the (L-I) battery is sometimes seen as the power source to rid the planet of the internal combustion engine and petrochemicals (good); it is also part of a polluting non-regenerative supply chain (bad); but new methods of local recycling are afoot (good). Deleuze and Guattari encourage the making of maps rather than tracings because maps are dynamic (if we drew a map a different day it would be transformed). 'What distinguishes the map from the tracing is that it is entirely oriented toward an experimentation in contact with the real.' (Deleuze and Guattari 1987: 33).

However, Figs. 1 and 6 are both tracings, overlays upon an infinitely expanding map that allows the author to structure their realities and choose what might be significant – the maker of the map is also an actor in this regard. Using ANT affords mapping and tracing based on the purposes of actors, their motivations for assembling and for remaining or leaving and acknowledging that human actors are not privileged over non-human actors, in what Latour (1987) calls symmetry or symmetrical analysis. Indeed, Latour (1996) notes that Actor Networks are not fixed like a computer network and are not topographic – ANT does not give them shape or define them by their system. As Latour (1996: 5) suggests, 'the type, number and topography of connections is left to the actors themselves'. A network in ANT is therefore defined by the actors, i.e., those that contribute are the network (Latour 2005).

This means that everything is changing all the time and it is the networks that hold together that are the exceptions. What forces, policies, and interests combine to continue the Wobble cycling assembly? The Wobble network can be mapped and once we know the actors in the network, we might change it by introducing new actors. The Wobble map represented in Fig. 1 illustrates the intertwining of the digital and the human each having multiple purposes for combining. Digital actors seek to amplify, record, and enhance human experience but also ostensibly capture, manipulate, aggregate, and sell human behaviours as a form of 'surveillance capitalism'. As Zuboff (2019: 6) notes 'many old inequalities are deepened, while wholly new axes of exclusion and domination threaten every unprotected dimension of human experience'.

However, this is not a permanent state, action can be taken, maps redrawn, networks redesigned, and rights repossessed. If, as Zuboff notes, human experience is rendered as 'behaviour' where surveillance capitalism 'wants your bloodstream and your bed, your breakfast conversation, your commute, your run, your refrigerator, your parking space, your living room, your pancreas' (2019: 17), then undoubtedly actions have effects. Actions can be taken, actors switched, new tracings made, and the production system reconfigured through the flows of information derived from experiences. All that needs to be done is to draw the map, recognise its extent, and then redraw it. As Deleuze and Guattari (1987: 33) note a map is open to constant modification and can be 'reworked by an individual, group, or social formation'.

Drawing the map and opening the black boxes of those actors that disappear as part of the ubiquity embedded in the postdigital-biodigital convergence (Peters et al. 2021b) may allow us to reconfigure activities towards a rights-based bioeconomy. The place to start however is in our contextual and situated practices and the ANT toolbox allows an analysis of the mundane and an investigation of that which is othered. The starting point for further analysis of any postdigital or any biodigital network is to map the actors and trace their connections and reasons for taking part. The utility of this is that anyone can do it by starting within their own context and drawing out their map. It starts with the mundanity of life as we know it, that supermarket app you just downloaded or the offer of an apple watch by your insurance company – the warp and weft of the everyday. Once your social assembly has been mapped and traced and the motivations of the actors investigated any actor in the network can be used as a point of departure – by realising that one thing (an actor) can stand for another (a network) (Law 1992).

In this way, we can trace connections to other maps by looking at the range of actors employed, texts, software, mine workers, supply chains, partners, and decide how aligned our practices are to realising a bioeconomy. By knowing this we can make decisions about our actions and 'act back' 'building networks and chains which achieve different ends' (Fox 2000: 863) towards a sustainable future. Likewise, we can reclaim our data rights by recognising the acts of digital trespass against us and decide on whether our data can be aggregated for the common good (Strava Metro) rather than used to maintain the forms of consumption and production that a resource-based economy demands.

The Wobble is a case in point, different times need different assemblies of the social and purposes for action. Data consciousness, an awareness of digital trespass and supply chain transparency in the context of the Wobble can perhaps replace the Clarion cycling club call for class consciousness and a rebalancing of the inequities in the industrial age. Cycling groups may be able to reconfigure their networks to align with bioeconomic aspirations by discarding actors that affect their purchasing decisions in the digital industrial economy and, by considering their reasons for riding and the continuing utility of the range of actors that support them. Complex systems only require small acts of resistance to effect change and create a sustainable future.

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From Dead Information to a Living Knowledge Ecology

David Neilson and Nathaniel F. Enright

1 Introduction

A central emphasis in *Capital Vol. 1*'s (Marx 1976) account of capitalism's logic of extended reproduction is the class-struggle-driven relationship between 'living labour' and 'dead labour'. This chapter builds on Marx's distinction in the light of capitalism's historical shift from the material world of production towards the immaterial world of knowledge, with particular reference to the history of libraries. Theoretically, it examines the immaterial dimension of capital accumulation and class struggle as the relationship between 'living knowledge' and 'dead information'. The contemporary immaterial form of the class struggle for socialism is centrally about resisting and reversing capital's project to transform living knowledge into dead information.

In developing this critical analysis, we draw on Peters' (2012) conception of 'bio-informational capitalism', Autonomist Marxist readings (Mosco 2005; Pasquinelli 2015), and critical library studies (Harris 1973; Enright 2011, 2013). Discussion of the struggle to reverse the capitalist direction of the relationship between living knowledge and dead information draws on the discourse of 'knowledge socialism' (Neilson 2020b; Peters 2020; Peters and Jandrić 2018a, b). 'Knowledge socialism' is the movement to challenge the commodification of academic knowledge that ultimately aspires to achieving 'true social and intellectual inclusion', a full 'sociality of knowledge by providing mechanisms for a truly free exchange of ideas' (Peters 2020: 7). By building on Marx's socialist critique of capitalism with special application of regulation theory and critical scholarship within Library and Information Science (LIS), knowledge socialism is practically

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extended to refer to the project to design, construct and manage a democratic socialist framework of global-local regulation, institutions of cosmopolitan solidarity, and a global virtual civil society (Neilson 2020b, 2021a, b).

Knowledge produced under capitalist social relations necessarily expresses a contradictory relation, in that its producers are both subordinated to the capitalist project of 'dead information' yet at the same time are enlisted to deliver it. Nonetheless, like the industrial working class, knowledge workers are being subjected to capital's project of subordination and elimination, thus implying a knowledge-worker-led countermovement to resist and reverse the capitalist process by putting dead information in the service of living knowledge. Knowledge workers are uniquely placed to become the twenty-first century spearhead of the labouring population's movement for socialist change, i.e., to become a 'knowledge proletariat' struggling against dead information that ultimately implies the practical constructing and coordinating of a world driven by living knowledge.

Neoliberal-led capitalism's present descent into multiple interacting crises makes the knowledge socialism project central and urgent. Practically, its imputed project is to consciously develop and manage the institutional framework of a cosmopolitan democratic socialism that can empower collective humanity to become the conscious agents of a world of democratic cooperation, solidarity and creative design crystallising in the project of a 'democratic socialist model of development' (Neilson 2021b, 2020b). This account flows from 'praxis' understood as the unleashing of a consciously causal subjectivity that moves beyond one-sided Marxisms that see only the structural logic. In contrast, 'knowledge socialism', the 'knowledge proletariat', and the 'democratic socialist model of development' all bring in, and make central, the consciously creative agency of thinking humans.

Specifically, this chapter looks behind the automatic and self-renewing human subordinating tendencies of capitalism, to the class struggle between the agents of capital and the agents of socialism. It begins by building on Marx's seminal contribution to this field, with special reference to knowledge work. It then argues for the reversal of capital's project to perpetuate its power by transforming the human interface into just the organic appendage of a self-perpetuating systemic logic. The chapter specifically considers the counter-movement to renew, extend and apply the idea of the public library to the creation of a super-library institutionalised as a 'world knowledge bank' dedicated to collecting and making freely available humanity's expanding knowledge. Moreover, the world knowledge bank transforms the library concept into something much more practical. That is, not just a repository, the world knowledge bank would be central to the active construction and management of a democratic socialist model of development.

2 Marx's Seminal Account

Central to Marx's (1976) mature account of the development of industrial capitalism is an increasing 'organic composition of capital' that refers to the increasing ratio of 'dead labour' to 'living labour'. Capitalist firms, spurred on by the 'coercive whip of competition', universally pursue increasing productivity by subordinating 'living labour' to, and then steadily replacing it with, the 'dead labour' of 'self-acting machinery'. From the outset, the structural imperative for capital to transform dead labour into living labour is also expressed consciously in class struggle. For the capitalists, it is the ongoing struggle to subordinate labour, both physically and mentally, to its will. For the labouring population, it is the struggle to challenge, and then transform, this oppressive process.

The conscious agents of capital seek a path beyond the natural limits of the 'absolute' exploitation of flesh and blood human beings who require regular sleep and food. This path leads them, in turn, to pursue the logic of 'relative' exploitation that drives capital's accumulation of an increasingly powerful human subordinating and replacing technology. The final aspiration of the perfectly regular automated machine system is not only overcoming the physical limits of living organic beings that make mistakes, but also overcoming the challenge of their wilful hearts and minds that regularly cause trouble. The self-reproducing tendency at the heart of capital logic thus infuses into the deep will and mentality of its agents.

While concentrating on the process of material production, Marx's analysis remains fundamentally valid in this era of unevenly developed neoliberal-led global capitalism. However, for those countries just now entering into capitalism's industrial stage, dispossessed peasants confront a scarcity of industrial working-class jobs in a world characterised by rapidly extending robotisation of material production and a growing relative surplus population (Neilson 2020a). This process of automation and redundancy, intensified by the exporting of work to low wage newly industrialising economies, is also making superfluous living labour that is engaged in material production in the industrially advanced capitalist countries (Neilson and Stubbs 2011).

At the same time, subordinating to, and replacing living labour with, dead labour, also increases employment outside of the sector of material production (Neilson and Stubbs 2011). Employment flows into a growing service sector of low-paid workers engaged in range of traditional human services. More in the advanced capitalist countries, there has also been growth of commodities and associated jobs in various on-line immaterial fields: from movies, to games, to social media. More directly, the capitalist mentality that seeks ultimately to win the class struggle by eliminating both physical and mental aspects of the 'fallible element' by the on-going development of automated 'self-acting machinery' extends employment into the information sector.

In his discussion of 'bio-informational capitalism', Peters (2012) observes another stage beyond the inorganic logic of automation that begins with the mechanical replacement of arms and legs and then extends to the digital replacement of brain functions. That is, the process of human replacement come full circle as capital's agents seek to infuse the dead logic of the automation tendency with a living biological expression. Ultimately, this aspiration is associated with projects to develop and combine Artificial Intelligence, living robots, and self-functioning information systems (see Dyer-Witherford et al. 2019).

Tendencies towards automated *information processing systems* are an element of such an aspiration that obscures the class struggle dimension of this process that runs in different forms and stages through capitalism's history. Invariantly, the imperative to increase competitiveness by privatising and automating labour fuses with capital's tendency to subordinate humanity, physically and mentally, to its power, vision, and will. In the present neoliberal-led phase of information capitalism, the labour of living knowledge workers, increasingly proletarianised and financialised, channels activity towards material and ideological capitalist goals. This situation is unambiguously the case for knowledge workers employed directly in capitalist enterprises. More broadly, it includes the outputs of academic research communities. Such outputs are being transformed into units of 'dead information' that flow through seemingly automatic global information systems, which rank and filter knowledge so as to uncritically reinforce the existing capitalist world by skewing the assessment of research outputs towards market impact criteria and capitalist goals of profitability.

Though based in capitalist imperatives of social reproduction, the elimination of the fallible organic element expressed as the project of self-renewing automation, fuses into the will and power of conscious capital. As with previous stages, but more powerfully in this bioinformational phase, capital's tendency towards self-acting and self-renewing production appears and is presented simply as a neutral technical process that conceals capital's long-term project to subordinate and ultimately, eliminate, humanity from its mode of accumulation. The inverse effect of capitalism's posthuman self-renewal tendency is human degradation, subordination, manipulation and alienation both for those still employed in the 'automatic system' and for those ejected from it and cast into the ranks of the 'relative surplus population'. Class struggle is always complexly relational, imbricated in the antagonist imperatives of the capitalist structure yet conscious at the same time.

The purpose of the technological movement is not only driven by the competition imperative that pushes capital to intensify labour's exploitation. Simultaneously, from the outset, it is about 'providing capital with weapons against working class revolt' (Marx 1976: 563). Capital's drive to class domination in its struggle with 'living labour' over the terms of exploitation fuses with 'living labour's' transformation into 'dead labour'. In the context of bioinformational capitalism, capital's drive expresses itself as the project to transform 'living knowledge' into 'dead information'. On the living labour side of the struggle, this project begets its opposition as the labouring population fights against capital's struggle for control, domination, and in the end, labour's elimination via technology. Ultimately, this oppositional struggle against capital implies, as a 'negation of the negation', the ideal imaginary of its opposite expressed as a world governed by the will and needs of the association of the producers which is the democratic socialist expression of the humanist imperative.

In the history of capitalism, this project begins as a struggle aimed directly against controlling and automating technology. In the end, it aspires to become the struggle to directly reverse the capitalist-led movement from living to dead labour, such that humanity can creatively direct technology towards its conscious human goals. Similarly, for ‘knowledge socialism’, this project is to reverse the relationship between ‘dead information’ and ‘living knowledge’ (Enright 2011). The fundamental idea is to create a world in which social reproduction is driven by harnessing automatic systems of production and communication to the creative will and purposeful application of the holders and institutions of socialised knowledge to meeting human needs.

Specifically, this chapter considers how bioinformational knowledge ecologies can be repurposed to enhance a human centred charting and designing of a process of extended and progressive social reproduction. This chapter reflects on these opposing tendencies in the knowledge class struggle over the form of ‘global information systems’. Rather than being subordinated to the economic and ideological priorities of capital’s vision and will, the post-neoliberal project of knowledge socialism is driven by, and seeks to put control back in the creative hands of, knowledge workers as agents of humanity.

The chapter looks behind the automatic and self-renewing human subordinating tendencies of the present capitalist form of this system, to the class struggle between the agents of capital and the agents of socialism. It argues for the reversal of capital’s project to perpetuate its power by transforming the human interface into just the organic appendage of a self-perpetuating systemic logic. The chapter specifically considers the counter-movement to renew, extend and apply the idea of the public library to the creation of a super-library institutionalised as a ‘world knowledge bank’ dedicated to collecting and making freely available humanity’s expanding knowledge.

3 From Marx to Libraries

The social motor of market competition pushes capital to invest in ‘dead labour’ making ‘superfluous’ ‘living labour’ that descends into the segmented ranks of the ‘relative surplus population’. The remaining ranks of employed ‘living labour’ find their work increasingly transformed by the introduction of self-acting machinery, that tends towards becoming an automatic system of coordinated machines driven by a single energy source mechanism (Marx 1976: Chap. 15). This machine system ‘really subordinates’ labour to its ‘unvarying regularity’ by reducing labour to being just one of its ‘appendages’ and by ‘removing idle moments’. Eventually, beyond machine operators the remaining workforce become just the ‘superintendents’ of ‘the beautiful labour of the machine’ (Marx 1976: 563).

Capital's structural logic that edges towards replacing living labour with moving machines becomes psychologically embedded in capital's human agents. As Marx implies, capitalism's structural tendency towards technological automation becomes animated in the conscious will of the capitalist class who ultimately seek living labour's elimination. The offensive of capital's agents against the counter-movement of living labour feeds its urge to replace labour with machinery that, unlike the destructive, imperfect and wilfully trouble-making character of organic human life, expresses an ideal logic of capital accumulation in the form of a constant, consistent and calculable automatic robotic discipline. Capital's deep but hidden goal is thus revealed as total mastery of the economic process by 'removing the fallible human element' altogether.

The urge to total control has a deeper historical origin in the mentality of the western Enlightenment's view of Nature. In the project of 'primitive accumulation', the capitalist agents of western imperialism extract material resources without concern for Nature, and then via direct enslavement correspondingly seek totally subordinated human resources, as if just like another material resource are to be used up at will. However, slave owners confront slavery's reality as an unsustainable and unjustifiable form of extreme human degradation and destruction that engenders revolt. Marx views industrial capitalism as transcending the limitations of slavery 'pure and simple'. However, the capitalist mode of production's structure breathes life into the residual mentality of slavery and Western entitlement that is manifest in the will of capital's conscious agents who treat people and Nature as disposable and dispensable (Neilson and Peters 2020).

The competitive imperative of growing surplus value feeds the capitalist compulsion to replace human-centred production with the automatic logic of the process without a human subject. Correspondingly, capital's 'prize fighter' economists celebrate the apparent absence of a human subject as they trumpet the 'natural' blind logic of the market's impersonal self-regulation. This narrative is also an ideological ruse confirmed by the seeming automaticity of both machine and market that obscure capital's will to extend and deepen its power and wealth. At the same time, the movement to replace living labour with dead labour directly connects with the development of knowledge and science whose living agents practically deliver capital's quest for labour's subordination and automation, but also end up becoming subject to the same process.

Instead of remaining its handmaid, knowledge becomes separated from labour and pressed into the service of capital. Knowledge inside the workers' heads is transformed into a 'science of management' that subordinates living labour to the coordinated routine of the detailed division of labour (Braverman 1974). Moreover, science that is a product of intellectual labour rather than arising directly from productive labour, is also enlisted in the service of capital. With the application of science to social labour on a large scale, the products of both material and immaterial labour are transformed into capital (Peters and Neilson 2020). Knowledge workers are exploited by and subordinated to, and at the same time are capital's key agents in constructing, automatic systems of information based control. In the end, the development of the social productive forces of both material and immaterial labour that via their transformation into capital come to appear as its own achievement.

For Marx, capital's relentless drive to separate, abstract and alienate knowledge from the subjects that compose it is central to capital's own reproduction. It is the primary tendency encapsulated in the long transition from industrial capitalism to information capitalism. However, despite Marx's obvious perspicacity in comprehending this trajectory, his analysis, notes Pasquinelli (2015: 50), is ultimately informed by an under theorised 'definition of information in contemporary terms'. Not simply limited to Marx, his contemporary interlocutors too seem to operate without rigorously defined parameters of some of the key terms of the debate, frequently conflating and reducing the categories of data, information and knowledge.

The point missed in much of contemporary theory is that once knowledge is incorporated and coopted into the production process it confronts the labouring population as information—an abstracted and de-materialised form removed from the everyday experience of labour and possessed most completely by capital. In this way, information exists as the property of capital, separated from the living knowledge workers who produced it, and appearing itself in a de-materialised commodified form of mystified reification (Marx 1976: 166). Information is the reduction of living knowledge to commodified units separated from, and in tension with, the creative will of its producers. Thus, the transfer of living into dead labour takes a double form: as the transformation of productive material living labour into automated machine systems, and as the transformation of the knowledge products of immaterial living labour into 'dead information' manifesting as automated systems controlling, appropriating, subordinating, transforming and ultimately replacing living knowledge.

One of the more perceptive critics of cognitive capitalism to emerge from the Italian Marxist milieu, Romano Alquati (1963 in Pasquinelli 2015), introduced the idea of 'valorizing information' to capture this movement from living knowledge to dead information. At the Olivetti computer factory, he observed the valorisation of information understood as centrally about capturing the knowledge of the workforce and its integration into capitalist cycles of production and profit. Here, Alquati finds information to be essential to capital's project. It is what the worker, by the means of constant capital, transmits to the means of production on the basis of evaluations, measurements, elabourations in order to operate on the object of work all those modifications of its form that give it the requested use value. Knowledge itself becomes increasingly subject to the same 'information valorisation' as its process and its products are subjected to evaluations, measurements, controls that transform it into commodities for sale, and into commodities that become subordinated to the priorities and goals, both economic and ideological, of capital. At the moment, this is part of a long-term tendency only partially realised and subject to counter-movements.

Living labour dominated by dead labour that is owned and controlled by capital and appears as its own achievement. Living labour as knowledge, that expresses itself as variable capital or variable knowledge, reanimates information but is continually absorbed by it. Thus capital divorces and separates knowledge from the worker and make it its own. For Marx, 'this perverted relationship necessarily produces … certain correspondingly perverted conceptions, which represent a transposition in consciousness' (Marx 1981: 136). As Enright (2011: 113) makes clear: 'information is exploited living labour and not just a neutral collection of facts but embedded in the distinctly capitalist social relations of the system in which it is produced'. That is, the violent metamorphosis from living knowledge to dead information appears as a phantasm which fundamentally conceals, as Marx (1976) put it, the 'material relations between persons and social relations between things'. However, the recuperation of knowledge as information is always provisional. Unlike other commodities, knowledge (like labour power), is never finally produced.

The apparently self-regulating knowledge ecology of information is subordinated to capital's conscious will via the neoliberal project to commodify almost everything. Class struggle in this context is about whether or not the new knowledge proletariat in the 'factory without walls' can appropriate this conscious will and transform it into knowledge socialism.

4 Class Struggle in the History of Libraries and Information

> Libraries seem to scholars like the air they breathe—hardly worthy of a remark unless in bad odor. (Matheson 1995)

This section focuses the class struggle between the capitalist project to construct dead information systems and the socialist project to create a socialised world of living knowledge in the service of a cosmopolitan world of cooperation and diversity with particular reference to the history of libraries. In the contemporary era of neoliberal globalisation, the cutting edge of the struggle is between the global automatic information system subordinated to the goals of capital, and the counter-project of a living knowledge socialism imagined in the form of super global library institutionalised as a 'world knowledge bank. Public libraries are a site of struggle between a broadly socialist advocatory movement that seeks to grow and defend institutions of publicly owned free knowledge available to the whole citizenry, and the capitalist countermovement to commodify and reify information. The capitalist counter movement is about subordinating free and public information and knowledge to the capitalist criteria of monetised market exchange and the goal of profit. This struggle gathers speed in the contemporary world under the neoliberal project of global capitalism that seeks the commodification of almost everything, including information. However, from the outset, libraries have been the site of class struggle.

The framing of the public library as 'an egalitarian institution providing universal access to information for the general public' (Honma 2005: 2) and 'a pillar of democracy by supporting informed, educated, and engaged citizenry' (Jaeger et al. 2013: 166) is deeply entrenched in conventional understandings of the history, function and purpose of the institution. The narrative emerging from broad sections of library officialdom is that the public library is indispensable for a 'thriving culture and democracy', a veritable 'arsenal of democratic culture'. A central tenet of this narrative focuses on the public library's sheer popularity. In the US, for example, it is alleged that '[f]ive times more people visit U.S. public libraries each year than attend U.S. professional and college football, basketball, baseball and hockey games combined' (Brindley 2006: 488). The situation is similar in the UK: 211 million visits to libraries surpass attendance at English Premier League football matches, cinemas and the top 10 UK tourist attractions combined (Wilson 2017: 4).

Whilst the concept of the public library and its commitment to the free flow of ideas and information aligns with the project to build knowledge socialism in the twenty-first century, there is a history of scholarship problematizing such claims and assumptions. Although appearing as an institution beyond reproach, its popularity and goodwill occurs against a backdrop of increasing funding cuts, austerity budgets and closures. Moreover, the dominant narrative libraries use to talk about themselves—democracy, social improvement, self-education and so on—conceals the myriad ways in which the library is both produced and reproduced by capitalist social structures, that is, a narrative construction which fundamentally ignores 'the development of libraries as the product of social and political currents working through society at large' (Harris and Garrison 1975). Actually, the dominant narratives work to conceal how in reality libraries are caught up in the capitalist tendency that seeks to control, appropriate and transform living knowledge for its own purposes.

Beginning with the publication of 'The Purpose of the American Public Library' in 1973, the work of heterodox library historian Michael Harris is central to historically specifying and critically re-situating the public library within a network of capitalist social relations as an apparatus of cultural reproduction and an instrument of social control. The largely unquestioned belief in the 'idealism' and 'humanitarianism' long associated with the genesis of the public library movement 'simply does not correspond to the facts', with Harris concluding that 'public libraries were generally cold, rigidly inflexible, and elitist institutions from the beginning' and that has always been an institution 'linked to the power and privilege of certain classes' (Harris 1973: 2509). Calling for 'a theory of the underlying structures of social relations, of the contradictions embedded in those structures, of the ways in which those underlying structures generate the appearances people encounter in everyday life', Harris' revisionist lens maintained a steady focus on the role that the public library played in the ongoing reproduction of capitalist social relations.

Library legitimating tropes into the present promote the view that the new knowledge economy is based upon the free flow of information and ideas, divorced from the material and social capitalist realities and preconditions of their creation and consumption. This disembedded sphere of information also functions as a denial of history that naturalizes and de-politicises the existing capitalist social order. Free floating neutral information without material, historical, capitalist anchors becomes a quasi-automatic objective terrain beyond the political, beyond contestation and thus immutable. When information is ideationally separated from materiality, a special exemption from the constraints of space and time is implied. This makes information into a kind of transcendental phenomenon, something that exists a priori before the labour of informatic practice calls it into being. From this problematic perspective, informatic practice may be deemed as unimportant, something mundane and less valuable than the IT infrastructure it supports.

For Mosco (2005), the information age appears as 'genuinely something new' with an incredible power to 'transcend spatial, temporal and material constraints' including distance, cities, geography, politics, space and time. In production, it has replaced labour and the relatively static logic of fixed plant and machinery as the central organizing force of society. It becomes seen as a 'transcendent, magical force that marks a break with history'. However, as Mosco puts it, this is 'to deny history … by removing remove from discussion active human agency, the constraints of social structure, and the real world of politics' (Mosco 2005: 35). A critical materialist theory of information directly confronts the arguments behind the claims that we live in a free-flowing post-material informational society.

For those in Library and Information Science (LIS), the fantasy of information unhindered by material limitations imagines the possibility of the total library, a project only dimly conceivable when Ptolemy I built the great Library of Alexandria at the end of the third century. Paralleling the confusion in library discourse between its democratic socialist pretension and possibility and its actual capitalist nature, is LIS discourse that envisages the possibility of organizing and making available the sum of all recorded knowledge, while being blind to its actual material and capitalist constraints in doing so. As such, it is subsequently argued, that in an economy grounded in and pivoting upon the production of knowledge, everybody has the potential to own the means of production and so, interfering with 'the economics of scarcity that is manifest in the class inequalities of capitalism' (Wilkie 2011: 52) and ultimately realises the elimination of class conflict itself.

Although many commentators have been enthralled by the disembodied immateriality of digital information, the necessity of comprehending the materiality of information has long been recognised by a handful of progressive scholars from information science and beyond. Whilst it may have been conceptually useful in the early stages of this transition 'from books to bytes' (Smith 1993) that wrests materiality and information from one another there seems to be an increasing awareness that the everyday world of information is fundamentally dependent on 'a vast substructure of old-fashioned material production' (Bey 1994: 5).

Bernd Frohmann (2000: 423) argues that a 'materialist information theory' is the very precondition for a 'meaningful information ethics', and Michael Buckland's (1991) famous precept 'information-as-thing' is now over a quarter of a century old. Still others have also emphasized the indissoluble link between information and materiality, even in its digital form. Katherine Hayles (2000), in her influential work *How We Became Posthuman*, argues against the alleged disembodied purity of dominant conceptualisations of information suggesting that information is always embodied. Hayles' uses the term informatics in an attempt to highlight the entwined and inseverable relationship of information with its materiality. For Hayles, informatics is best understood as the:

> material, technological, economic, and social structures that make the information age possible. Informatics includes the following: the late capitalist mode of flexible accumulation; the hardware and software that have merged telecommunications with computer technology; the patterns of living that emerge from and depend on access to large data banks and instantaneous transmission of messages; and the physical habits – of posture, eye focus, hand motions, and neural connections – that are reconfiguring the human body in conjunction with information technologies. (Hayles 2000: 313)

It is along these expanded axes—material, technological, economic, and social—that Hayles' consideration of information differs substantially to those frequently offered by information scientists and Silicon Valley ideologues. Flat, functional and one-dimensional descriptions of information tend to sanctify the fantasy of information turning information technologies into idealized and efficient instruments which promise universal and democratic access to information and ideas on the one hand, and the 'weightless', 'friction-free' circulation and exchange of capital on the other. Consider just one paradigmatic example from Australia: 'A thriving culture, economy, and democracy', asserts the Australian Library and Information Association (2007), 'requires the free flow of information and ideas'.

All conflict is erased. Information is neutral. Expanding upon Hayles' critique, Canadian surveillance scholar Martin French introduces the notion of 'informatic practice' which not only emphasizes the materiality of information but also the material quotidian practices that makes information the stuff of everyday existence. 'The concept', says French (2014: 230), 'is based upon the assumption that information has a material basis in the spatio-temporal milieu of everyday life'. Further, for French, the idea of informatic practice assumes that 'information is only ever manifest in the course of some modality of practice, whether undertaken by humans or nonhumans' and in this way tends to 'break with prevailing beliefs that immaterialize electronic, IT mediated information' (232).

Recent popular publications like *Tubes: Behind the Scenes at the Internet* (Blum 2012) as well as Wikileaks documents revealing the strategic importance of undersea Internet cables (ABC News 2010; Starosielski 2015) and media attention variously given to labour conditions in the vast Chinese factories building Apple's latest gadgets (Merchant 2017; Chan et al. 2020) or to the new fibre optic cables shaving nanoseconds off financial data flows (Steiner 2010) has led:

> scholars to reckon with the imbrications of information and materiality—something that, for a variety of cultural, technological, and philosophical reasons, we are now obligated to acknowledge. Obligated, because to ignore the materiality of information is to lack adequate tools for explanation, understanding, and praxis. (de Souza e Silva and Sutko 2011: 33)

The materiality of information and the enormous expenditure of human energy required to create it, disrupts the conventional assumptions about the very nature of information and the possibility of unfettered, universal access. Discussing intellectual property as constitutive of the material barriers to the free flow of information, Phillip Kalantiz-Cope (2010) offers a conceptual framework for interrogating the assertion and extension of property rights into the realm of information and ideas.

Importantly, one of the paradigms Kalantiz-Cope enumerates is ‘information materialism’. Such an approach:

> distinctively emphasizes the need for an integrated analysis of the production of tangible as well as intangible goods. Instead of separating intellectual labour from the material social world, this approach emphasizes the digital network, and the material infrastructure that the networks are built on, into the focus of critique. One part of this argument is that knowledge has never been ‘free.’ Rather, a significant proportion of public knowledge has been subsidized by the state in the form of universities, libraries, public cultural institutions and so on. In this sense, the state has played a direct role in the determining the ‘material’ order that contextualizes ‘immaterial’ production. The private appropriation of scientific and cultural knowledge is thus contextualized, refocusing questions of the scope of the public domain and the conditions of its adequate resourcing. (Kalantiz-Cope 2010: 141)

Central to the critical examination of the library in this neoliberal era is revealing how the immaterial world of information is actually connected to its material and human base. Converging under the broad rubric of the ‘neoliberal library’, a handful of critical LIS scholars have recently turned their attention to interrogating the politics of neoliberalism operating within and throughout libraries. In one of the earliest statements of the impact of neoliberalism on libraries, esteemed library scholar John Budd (2008: 175) observes: ‘The rhetoric of neoliberalism relies on insinuating the ideas of markets and transactions into common usage, so that practices that are market and transaction driven adopt the language as presenting truth.’ Likewise, Greene and McMenemy (2012), for example, trace the emergence and impact of neoliberal ideology on UK public library policy finding the discourse of the market ubiquitous in public policy and observe how ‘narratives of managerialism and consumerism’ are fundamentally recuperated by ‘neoliberalists to introduce reform and more radical public service restructuring’.

In the US context, John Buschman (2003, 2005) is one of the more perceptive critical voices examining the neoliberal library and has similarly offered a sustained critique of the movement toward managerialism within the library context. Similarly, Nicholson (2015) employs the shorthand ‘McDonaldization’ in order to readily apprehend the complexities of the strange bedfellows of higher education, libraries and neoliberal economic policy. Comprehending the pervasiveness of neoliberal ideology circulating through public institutions and libraries, Beilin (2016) concludes that global dominance of the neoliberal project is ‘today the most important … factors shaping … librarianship’ while Cope (2014: 6) suggests neoliberalism is a threat to the democratic potential of libraries, insofar as it ‘creates a discursive framework in which the value of information is determined by its ability to be monetized’. Moving beyond the purely discursive, a number of radical critics have attempted to uncover the relations of exploitation and social domination in the relentlessly neoliberal rendering of information literacy.

In her excellent examination of the ‘neoliberal library’ Maura Seale (2013) argues that the primary function of information literacy within the context of neoliberalism is to produce and to train the perfect neoliberal subject. In a similar way, Enright (2013) observes an irrepressible violence in information literacy subsumed by capital's obsession with human capital development. In broadly similar way, Beatty concludes that

> neoliberalism pressures us to assume that markets and competition are an efficient way to distribute resources, to believe it necessary for individuals to self-fashion themselves as useful to the system, and to reduce all judgments of value to purely economic terms. These and similar examples play out every day in library instruction, promoted by the information-literacy standards that underlie our teaching. (Beatty 2013)

Despite the obvious importance of critiquing the neoliberal foundations of information literacy and its centrality to the quotidian operations of the contemporary library, perhaps the most trenchant critique of neoliberalism in practice is Adler's (2015) recent examination of the Library of Congress. Providing a forensic look at the recent history of the Library of Congress through protests, budget cuts and austerity budgets, staff layoffs, deprofessionalization and deskilling, increasing corporate alignment and changing revenue streams, US cultural imperialism and the reproduction of hegemonic ideologies through cataloguing and classification and the uneasy relationship between democracy and an increasingly neoliberal state, Adler effortlessly uncovers the complex interplay between capital, state and library. Revealing the ways in which neoliberalism has taken hold in the post Reagan era, Adler finds that:

> Libraries not only have adopted neoliberal management techniques but, more importantly, in a global sense, have significantly contributed to the production of a neoliberal ideology, propelling the notion that equity of access to information provides an avenue for opportunity and democracy (Adler 2015: 26).

In sum, the class struggle around libraries and the control of information is between the democratic socialist forces that advocate for public living knowledge and the capitalist forces of commodification that reduce knowledge to disembodied and dematerialised systems of dead information. The struggle continues to be won overwhelmingly by the forces of capitalism. However, as capital increasingly dominates it also reveals that it is leading the world towards ecological, economic, social, psychological and political collapse. Thus, at the very point that it moves towards total domination, it simultaneously reveals itself and thus incites the counter-movement.

5 Reversing the Trend: A Transformed Public Library Project and the Democratic Socialist Model of Development

Marx's *Capital Vol. 1* (1976) focuses on the hidden deep laws of capitalism's extended reproduction, *as if* a process that unfolds independently of our conscious human design and will (Neilson 2017; Peters et al. 2020). Actually, this structural process becomes animated in capital's consciously wilful agents who, hidden behind capitalism's seemingly subject-less social process of structural reproduction, seek to remove the fallible human subject from the accumulation process. Key to the socialist movement in the twenty-first century is critically revealing how the apparent absence of a subject is just a way that capital mystifies its control. Further, while the agency of capital is about removing the agency of labour and subordinating human will to its power, socialist agency is the wilful counter movement to subordinate capital to the conscious movement of living creating humanity. Bringing in Marx's early work that foregrounds how capital alienates humanity from its natural biological well-being and the causal role of our wilful and creative knowledge in driving our emancipation under socialism is an epistemological precondition of this countermovement.

Key to the socialist project is reversing the process by which humanity is subordinated to a logic of social reproduction that is beyond its control and in contradiction with its needs and goals. The socialist transformation of capitalism is centrally about putting a wilfully creative human knowledge at the centre of a social process dedicated to meeting human needs. In turn, knowledge socialism refers to the imaginary of a living system that while dynamically renewing, puts in charge the general intellect, understood as the collective will of socialised cosmopolitan world knowledge workers dedicated to producing, procuring and distributing living knowledge to the world's population.

The essential human purpose of such accumulated and socialised knowledge is communicating and sharing the diversity of human experiences, cultures, and expertise in the service of the cosmopolitan goals of universal solidarity, enlightenment and pleasure. Its practical purpose is to facilitate the direct and universal meeting of human needs across, and with sensitivity, to the specific situation and requirements of peoples living in diverse local settings. Moreover, knowledge socialism seeks construction of an organisational structure integral to transforming the neoliberal-led form of contemporary global capitalism into a democratic socialist alternative 'model of development' (Neilson 2020a, b).

The imaginary of the 'world knowledge bank' (Neilson 2020b, 2021a, b) has its historical roots in the original democratic socialist aspiration of libraries expressed ideally as providing citizens with universal, egalitarian and free access to the world's knowledge. As outlined above, this aspiration has never been realised in practice. Not only has it been subject to the counter capitalist forces of commodification, subordination and disembodiment, it has been subordinated to western and elitist conceptions of knowledge. Further, especially in the current neoliberal era, the public library for all citizens has been starved of resources and is constantly diminishing in its holdings relative to the massive growth of commodified knowledge transformed into dead information that is increasingly subordinated to capitalist goals.

Commodified knowledge refers most obviously to privately patented and protected 'intellectual property' that has been an integral part of capitalism's history but that now is even more central to the technological rent dynamic characteristic of this perpetual innovation stage of capitalism led by the neoliberals. Increasingly, commodified knowledge becomes central to the world of the neoliberal academia. Knowledge workers in these institutions are being subordinated to capitalist goals via the terms of their work, employment, security and promotion that skew teaching and research towards market criteria of performance, and competitively funded research. It also is expressed in the global network of academic libraries that are integral elements of commodified global information systems and privately-owned publishing houses. The commodification of public knowledge for capitalist ends is also expressed in the distorted forms of civil society debate and communication, i.e., of 'prosumption' within the frameworks of profit-driven social media firms.

In contrast, the practical imaginary of the 'world knowledge bank' is integral to the class struggle of the labouring population that seeks to reverse the capitalist subordination of 'living labour' of knowledge work to commodification and the 'dead labour' of information. It expresses, but also radically extends in scope, the fundamentally democratic socialist aspiration of libraries especially in terms of education, democratic debate, and knowledge. Moreover, it extends in terms of function in that the primary mission, boldly stated, is to construct a global institutional framework that facilitates a world driven by socialised living knowledge. In such a world, these priorities are informed by the needs and aspirations of the world's citizenry that, in turn, correspond with the diversity of local economic needs and cultural formations. A whole army of active living knowledge workers diversely located in the social structure, are thus charged with the multi-faceted aspects of practically resisting the present capitalist world of information, and delivering this alternative knowledge socialism framework.

The democratic socialist model of development, within which knowledge socialism in the institutional form of the world knowledge bank would be central, presupposes as a necessary precondition the transformation of the present Empire form of the United Nations into a genuinely cosmopolitan democratic federation of united nation states. The United Nations is thus understood here as the trans-national-state site of the 'condensation' of the class struggle. This struggle is schematically represented as between, on the one side, the powerful agents of the US hegemon who in league with other rich and powerful nation states and transnational capitalist forces has resulted in the United Nations becoming the agent of the neoliberal model of development. On the other side of this struggle, are those knowledge workers who support and pursue the United Nations generic aspiration defined as the democratic project of cosmopolitan cooperation to universally facilitate the meeting of human needs. Thus, rather than seeking its institutional replacement, anti-neoliberal knowledge workers located in the United Nations, seek the knowledge socialist transformation of the United Nations. These knowledge workers aligned with those located in public libraries, in Universities, in public sectors, and in education and information sectors generally, and that together define what can be named as the 'knowledge proletariat'.

Agents of the world knowledge bank and the democratic socialist model of development, both within and beyond the UN, seek the transformation of the UN into the instutional framework of a cosmopolitan democracy focused on the goals of universal solidarity, cooperative endeavour and material security. These goals are expressed as facilitating a world of nations whose different economic situations and needs can be met universally on their own terms and whose diverse cultural formations can be shared in a spirit of respect, celebration and mutual exchange. As a global regulatory agency within this reformed United Nations, this 'world knowledge bank's' scope would range across procuring, storing, distributing, and exchanging of a range of different kinds of knowledge including cultural expression and democratic communication, and pure and applied sciences dedicated to understanding the world and practically transforming it, while sustaining it organically, into products that can meet humanity's needs directly and locally (Neilson 2021a, b).

The world knowledge bank thus transforms the public library concept functionally, to include the many forms of practical knowledge that are applied to the world of material production, including in agriculture, industry, and health. However, as such, it would be dedicated in particular not just to procuring, holding and making available to all the world's nations existing capitalist knowledge. The world knowledge bank would also be practically engaged in directly promoting innovative technologies that align with the mission to facilitate forms of local accumulation that prioritise the meeting of humanity's primary material needs in a sustainable way.

The library would therefore seek to promote and fund ongoing research developments of local green technologies focusing first on those that can sustainably meet humanity's primary food and shelter. It would also seek to not just procure medicines but would actively promote the development of health products and technologies that can be produced at the local level. As well, the world knowledge bank would be part of a network of agencies dedicated to passing on such practical forms of knowledge to local populations. Also, agents of the world knowledge bank would be directly charged with cooperatively developing the national-trans-national regulatory framework that can directly reverse the neoliberal model of development and make a solidaristic world within which many local worlds can fit in a complementary dynamic (see Neilson 2021b).

The world knowledge bank is thus imagined here as being the central hub in creating a new model of accumulation that is named here as a democratic socialist model of 'glocalisation', where knowledge is globally procured and distributed, while actual production is facilitated locally. The world knowledge bank is imagined here as a hybrid global regulatory agency that includes both a super-public-library function and a much more practical set of knowledge applications for making and maintaining a democratic socialist world of accumulation. Thus, we imagine a world dynamically regulated by a living knowledge ecology.

6 Socialism and the Knowledge Proletariat

Knowledge has become increasingly untethered from its producers and increasingly inaccessible as it comes under the sway of capital's quest for profit and power. The vast production of knowledge is progressively subsumed as capital's cognitive surplus. Knowledge produced under capitalist social relations, even an apparently neutral, objective science, is capitalist class knowledge. Despite the knowledge to remake the world, capital's bioinformational commodification and automation of knowledge and knowledge systems reinforces the present path towards organic collapse.

The history of capitalism is read here as a history of class struggle between the live force of humanity's labour and capital's increasingly conscious will to subordinate and replace, both material and immaterial living labour, with forms of dead labour. The struggle for socialism, understood in this framing, is fundamentally about reversing this relationship such that humanity can become the collectively cooperative architect of its own destiny. This is a reading of Marx's conception of socialism best defined at the end of *Capital Vol. 3* in the following way: 'Freedom … can only consist in this, that socialised humanity, the associated producers, govern the human metabolism with nature in a rational way, bringing it under their collective control instead of being dominated by it as a blind power.' (Marx 1981: 959)

Old Marx's conception is too abstract to meet the specific requirements of the struggle for democratic socialism in the twenty-first century. In this reframed version so briefly outlined here, the first priority is to set the terms of the national-trans-national connection that Marx left to one side, and that simultaneously return attention to the specific contemporary relevance of Marx's concept of praxis read here as the 'point of knowledge is to change the world'. Today, the project of democratic socialism now confronts a vastly complex planet-encompassing capitalist system that has subordinated nations and peoples to the multi-pronged imperatives of competition and capital's quest to make a world in its image that is actually turning it into a dead dystopia of robots and organic material and human devastation.

The knowledge agents of the project of democratic socialism in the twenty-first century must be able to offer an alternative regulatory blueprint that transforms the present world of capital's global domination, facilitated by the empowering of its vast corporations on the terrain of the global market terrain of its 'neoliberal model of development', into a world of cooperation and local empowerment. The regulatory transformation practically requires the reframing, redesigning and transforming of this capitalist world into a glocalised model of accumulation grounded in democratic socialist national-trans-national-regulation. In the making of democratic socialism in the twenty-first century, a heavy weight of responsibility falls on the knowledge proletariat who become central to practically delivering this vision, both for transforming capitalism and for practically constructing the framework of this new world in which everyone can meet not only their primary material needs in freedom and security, but also can express their higher needs through a world of democratic cosmopolitan sharing and debating of knowledge as citizens of our one world.

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Part III
Teaching and Learning in Postdigital Knowledge Ecologies

Postdigital-Biodigital: An Emerging Configuration

Michael A. Peters, Petar Jandrić, and Sarah Hayes

1 Introduction

As the world approaches the first anniversary of the Covid-19 pandemic, biology, chemistry, physics, and other traditional disciplines in the natural sciences converge in the concept of technoscience and the transdisciplinary 'nano-bio-info-cogno' paradigm (Bainbridge and Roco 2006). Social sciences and humanities explore emerging concepts such as biodigital philosophy, postdigital knowledge ecologies (Peters et al. 2021a), bioeconomy (Peters et al. 2021b), viral modernity (Peters et al. 2020b) and others. Educators and develop 'emergency remote teaching' responses (Hodges et al. 2020) as well as broader and deeper concepts such as precision education (Williamson 2019) and postdigital ecopedagogies (Jandrić and Ford 2020). Disciplinary convergences, development of new concepts and of course online learning, have been around for a long time. Yet it is fair to say that no area of human activity, and no area of intellectual work, has remained untouched by the Covid-19 pandemic.

During the fateful year of 2020, Michael A. Peters, Petar Jandrić and Sarah Hayes have extensively contributed, as authors and editors, to these research efforts.

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As we move beyond immediate responses and take our first stabs at more general questions pertaining to our (post)-pandemic reality, our work, separately and together, has surfaced some important themes and questions. Based on our previous works on collectivity, including but not limited to interconnected notions of knowledge socialism (Peters et al. 2020a, b) and postdigital dialogue (Jandrić et al. 2019), we decided to explore these themes in a trialogue. Keeping each individual voice, our trialogue seeks a common ground between its authors' positions and exposes various cracks and tensions. While we tremendously enjoy rare occasions when we have arrived at a full agreement, it is within these cracks and tensions that we see room for development of our individual and collective work.

Our first theme concerns clarification of the main concepts and terms. Pandemic responses require urgency, so it is hardly a surprise that recent works have paid more attention to ideas than to precise ways of expressing these ideas. Yet ideas cannot be divorced from concepts, and concepts cannot be divorced from language. It is with this understanding, that we undergo an exploration of relationships between various concepts such as postdigital, biodigital, bioinformational and so forth – concepts which, we feely admit, have been used in rather non-systematic ways even in our own recent works. This discussion of concepts and terms brings about our second theme: convergence. After decades of experience we are already well-used to 'low-level' convergences such as biophysics and technoscience, yet their mutual combinations and 'higher-level' convergences such as 'nano-bioinfo-cogno' (Bainbridge and Roco 2006) still leave us baffled. How do we make sense of something, which is at the same time everything else? Our third theme, education, offers a way of approaching new concepts and convergences at their point of intersection in educational praxis.

2 The Many Faces of Postdigital

Sarah Hayes (SH): I had been wondering about the reconciling of postdigital and biodigital, and I think it is very helpful to debate the use of these terms. As we have applied the idea of postdigital, we have used the proviso that it is useful, adaptable but an imperfect, partially developed concept. '[A]s we have already discovered with posthumanism and postmodernism, the prefix post(-) signals that we have something to talk about.' (Sinclair and Hayes 2019: 129) I have always thought of the concept of the postdigital as ontological as well as epistemological, with authors bringing all manner of interpretations connecting diverse traditional and contemporary theories. Do you envisage biodigital as a progression on from postdigital, or a break with postdigital, given biodigital is such a major shift?

In *Postdigital Science and Education*[1] I have really liked the inclusivity aspect of the community using a messy notion, where people have shaped an ongoing

[1] See https://www.springer.com/journal/42438. Accessed 5 October 2021.

'postdigital dialogue' (Jandrić et al. 2019). So, my other question concerns 'biodigital dialogue' and your thoughts on how you see it shaping?

Michael Peters (MP): I am not sure I can answer these questions but postdigital operates in some way as a critique of the digital as a technological fix as I argued in one of my papers (Peters and Besley 2019). Postdigital also implies that other arrangements are possible so for me to informatize biology (bioinformatics) is only one interaction or integration; the other is biologizing information such as organic memory. When that happens as it will more often, then, we move from epistemology to ontology, i.e. humans are open to becoming something different, to evolving into biodigital beings. What that means is still in the making – new forms of synthetic life that may also be part of humans.

Surely this is postdigital but it is also an evolutionary advance on the digital that can become human – an open possibility. When the convergence goes through many iterative cycles in the next decades it may mean a new form of genetic-digital intelligence where conversation and dialogue are more easily facilitated perhaps through direct thought transfer. I'm not a futures scholar and also I am neither trained in biology or computing, but we have seen many 'generations' in both – what new developments occur will depend on new waves of innovation and development. But the integration – not sure this is the best word – certainly means new plants, modified animals and modified humans. And it does potentially make possible bioeconomy that is environmentally self-renewing. This surely is significant when facing the prospect of mass extinction. But we need to think more about this question.

Petar Jandrić (PJ): As a group of us wrote in our first postdigital paper, '[t]he postdigital is hard to define; messy; unpredictable; digital and analog; technological and nontechnological; biological and informational' (Jandrić et al. 2018: 895). In my view, bioinformation and biodigitalism are intrinsic – and very important – parts of the postdigital idea. I would argue that postdigital is indeed, as Michael said, a critique of the digital as a technological fix. Yet I would also argue that the postdigital is much more than that – it is a wide-open position or perhaps even worldview which encompasses various reconfigurations between technologies and humans. This applies to all kinds of technologies, including but not limited to biodigital technologies. So for me, the biodigital is an important aspect of the postdigital idea, but it is far from the only one.

Speaking of examples from the conclusion to our 'Biodigital Technologies and the Bioeconomy: The Global New Green Deal?' chapter (Peters et al. 2021b), this implies that technological unemployment and bioeconomic reconfigurations of work are not at all in conflict. Rather, these and other diverse transformations are a part of the same cultural evolutionary shift slowly taking place in front of our eyes. A few years back, the question of the day was technological unemployment; today, it is the Covid-19 pandemic. We, humans, always tend to focus to what seems to 'hurt' us most at any given moment; yet we always need to contextualize our interests into a wider perspective. To continue with the example, we cannot look at technological unemployment without looking at bioeconomic reconfigurations of work (Peters et al. 2019). Since our current interests cannot be divorced from our earlier interests, our previous work also provides important input for our present work. I think that the concept of the postdigital could be used as an integrating factor, or a 'higher' conceptual plane, at which our interests may come together.

SH: So, if we think of postdigital as Petar describes it, as a wide-open position/worldview 'which encompasses various reconfigurations between technologies and humans', we might debate all manner of other arrangements, interactions, convergence and integration from any stance. In my forthcoming book I explore 'postdigital positionality' and invite debate on broad connections with inclusivity across humans and data-driven technologies (Hayes 2021). I include interactions with my airing cupboard and hot water tank, as one playful example. Static though the hot water tank may seem just now, it could be invited like other material or organic items to become digitally intelligent. As part of the algorithmic internet of things (AIoT) it joins 'a paradigm shift where anything and everything can be interconnected via a communication medium' and 'security is a prime concern' (Pal et al. 2020). Therefore, I question what reforms are needed to inclusivity policies (that still centre around human-to-human discriminatory practices) to now be inclusive of a hybrid assemblage of devices and potential data bias, that humans now intimately interconnect with (Hayes 2021).

We can go further to contemplate too, as Michael suggests, where 'organic memory' might lead and indeed how much 'humans are open to becoming something different, to evolving into biodigital beings'. Given that this is 'still in the making' and 'new forms of synthetic life may also be part of humans', my next question concerns how this now works in terms of subject disciplines and theory? What broader positionalities might we adopt in order to theorise the paradigm shifts evolving and converging in postdigital society? As we have collaborated on articles and books, we have examined the dialectic between technologies and humans through critical theories and made our links to other disciplinary traditions and conventions as well as underpinning political economy. Yet we might wonder now at how disciplines may converge differently under, or across, new bioinformational and biodigital paradigms.

Taking the humanities as one example that has developed branches of digital humanities and posthumanities (Braidotti 2019), this concerns more than simply extending a discipline within formerly agreed traditions. If as Michael discusses 'new plants, modified animals and modified humans' (as well as modified hot water tanks) emerge, how is this interpreted from the perspective of say, art? Many artists have applied postdigital theory which permits argument to develop from any point in time or disciplinary or interdisciplinary viewpoint. These paradigm shifts bring new questions though, such as 'linking art with human dignity' in any 'reconsideration of our traditional notions of nature and the human body' (Zwijnenberg 2014: 131). As technologies and conditions converge into 'algorithmic medicine' what are the implications for 'digital health'? (Petersen 2018). As we contemplate these examples at a philosophical level, there are legal, practical, methodological and ethical questions that cluster, not to mention those concerning research funding bodies and policy.

MP: I don't see conflict between the postdigital condition and biodigital technologies except that one is a 'condition' and the other is a working technology – the result of technological convergence between new biology and digital technologies. Biodigitalism is a broad term trying to work out the lines of convergence going forward and it has been spectacular. It also offers the prospect for bioeconomy that can provide environmental self-renewal and synthetic enhancement. We in the humanities need to understand the principles of 'new biology' and genomic science in particular, in order to discuss the prospect and reality of *biologizing the digital*. This is surely postdigital but a form of postdigital that is not confined to critique and is able to recognize the biological paradigm of the digital.

We get close to understanding this paradigm in artificial neural networks, digital organisms, evolutionary algorithms, evolutionary computation, genetic programming, mathematical biology, neuro-organic evolution and organic computing, to take some recent advances. We can pick up on Dennis Bray's (2011) *Wetware: A Computer in Every Living Cell* where he argues that each individual cell contains thousands of enzymes, each performing reiterative, molecular processes, that act like transistors that can be ordered in pathways, or electronic circuits, to perform logic operations – the equivalent of a natural computer. Bray argues that the most basic form of cellular life exhibits a highly complex computational structure, just like a computer which is crucially important in biorobotics. Thus, as one blogger puts it: 'Organic computers, sometimes also referred to as wetware computers, can be described as computational devices that are composed of organic materials, such as living neurons. While conventional computers can only operate in binary, a neuron can be in thousands of different states.' (van Hooijdonk 2019) Van Hooijdonk also reports on how researchers use clustered regularly interspaced short palindromic repeats, or CRISPR, to create a biosynthetic dual-core computer within human cells, and he indicates that '[t]he first reprogrammable DNA computer has arrived'. This is definitely postdigital in that organic computers may become a viable alternative to silicon-based devices. Researchers have also developed a method to 'genetically' engineer a better type of memory using a virus (Singapore University of Technology and Design 2018).

There are many examples where 'organic memory devices show promise for flexible, wearable, personalized computing' where '[b]rain-inspired electronics with organic memristors could offer a functionally promising and cost- effective platform' (American Institute of Physics 2020). Others have argued for organic molecule-based data storage and neuromorphic computing. Organic memory technology is a new field that demonstrates the power and potential of an aspect of organic computing. As Nau and List-Kratochvil (2015) summarize, 'the ongoing development in organic memory technology based on resistive switching and transistor-based memory from the material development, processing as well as from the device operation point of view'. Building organic computing devices indicates a couple of things; how technological convergence, especially at the nanolevel, creates new paradigm; and the extent to which cultural evolution is driven by the twin forces of new biology and 5G computing. To me this speaks to both the postdigital and biodigitalism, which has huge implications for education and science especially at the level of cognitive science.

3 Postdigital Convergences

PJ: In 1998, Nicholas Negroponte based his prediction that '[l]ike air and drinking water, being digital will be noticed only by its absence, not its presence' on the following premise: 'Yes, we are now in a digital age, to whatever degree our culture, infrastructure and economy (in that order) allow us. But the really surprising changes will be elsewhere, in our lifestyle and how we collectively manage ourselves on this planet.' (Negroponte 1998) After 20-odd years, it is now obvious that the most surprising changes surpass well beyond Negroponte's predictions. The world has not progressed as far as Ray Kurzweil's singularity (2005), but biotechnologies reach much deeper than culture, economy, lifestyle or collective management. Reaching all the way to questions pertaining to human nature, our biotech present is somewhere between Negroponte and Kurzweil. Biotechnology is foundational to our postdigital condition, inasmuch our postdigital condition creates conditions for development of biotechnology. These two concepts are mutually foundational, and obviously not conflicted – but that does not imply that they are the same. So what can we learn from their mutual relationships?

An obvious point of departure, kudos to Michael, is that 'one is a "condition" and the other is a working technology'. When we develop knowledge about a condition, we are in the realm of science (lest we forget the original meaning of the Latin word *scientia*, which is knowledge). When we develop a technology [defined by the Greeks as the combination of *τέχνη (technē)* and *λόγια (logia)*], we are in the realm of application of science to the practical world. There are many conceptions of both science and technology, and we do need to urgently explore their latest developments in the postdigital world. However, this cannot be done in isolation, as the convergence of biology and information is based on another hugely important convergence of science and technology or technoscience.

In our previous chapter (Peters et al. 2021a) we examined this convergence in more detail and identified several important 'epistemological shifts in the post-war period emphasizing new knowledge ecologies, technologies and research fields, that reflect a set of technological convergences that integrate, multiply, expand, broaden and synthesize existing fields in genomic and information science'. In another chapter (Peters et al. 2021b) we showed close links between biodigital technologies and the bioeconomy, suggesting that identified epistemological shifts are closely linked to (political) economy of (techno)scientific production. This signals that our neatly divided convergences (biology+information, science+technology, etc.) require a meta-convergence. We, thus, arrive to the postdigital convergence of information, biology, science, technology, politics, society and various other phenomena that remain unmentioned. In its original formulation, this postdigital convergence has arrived from our descriptions of the postdigital condition (see Jandrić et al. 2018), but it equally speaks to 'lower-level' convergences such as science+technology.

Now that we outlined these complex relationships between various convergences and their levels, a crucial question is: What is to be done? Developing possible approaches to our understanding of reality (science) and transformations of reality (technology), I am painfully aware of our human limitations. Rome was not built in a day, and we cannot solve all the world's problems at once – therefore, we need to 'attack' problems one by one. Such approach fits well with the structure of academic publishing, so our analysis of techno-convergence is one research paper, bioeconomy is another research paper… *ad infinitum*. While it is completely legitimate (and often necessary) to focus one's work to lower-level convergences and their consequences, we need to remember that lower-level convergences cannot be fully understood without the higher-level postdigital convergence. For instance, any discussion of the science+technology convergence will be incomplete without consideration of political economy. This reconfiguration of relationships between traditional scientific and technological disciplines is one important point at which our theories of the postdigital condition enrich our theories of biotechnology and vice versa.

SH: This would seem a good point at which to turn this postdigital trialogue about the biodigital implications discussed so far, in the direction of questions concerning language and behaviour. I find myself reflecting on how so much of our postdigital debate has drawn on the consequences emerging from how our political economy is organised, as Petar reminds us above. If our biodigital dialogue draws on bioeconomy, then, will we need to examine 'political bioeconomy' as a new, or extended field of thought, or alternative way that society is organised? How might this look beyond our current political economy? Having closely examined how policy discourse about technology has been shaped through political economy, to limit us within restricted instrumental approaches (Hayes 2015; Hayes and Jandrić 2014; Jandrić and Hayes 2018), I am interested in what new discourses and related behaviours might emerge through political bioeconomy. Rather than a dominant discourse about how technology will automatically enhance experience (as if experience were something universal that we all share), might we discuss new forms of 'political bioeconomic discourse'?

How might these new discourses then contribute to new directions for postdigital debate? These ideas really pick up from where our 'Biodigital Technologies and the Bioeconomy: The Global New Green Deal?' chapter left off, as we called for 'new understandings of bioeconomy fit for our biodigital moment in history' (Peters et al. 2021b). What kinds of reasoning powers will we be likely to require then in a political bioeconomy? In *Postdigital: Using AI to fight coronavirus, foster wealth and fuel democracy*, Thomas Ramge (2020) questions how human beings can use artificial intelligence intelligently. He argues too that 'artificial intelligence will not be able to relieve us of the burden of thinking, nor will it be able to tell us the right way to act socially' (Ramge 2020). Citing the combined efforts of humans and machines to fight Covid-19, Ramge argues from a postdigital point of view that whilst information technology solutions might have assisted in the struggle against the virus, the human behaviour of social distancing has saved millions of lives. Ramge discusses ‘the dialectic of digitalisation’, including when governments and political leaders discover how they can use the innovations of surveillance capitalism to manipulate and control people’s decisions. Thus, we are left with many tantalising questions concerning how the dialectics of politics, language and behaviour might play out in a political bioeconomy. I am also fascinated to know more about the shape that political bioeconomic discourse might take.

MP: I think biotechnology and biodigital technology are very different: the former is the use of biology to make products which has a specific technological trajectory, while the latter can be regarded more as a philosophical platform for planet Earth as evidenced in principles of bioeconomy – that is, environmental self-renewal and synthetic enhancement. This means that biodigital technologies, or the biologization of digital processes, are a reflection of a very different kind of political economy – a great question that you raised Sarah! In one strict sense, biodigitalism and biodigital technologies must be in sync with principles of sustainability (and the Millennium goals) aimed at the survival of humanity as a whole. (We have come some way now to energy self-renewal systems.)

But this development of biodigital technologies is proceeding unevenly and the pattern of ownership is worrying when big multinationals like Monsanto own genomic rights – where a company can own plants or animal species. These very large biodigital multinational companies cannot be controlled simply through bioethics but require an advanced biopolitics that analyses ownership of the biosphere with rights and ownership, production and evolution, of life itself. In some ways this biodigital development represents the stuff of science fiction concerning ‘cyborgs’, human/machine clones, robots and AI. In another way, these biodigital technologies indicate that the future has already arrived when one looks at the growth of the techno-state that raises many issues to do with ‘techno-politics’ and ‘techno-science’ (Peters 2020a, b). All of this is part of the postdigital – what you get when you biologize the digital, which also means biologizing digital capital. When it goes wrong either by error or design the consequences could be catastrophic because we might be talking about the destruction of an entire ecosystem especially in relation to destructive synthetic biological constructions that get lost in the system.

4 Postdigital Education

PJ: The digitalization of biology, and biologization of the digital, now permeates all aspects of our lives. Virginia Eubanks’ (2018) *Automating Inequality: How High-Tech Tools Profile, Police and Punish the Poor* presents powerful testimonies of what happens when algorithmic technologies decide about human destinies. Our *Education and Technological Unemployment* (Peters et al. 2019) points towards biological consequences of changes in the workplace. Shoshana Zuboff’s (2019) *The age of surveillance capitalism: The fight for a human future at the new frontier of power* is probably the most detailed study of complex entanglements of tecno-surveillance and today's capitalism. Yet, I would argue that the biological aspect is probably most prominent in extensive dataification and algorithmization of education (Jandrić and Ford 2020); these days, it culminates in testimonies and analyses of teaching during the first wave of Covid-19 lockdowns (Jandrić et al. 2020, 2021a, b).

Education is often understood as a field that permanently lags behind technological and social development. A few years back, Siân Bayne wrote: 'When we look at the last few decades of thought about the position of the human in the humanities, the social sciences and even in the sciences, it always surprises me how far behind education has remained.' (Bayne in Jandrić 2017: 210) Similarly, Neil Selwyn admits: 'I should confess to not paying super-close attention to the 'education studies' literature in general. I try to read everything but the education literature, as this tends to where the most interesting ideas, debates and discussions about technology (and often education) take place.' (Selwyn and Jandrić 2020: 994) While it is perhaps unusual to look for the latest developments in the field of education, there is a small but rapidly growing body of research exploring the digitalization of biology and biologization of the digital worthy of our attention.

A useful concept to start with is Ben Williamson's 'precision education'. According to Williamson,

> A new interdisciplinary educational science focused on the quantification of students' affects, bodies and brains, captured in the term 'precision education', has emerged as a priority among scientists, foundation funders, philanthropic donors and commercial entities. Set in the context of intensive scientific advances in the biological sciences, including psychophysiology and biometrics, neuroscience and genomics, precision education raises fresh questions about the intersections of biology with society, politics and governance. (Williamson 2019)

Williamson's precision education is based on a trialectic between psychodata (obtained from psychology and psychometrics), brain data (obtained from neuroscience) and biodata (obtained from human genomics). This trialectic is another example of convergence, this time at a very practical level. It is connected with 'new forms of scientific educational research and evidence creation [that] is reconfiguring the conditions for knowledge production, and reconfiguring understandings of the human beings that are the subjects of education policy and governance' (Williamson 2019). It is in Williamson's precision education, that we can see the concept of biodigitalism and our theories of convergence in action.An interesting outgrowth of these developments is the concept of epigenetics, which refers to heritable changes in (human) genes that do not alter the underlying DNA sequence. According to Pickersgill,

> writings from educational researchers, for example, are enrolling epigenetic findings and ideas to support various positions or approaches. These contribute to a vision of biology that aligns closely to often pre-existing ideas about the Good Society and the kinds of policies and practices necessary to reach this. Through disparate writings, then, epigenetics and education are increasingly being made relevant to one another. (Pickersgill 2020: 79)

In the context of Covid-19, Johnson et al. (2020) present 'evolutionary biology and epigenetics as a foundation for an argument for reconfiguring the parameters of learning and educational organisation'. Precision learning, epigenetics and other educational projects at the fringes of biology and information are now all parts of a wider notion of postdigital education.

SH: Picking up on the question of whether education lags behind technological development is interesting to contemplate a little further through a postdigital lens. Should only a chronological perspective be applied, then it could seem that education just doesn't keep up. For example, thirty years ago Hlynka and Belland (1991: v) argued that it is 'ironic that educational technology, a field which prides itself on being within the vanguard of change, suddenly appears instead to be lagging behind other fields and disciplines'. They added that 'educational technology appears to have become stuck fast in a technological means-end model' (Hlynka and Belland 1991: v). In the disappointing decades that have followed, despite rapid digital progress, this fixed means-end identity for technology within education has been persistently reinforced via policy discourse based on a neoliberal economic model (Hayes 2015, 2019; Hayes and Jandrić 2014; Olssen and Peters 2005). This could now be set to change, as advanced biodigital developments and principles of bioeconomy require education based on environmental self-renewal, rather than consumer consumption (Peters et al. 2021a, b).

Taking a postdigital perspective disrupts the means-end model of rationality and also enables a longer look back. This reflexive review may pick up on historical points that connect with current sustainable goals but it need not be constrained by too chronological an account of education, or education technology. Looking back, but with an eye to the future, this postdigital trialogue that we are currently engaged in connects, therefore, with longer emancipatory educational purposes (Biesta 2009) rather than short-term, means-end processes. In shedding *instrumental* values, our judgements can now be based on *ultimate* values: values about the aims and purposes of education for all citizens (Biesta 2009), as we anticipate what a digitalization of biology, and biologization of the digital, might contribute.

In this way, we might now pick up the strands of educational movements that have persisted, stalled, failed even and re-engage with pre-digital initiatives that support current emancipatory self-renewal goals. Taking its departure point the Declaration of the UN Conference on Human Environment (1972), UNESCO's Education for Sustainable Development: a roadmap (2020: 65) proclaims that 'to defend and improve the environment for present and future generations has become an imperative goal for mankind'. Whilst we don't seem to have done too well on that score overall, there are educational movements and purposes aimed at inclusion and opportunity for all that have persisted, despite funding cuts and attempts to impose simplistic means-end models of progress.

Thus, at the same time as discussing the latest biodigital advances, there are questions to consider relating to the very notion of 'literacy', as it has been enacted so far in relation to citizens, and how it might now relate for example to 'precision education' (Williamson 2019) and the postdigital challenge (Jandrić 2019). What we discuss as literacy in language, digital skills, data or all of these, may now require a new hybrid concept that we need to come up with. New terminology may be needed to help us to visualise, for example, how 'citizen literacy' (Casey 2020) might develop at the intersections where biology, technology, economy and politics meet. Given that education has always needed a spread of provision and techniques to reach society's most disadvantaged, it is currently hard to visualise whether all citizens can, will or even should be, absorbed into the latest advances we describe. In *Brain Culture: Shaping Policy Through Neuroscience*, Jessica Pykett (2015) argues:

> Learning can never be understood simply as a brain process. Rather, there are high political stakes in neuroscientific explanations of the learning process in terms of delimiting learning norms and dealing with learning differences in real places. Education is more than the aggregate sum of people learning. The shaping of conduct, behaviour and educational outcomes is a social and cultural endeavour essential to the governing of citizens in specific contexts. The brain of the learning person is not just an algorithm to be optimised. (Pykett 2015: 138)

Perhaps there will be no choice in how humans eventually become 'optimised', but then better to raise these questions now when matters are still emerging, than assume once again that we are all proceeding 'towards a pre-specified end' requiring no further debate.In *The Digitalisation of (Inter) Subjectivity: A Psy-critique of the Digital Death Drive*, De Vos suggests that when faced with events that have potential to change both the world and ourselves, we are forced to pose the '*what will* become of us?' question. However, given that humans always have the capacity to imagine themselves as something different, is the human subject ever simply what it is: 'If to be human is to be able to imagine oneself as being different then does this not signal that one never simply coincides with oneself, that one is always already other to oneself?' (De Vos 2020) With this tantalising prospect in mind, we can contemplate our digitalization as a society and as human subjects, via *subjective (self)interpellation* (De Vos 2020). To reflect therefore on how 'capitalism has finally managed to surpass both its material boundaries and the need for concrete people' enables us to imagine routes ahead that a commodification of subjectivity via digitalisation might take us (De Vos 2020).

Whether these are paths of emancipation or alienation could, therefore, depend on us continuing to 'engage explicitly with values in our decisions about the direction of education' (Biesta 2009). By taking an interdisciplinary postdigital perspective, we can maintain this debate where we are always already other to ourselves. It is a necessary dialogue because once reconfigured conditions for knowledge production, and understandings of human beings are altered beyond recognition, and endorsed via policy, it may then already be too late.

MP: Thanks, Petar for reminding us of these leading research works. I guess my emphasis has been on the concept of *technological convergence* outlined in a couple of papers focusing on the US National Science Foundation and the way in which the Foundation has funded research on the 'nano-bio-info-cogno' paradigm as developed by Bainbridge and Roco (2006). It is certainly the case that NSF believe that the 'cognosciences' (and therefore education) has lagged behind and this has motivated heavy investment in the learning sciences including biologically inspired learning systems, affect technologies, computational theory and cognitive modelling, spatial intelligence and temporal dynamics by the US National Science

Foundation (Peters 2020c). This ‘deep convergence’ represents a new technoscientific synergy that is the product of long-term trends of ‘bioinformational capitalism’ that harnesses the twin forces of information and genetic sciences that coalesce in the least mature ‘cognosciences’ in their application to education and research (Peters et al. 2021b). This description of convergence illustrates that it is not just one technology – digital or biological – but rather several acting together especially at the nanolevel, and the application of this model to the ‘cognosciences’ is being presented as the new paradigm with obvious reference to education.

While there has been much emphasis on the digitalization of the sciences and in particular, the way that digital technologies are changing how scientists work, there has been relatively little focus on the, and what I have called the ‘biologizing of digital reason’ (Peters 2017). I tried to develop this relation above in discussing ‘organic memory’ by reference to the most recent research. We are only at the very early stages of this process. Some fifteen years ago the US National Research Council set up the Committee on Frontiers at the Interface of Computing and Biology that produced the report ‘Catalyzing Inquiry at the Interface of Computing and Biology’ (Wooley and Lin 2005). In the Preface, John Wooley writes:

> computer scientists have pondered the significance of biology for their field. For example, computer scientists have explored the use of DNA as a substrate for new computing hardware and the use of biological approaches in solving hard computing problems. Exploration of biological computation suggests a potential for insight into the nature of and alternative processes for computation, and it also gives rise to questions about hybrid systems that achieve some kind of synergy of biological and computational systems. And there is also the fact that biological systems exhibit characteristics such as adaptability, self-healing, evolution, and learning that would be desirable in the information technologies that humans use. (Wooley and Lin 2005: vii)

There is no question of the impact of computing on biology, or consideration of a paradigm change, especially with the spectacular growth of computational biology. The impact of biology on computing is still as yet largely unfulfilled with clear potential for computer design, software, memory, intelligence and learning. The notion of a biological computer is now commonplace in the literature where DNA is conceived of as the substance for massive and growing memory and swarm intelligence and neural nets offer a different approach to algorithmic programming.

Clearly the representation of human functionality by digital computing is greatly enhanced by the introduction of biological models. For instance, researchers in nanomedicine have already begun to experiment with molecular-scale computing devices to be embedded in our bodies to monitor health and treat diseases before they progress. As a report in Scientific American puts it: ‘The advantage of such computers, which would be made of biological materials, would lie in their ability to speak the biochemical language of life.’ (Requarth and Wayne 2011) As one research report puts it: ‘Synthetic biology aims to develop engineering-driven approaches to the programming of cellular functions that could yield transformative technologies. Synthetic gene circuits that combine DNA, protein and RNA components have demonstrated a range of functions such as bistability, oscillation, feedback and logic capabilities.’ (Green et al. 2017) Molecular-scale computing devices embedded in bodies and brains is no longer science fiction and it raises both political and ethical issues (see also Grozinger et al. 2019).

The question – does biodigitalism still fall within the ambit of biopolitics? – is important because in the field of education there has been quite a lot of discussion that follows Foucault's biopolitics (Peters 2007, 2015; Pierce 2013). It is not clear how biotechnology and biocapitalism affect Foucault's concept of biopolitics or the extent to which biodigital technologies introduce new patterns of biopower in modern life focused on the biotechnological 'utopia' of promoting and optimizing life as an aspect of biocapitalism (Yu and Liu 2009) based on the molecular reordering of the body, intelligence and nature, more generally. The intrusion of positive eugenics into education, life-saving and life-enhancing technologies and the 'genetically connected child' indicate the magnitude of ethical issues surrounding the new politics of human and particularly child biotechnology including 'designer babies'.

I found your discussion, Sarah, linking both to sustainability and to brain science very useful and suggestive of lines of inquiry. Linking the biodigital to both sustainable development and to education for sustainable development as twin aspects of a single logic. Biodigital technologies provide the basis for a new naturalism based on the growth of natural and synthetic organisms and systems, and a path-breaking science with very serious political, ethical and educational implications. The biologizing of information and computing is less obvious than the digitization of science and so far only in very early stages and yet it heralds a coming hybridization and interface that may be revolutionary.

5 Biodigitalism as Technoscience

MP, PJ, SH: The concept of postdigital condition describes reconfigurations between various technologies and humans (Jandrić et al. 2018). Early postdigital scholars focused to reconfigurations between the analog and the digital (Cascone 2000; Cormier et al. 2019); two decades later, the theme of the day is biology. As can be clearly seen from posthumanist literature (e.g. Braidotti 2019), these various reconfigurations cannot be thought of without each other. While our research efforts often focus to lower-level convergences between traditional disciplines such as biology+information or science+technology, we always need to maintain their grounding in the over-arching postdigital convergence between all sorts of disciplines and technologies produced by these disciplines and their convergences.

From the postdigital bird-eye perspective, various terms and concepts can be easily distinguished by the way of reduction to fundamental disciplines. Biotechnology refers to the convergence between the science of biology and technology, or technoscience. Biodigitalism refers to the convergence between the analog (biological) and the digital (informational). Biodigital technology refers to the convergence between the analog (biological) and the digital (informational) together with the convergence between science (biology) and technology (information). Bioeconomy expands from natural sciences to social sciences and converges biodigital technology with economy. However, economy also results from a convergence of disciplines such as mathematics, psychology, sociology, political science and many other disciplines – and these days, most of these disciplines undergo their own biotechnological and biodigital convergences. Writing a full definition of bioeconomy would result in a very long line of fundamental disciplines and their mutual reconfigurations; depending on one's definition of a fundamental discipline, this line can always be contested and/or written differently.

As we approach complex concepts such as bioeconomy, the reductionist approach reaches its limits. These limits are ontological, because reduction to (easily contested) fundamental disciplines does not necessarily correspond to the nature of described concepts. These limits are also epistemological, because knowledge about constituents does not imply knowledge about a whole. It is with this understanding, that postdigital theory strongly advocates a postdisciplinary approach to research (Jandrić 2020).

Postdisciplinary research 'is both a rupture in our existing theories and their continuation' (Jandrić et al. 2018: 895). A typical case in the point is education, which has not in any way left behind the traditional question, 'what kind of society do we want to live in?', and its close links to hugely important aspects of our social lives such as freedom, justice and democracy. Developing the notion of precision education, Williamson (2019) points towards a convergence of education's traditional themes with psychodata, brain data and biodata; this implies that bioscience (psyche, brain, bios) needs to merge with data science (big data and algorithms) and also with social and political science (justice, democracy). Williamson (2019) finds his convergence in the concept of digital policy sociology. 'Building on existing "policy sociology" approaches combined with emerging insights from "digital sociology," digital policy sociology extends the analytical gaze to new technical actors – nonhuman software and hardware, as well as human experts, technology companies and promotional organizations.' Digital policy sociology is a good example of a postdigital research approach (because it freely combines the analog and the digital, the biological and the informational) and a postdisciplinary research method (because it is based on a high-order convergence between foundational disciplines, in which none of the foundational disciplines remain unchanged). As we proceed into the postdigital age, research approaches and methods based on high-order convergences mushroom all around us. It is through postdigital theory that these approaches and their results can come together into a larger narrative of modernity.

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Digital Culture, Media, and the Challenges of Contemporary Cyborg Youth

Steve Gennaro and Douglas Kellner

1 Haraway and Cyborgs: An Introduction

Donna Haraway's 1985 essay 'A Cyborg Manifesto' evokes the spirit of Marx and Engels and their 'Communist Manifesto' (1848/1976) to envision the metaphor of a cyborg as a way to engage politics of identity concerned with intersectional feminism. The manifesto is part ironic, part prophetic, part a call to arms and part revolutionary theoretical action. As Haraway notes, it is important to recognize technologies as 'crucial tools recrafting our bodies', and how the tools not only recraft human bodies, but social relations too, marking them 'as frozen moments of the fluid social interactions constituting them, [and therefore] they should also be viewed as instruments for enforcing meaning' (Haraway 1985/2006: 130).

These *informatics of domination* are contentious and oppressive, but they are not fixed or static, since Haraway reminds us that the boundary between tool and myth is permeable, and that all moments of oppression, power, and marginalization, can also be seen as a locus for hope and change. If technology as oppressor exists, then its binary opposite, technology as liberator must also exist too![1]

[1] Informatics of domination is a Haraway term that she equates to the technological social equivalent of white, capitalist, patriarchy (Haraway 1985/2006: 128), and later goes as far as to say: 'The only way to characterize the informatics of domination is as a massive intensification of insecurity

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So what, then, do we make of today's teenagers, who conduct themselves live like cyborgs, whose connection to their tools has become so profound and so seamless that it's difficult to tell where the tool ends and their bodies begin? And what, then, does this mean for the informatics of domination in the lives of young people, whose identities are heavily mediated by the technology of social media platforms? Do they live separate mediated identities in digital spaces – different from their physical existence – or are they instead cyborgs in both the physical and the digital realm, occupying neither fully?[2] And how do they construct and live features of their identities such as gender, race, class, and sexuality in their virtual digital lives?

In the current media saturated environment, the content of the media – be it friends' lists, tweets, snapchats, tik toks, likes, or wall posts – all require critical media and digital literacies for decoding and understanding emergent digital media and cyborg youth. However, the same could be said about earlier advancements in communications technology from print to radio, or radio to TV.[3] Primary differences between the current transformations in media and their interactions with human beings and earlier historical media technologies include the *primacy*, *intimacy*, and *expediency* of the mediums themselves in today's high-tech worlds across which the media travels. Unlike earlier advancements in technology, in the current digital media environment, the actual mediums themselves, which transport media content, are no longer merely an extension of the individual, but also involve an entangled embodiment of technologies, capitalism and selves.

This matrix constitutes a hybrid of *poiesis* and *technē*, and is deployed by a centaur of human and machine.[4] And while a political economy of technology of media would suggest an exploration of the objects, apparatuses, and physical spaces that translate and transpose their images, messages, and ideologies, the necessity to emphasize and expose the uses and power relations of the objects and hardware themselves is central to the current moment because of the primacy, intimacy, and expediency of the technology apparatuses, encompassing an ever-expanding range of media.

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and cultural impoverishment, with common failure of subsistence networks for the most vulnerable.' (1985/2006: 134)

[2] Whereas we are writing on contemporary youth and technology, we are aware that the cyborgization of human beings today crosses all dimensions of age, including ourselves and our generations, as well as those before us.

[3] Older generations have always attacked the latest forms of youth culture and from film to radio and television to rock and roll and succeeding youth cultures, there have been a succession of moral panics around media and youth – a theme emphasized by British cultural studies in the 1970s and beyond (see Hebdige 1979 and Kellner 1995/2020).

[4] The Greek words *poiesis* signifies aesthetic creation while *technē* signifies technique and technologies. Heidegger argued that *poiesis* and *technē* could inscribe a world, as he and Nietzsche argued Greek tragedy did for the Greeks and Heidegger claimed Holderlin's poetry did for the Germans at a point in history (on Heidegger and poiesis, see Di Pippo 2000). We will argue that today's cyberyouth find themselves in a new aesthetic and technological world constituted by their digital devices and culture that are aesthetic-technical creations that inscribe their bodies, selves, and relations to the world.

While many of our recent works examined the content of media and its importance to understanding changing social landscapes and the critical importance of critical media literacy (CML) involving the politics of representation and its significant dimensions of gender, race, and class, our project in this study revisits the philosophical concept of the cyborg and the ways that youth and others are shaped by technology and digital cultures. As a description of the relationship between contemporary youth and their technologies, the project requires a particular focus on the role that technological forms play in understanding media and the lives of cyborg youth. For Haraway 'the cyborg is a matter of fiction and lived experience that changes what counts as women's experience in the late 20th century', and this is precisely what we are seeking to understand for contemporary youth, giving further credence to Haraway's claims of cyborg as a 'hybrid of machine and organism, a creature of social reality as well as a creature of fiction' (1985/2006: 117).

2 Engaging and Theorizing Cyborgs and Cyberspace

IF contemporary youth are cyborgs, THEN it is their physical selves that are now the containers for their digital identities. More on this unpacking of objectivity and subjectivity of digital selves will follow later, but let us first examine the containers or mediums that house specific media. If new media require new literacies, it is not only the ability to decode the letters and symbols, but the ability to decode the forms or containers, that acts as conduits of media messages (and ideologies inherent in all media content) that is essential to developing new critical media and digital literacies for cyborg youth. This process will help to gain an understanding of what is at stake politically if the container moves from outside the individual into the individual themselves.

One of the real challenges facing the ongoing analysis of literacies in the digital environment is the focus on the Internet as an object for study and exploring transformations and permutations of Internet culture in the lives of cyborg youth. Questions abound in ethnographic research and quantitative data analysis surrounding how the Internet has created a digital landscape that has transformed the social relations and lives of individuals. In line with this type of analysis is the discussion of the potential and pitfalls of the Internet as a space for activism, for political participation, and the dynamics of subversion or marginalization (Kellner 2021). However, the 'Internet', as it has been theorized for the last two decades, does not exist, primarily because the Internet itself is in fact not an object open for analysis, that we can remove from social context, or the intricacies of its coding, for exploration. The Internet is neither hardware or software, form or filler, content or container. The Internet is not only a space we can visit, activate, engage with, or take part in, but an environment in which we live on-line identities.

Certainly, at one point, early in the development of online technologies, going 'online' meant using the world wide web via the Internet. However, these terms (online, World Wide Web, and Internet) are not interchangeable. For example, most businesses who use online spaces for the transportation of email or other encrypted data do NOT house their email servers or business databases on the World Wide Web. This is true for the Universities where both Kellner and Gennaro teach. York University, where Gennaro teaches, housed its student, staff, and faculty email prior to 2020 on a private server where students, faculty, and staff accessed their email by typing https://mymail.yorku.ca/ into the address tool bar of their web browser. What was absent from this web address was the "www" and that is because the server was not on the World Wide Web. In fact, if you were to type https://**www.**mymail.yorku.ca into the tool bar it would not take you to your email since a webpage by that name did not exist! The same experience is true for private messaging, which happens between two handheld devices using BBMs, WhatsApp, or a private messaging function of a social media platform. The majority of digital interpersonal (person to person) communication in digital spaces in the 2020s does not exist on the Internet or the World Wide Web. Instead, it exists through social media channels, via mobile phone to mobile phone text messaging, or through products such as Apple's Facetime or Facebook's WhatsApp or Facebook Messenger; none of which require the opening of a web browser, the use of the World Wide Web, or even access to the Internet. Think about it, when you sign up for a mobile plan with an access provider you pay not for Internet access, but for a data plan!

The Internet as a concept is now an outdated model for exploring and understanding social relations in digital environments. After all, the Internet is not just a home for information, an entrepot for business, or a den of thieves and demons, but is many other things as well. The 'Internet' is an empty word we have assigned as a cover-all that is supposed to encase all of intersecting players in digital environment, such as media outlets, service providers, hardware and software builders, advertisers, game players, emailers, bloggers, social media influencers, and other online participants.

Indeed, how can one word possibly describe with any accuracy or speak for the many interesting players and activities online? The answer is, that it can't! And when we try to create digital theories built around exploring the Internet, what gets overlooked or left out is the fact that in the digital world there are many active participants who are part of an ongoing process in the creation of meaning simultaneously, instantaneously, and continuously in many domains. Using a phrase as simple as 'the Internet' to explain a series of processes as complex as those found in digital environments, not only hides the power relations and inequality of resources (and inequality in access to those resources), but it also simplifies the processes of being online to the lowest common denominator to suggest that it is only an exploration of content and content provider that is required to be digitally literate – and this is simply false!

Instead of viewing the Internet as a space for unpacking digital landscapes, a more concrete focus is required on the mediums themselves that allow for online access. Certainly, there is a benefit to exploring the media outlets, service providers, and content generators online, but of equal importance is a discussion of the mediums that access the endless streams of digital content. In addressing cyborg youth in the following analyses, we carry out an exploration of the mobilization of the technologies through which individuals access media. In this space, media and medium take on separate roles. In basic grammar, medium is the plural of media, but for a more in-depth analysis, the two terms need to be separated so that medium provides for a description of the container that houses the content and media takes on the definition of the content itself. In separating media and medium into two distinct terms we see a new and vital reconceptualization of Marshall McLuhan's (1964) argument that the medium in is the message. It is about form as much as function. It is about container as much as content. Nowhere is this media/medium entanglement more obvious and at the same time in greater need of decoding then when discussing the notion of cyborg youth whom themselves occupy both sides of this coin.

Since the handheld smartphone or tablet is often the first point of media contact for many individuals in today's high-tech world in the overdeveloped countries, in that the news or information to be accessed is first received by the user via their handheld devices, understanding the *primacy* of the medium is a key requirement for critical media and digital literacies. Furthermore, an apparatus like a smartphone or tablet are both handheld and mobile, and are generally kept close to one's personal body.[5] In addition to their close physical proximity to users, the type of applications downloaded to the device and used multiple times daily by users such as email, Facebook updates, tweets, and calendar, news updates, and weather information, all allow the apparatus to perform many of the social roles previously occupied by friends, partners, assistants, and so on, and highlights the importance of understanding how the *intimacy* of the medium requires a further unpacking and explication for critical media and digital literacies.

Lastly, media messages are sent and received instantaneously and often without censor by the sender and without sorting by the receiver and without an active participation from the individual to access diverse opinions and to take part in active discourse. As has become apparent over the last two U.S. Presidential Elections (2016, 2020), exploring the dissemination of news via social networking sites like Twitter, the *expediency* of travel of information becomes a core arena for further research for critical media and digital literacies.

Information functioning in politics is often described by particular biases, and bias can best be defined as a lack of diversity in representation. This lack of diversity refers to all three prongs of Douglas Kellner's (1995/2020) three-pronged approach to critical media and cultural studies: political economy, textual analysis, and audience reception. On this model, one analyzes the production of broadcasting news and entertainment, or on-line communication; textual analysis of the ideology and

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[5] It is important to note that this primacy, intimacy, and immediacy are not unique features for the developed world. In fact, in many of the 37 sub–Saharan African nations, the primary access point for online access is via mobile broadband. According to the GSMA, in 2019, sub-Saharan Africa had 816 million SIM connections, accounting for a penetration rate of 77% of the population. Furthermore, while there were 272 million users mobile Internet users in 2019 GSMA projects that number to almost double to 475 million users accounting for 40% of the population by 2025 (GSMA 2020).

messages; and audience reception study of how different audiences receive media messages (Kellner 1995/2020, 2009). For instance, one could analyze how different U.S. cable news network analyze a particular political event in the Trump or Biden era as presented by the major U.S. cable networks like CNN which generally has a centrist optic, contrasted to Fox which has a conservative/pro-Republican/pro-Trump bias, while MSNBC has a liberal and pro-Democratic Party bias (see Kellner 2010). Or one could analyze the on-line campaign in the 2016 U.S. presidential election in which the Russians used Facebook and other social media to spread, often by bots, pro-Trump messages and anti-Clinton disinformation (Jamieson 2018).

For Michael Bugeja in *Living Ethics: Across Media Platforms* (2007: 215), an irony exists in our technological age: while the world is getting more global, the world view of news professionals is not necessarily doing the same, and 24/7 globalization allows audiences to feel they are exposed to a 'sense of diversity' without ever actually experiencing it. This lack of lived diversity refers to not only the news we see on the television or read in daily newspapers, but also to the education of journalists, the hiring process of the media companies, how the stories are told to the public and then how those stories are then lived out by the public themselves. And this is what makes representation such an important issue, because how a society talks about its citizens can tell us a lot about that society's values, culture, priorities, and inherent power structure. Think simply about who gets represented and who is left voiceless. This is why media discourse in spaces such as news or search engine results are important spaces for analysis and critical media and digital literacy, because discourses are symbols, which reflect both the desires and the fears of a particular society, often through the misrepresentation and essentializing that represents one as many and cultural myth as reality.

When news is sent to our phones directly, the personification of that news immediately suggest to us that its content is real, legitimate, trustworthy, unbiased and that it fully represents the world locally and globally it purports to cover. However, in news media, too often bias appears as stereotypes, racial inappropriateness, and cultural exclusion. Further, this bias appears through symbols, which get encoded by news agencies, but require a more active decoding from viewers. When the news arrives in one-lined tweets, if the reader does not click to read the entire story, or spend some time unpacking who the source is and what the context of the story is, then the news itself gets swallowed and digested without being chewed, and transmitted without consciousness of its message and potential effects. The expediency of media and the sensationalized one-liner headline that was written to lure the reader to the news corporations home site, instead becomes naturalized as the news itself and then takes on the perception of truth – even when the perception is an empty and hallow symbol, or an outright lie.

For Bugeja, there is a gap between the representation (how the media portrays people) and reality (who those people really are). The expediency of digital media extends this issue on the professional practice of media professionals in that 'technology promised a global village and delivered an indoor simulated one instead' (Bugeja 2007: 215). Yet what becomes of the relationship between the subject and object when the object no longer exists as an extension of the self, but can be argued to replace the self entirely? The *primacy, intimacy,* and *expediency* of the technology apparatus (aka the mediums) now pose greater ontological questions which we take up in the following section.

3 The Objectivity and Subjectivity of Cyborg Youth

Following Haraway, deconstructing the politics of the cyborg requires a feminist political economy of both the objectivity and subjectivity of youth, where communication technology and human biology are both crucial tools for unpacking how young people recraft their bodies in each technological moment. In her work, 'Intersections and New Directions on Feminism and Political Economy', Ellen Riordan (2002) notes that:

> Feminism seeks to understand and theorize power as it pertains not only to women, but also to other groups marginalized on the basis of their race, class, sexuality, religious background, ethnicity, age, disability, etc. A feminist political economy…seeks to understand these interconnections and how different groups of people are politically, economically, and socially disenfranchised. (Riordan 2002: 13)

It is true, as Haraway states, that technologies 'are frozen moments of the fluid social interactions constituting them', but they are also 'instruments for enforcing meaning' (Haraway 1985/2006: 119). These tools, new technologies, and digital devices embody and enforce social relations – and in doing so, impact young people disproportionately – and this marginalization is then multiplied across intersectional lines of race, class, gender, sexuality, ability, and more. However, despite this crystallization of unequal power dynamics in the technology, Haraway is also quick to point out that the inequities of the tool are not fixed or static, since the boundary is permeable between tool and myth; and as story-telling creatures we possess the possibility to use the tools to speak back and tell different stories.

Another way of putting this point is that although the objectivity of cyborg youth is partially constituted through their interaction with media and digital technologies, they can resist the dominant meanings and create their own subjectivities. That is, women can submit to or resist patriarchal images of women, while people of color can resist racist constructions of race and ethnicity and create their own identities, and deconstruct hierarchies between white and black, with slogans in the 1960s like 'Black is Beautiful!', or by asserting in the contemporary moment that 'Black Lives Matter!' Further, all individuals can question the politics of representations in media narratives and depictions of gender, race, class, sexuality, and the other constituents of identity, calling out and critiquing sexism, racism, classism, or homophobia in the media. Yet this critical decoding of media requires the cultivation of critical media and digital literacies so that individuals can be the subjects of their own creation, rather than the objects of domination.

Critical media and digital literacies are distinguished from many varieties of media and digital literacies through the engaging of the politics of representation and the dynamics of gender, race, class, sexuality, and identity, with active decoding and in some cases contesting dominant representations and, for instance, sexist, racist, or homophobic media representations presented as objective norms. The media provide role models for right and wrong behavior, style and fashion, social role models and professions, and show how institutions function from the world place to law to policing and to business and politics that are dominant social forces in state capitalist societies. The task of the creation of cyborg youth who resist sexism, racism, homophobia, and other biases thus requires critical media and digital literacies that we will further discuss in the next section.

4 Critical Digital Literacies for Cyborg Youth

What are the Critical Digital Literacies necessary for Cyborg Youth to negotiate the high-tech future and deal with a myriad of questions concerning schooling, jobs, family, media, and the future? In one sense, the situation of contemporary youth encompasses the betwixt-and-between period negotiating from childhood to adulthood that has been the perpetual adventure of youth through the ages. Youth must negotiate its relations in the family, with their cohorts, with schools, and institutions like the law, the police, jobs and business, as well as the demands and challenges of society at a point in time in history. As explained by adolescent psychologists, such as Hall or Freud, or even Erikson and Piaget, this stage of development involves finding one's position in the world, navigating social and cultural expectations, defining and redefining social relations to institutions, and developing physiologically as an individual human being (see Gennaro 2010).

Like the previous generation that grew up with broadcast media and plunged into social media at an early age, today's digital youth are 'early adopters' of new technologies who have grown up with a cornucopia of digital devices, depending on their economic class, region, and circumstances. They spend more time on social media and with their digital devices than did previous generation of youth with their media.

In fact, the change in media use is so stark, that if we compare American teenagers in just a five-year period, from 2014 to 2018, we see a significant uptick in social media engagement. According to PEW Research data, in the United States of America, teen access to smartphones rose from 73% of teens surveyed in 2014–2015 to 95 in 2018 and usage rates spiked to almost half of all teens claiming to use the Internet 'almost constantly', including social media visits 'several times per day' (Anderson and Jiang 2018). This engagement, according to PEW Research, is not just about conversations or socializing with friends. The engagement and practices of young people online occupies several key roles in youth identity formation and development: there is play, there is socializing with peers, there is social-self presentation, there is the exchange and gathering of news and ideas, and even (in large part as a response to Covid-19) these spaces currently are occupying primary spaces for education.

Hence, like previous generations, Critical Media Literacy is a necessary component of Critical Digital Literacies (CDL), which are necessary for survival in the high-tech world of the present and future. Print and Broadcasting Media are still major forces in the economy, polity, social life, and a diversity of contemporary cultures, even if they are accessed through digital devices and circulated further through digital circuits of communication. There was once concern that the Internet would replace previous forms of news and information delivery. Questions were asked, such as, if The New York Times goes online, will this be the death of newspapers? Recognizing now that Jay David Bolter's claims of *remediation* as a valuable path for understanding how new technologies builds on previous ones, not to replace, but instead to remediate and incorporate, we see that remediation now perhaps best describes the current technological moment for young people (see Bolter and Grusin 1999). It may also best describe the process of 'cyborgization' that is occurring to young people themselves too. Cyborg youth have not replaced contemporary youth or contemporary youth experiences, but instead represent for us a remediated version of the self and the processes of youth exploring the world in the digital age.

Critical Digital Literacies necessarily involve becoming literate in high-tech environments and being proficient in the use of social media, digital devices, and access to the digital worlds of information, entertainment, games, social connections, and the far corners of the digital world. This requires engaging multiple subcultures which involve youth in special interests, not always legal or socially approved, involving sex, exchange of music and video materials, pranks and hacks, secret societies, and spaces not known to their parents, teachers, or even many digital culture researchers. Instead, youth themselves are remediating their experiences of *Sturm und Drang* revolts that were once only to occur outside of the home, outside of school, and outside of adult supervision. These 'third spaces' of youth experiences are where a youth's *Bildungsroman* happen, and youth seek their own life paths and experiences are now existing for public display on social media channels.[6]

Critical Digital Literacies necessarily involve becoming literate in all dimensions of high-tech environments including the construction of new spaces and environments. Digital Youth learn coding at an early age and how to make their own environments or to subvert or reconstruct existing spaces. Harry Braverman (1974) discussed how capitalism, Taylorism, and the assembly line deskilled labor and created worker bees subject to the domination of monopoly capital. Haraway argued how the end of the twentieth century witnessed a new capitalist structure 'the homework economy', made possible by the new technology and which did not result in

[6] *Sturm und Drang* are German terms describing the 'storm and stress' of German youth struggling into maturity and which were the focus of The German *Bildungsroman* (i.e. the novel of experience). These novels described epics of youth gaining experience of the world by writers like Goethe and Schiller through Thomas Mann that documented the adventures of youth forming themselves as individuals and creating their identities and fortunes in the world. Herbert Marcuse wrote his doctoral dissertation on the German *Bildungsroman* which is interesting since Marcuse became a revolutionary role-model and guru for youth himself in the 1960s (see Kellner 1984).

just a deskilling of labor, but instead a re-organization of labor where ‘the factory, home, and market are integrated on a new scale’ and a redefinition of who are the working class (1985/2006: 130). A homework economy for Haraway is about a feminization of labor, a deskilling of labor, a dehumanization of labor, and a merger between the factory, home and marketplace.

Haraway’s analysis raises significant issues around areas of gender, race, sexuality, and ability. For example, if we draw on Haraway’s discussion of the homework economy and the ‘feminization of poverty’ we see that there are real consequences in the everyday lives of women and a concrete example of this at the turn of the millennium can be seen from a quick glance at the lives of single working moms in Canada. According to 2006 Census data, 31.6 million people lived in Canada and reported an average family income of $82,325. Lone parent families earned an average of $42,000 per year, and female parents accounted for 75% of lone parent families. On average, women in lone parent families reported earning $13,000 a year less than male lone parented families, and accounted for almost all of the 2.2 million families who (or one-quarter of all Canadian families) who reported a family income under 40,000 annually (Statistics Canada 2021).

Furthermore, today’s youth face a gig economy where they do not have the security of their parents who may have had corporate jobs with life-time security and benefits, or unionized working class jobs that at least provided some security and the possibility of trappings of a middle class life, before deskilling or the homework economy took root. Labor in a gig economy, by contrast, is mediated by the demands of an ever-evolving labor market with no security against economic downturns, recessions, or the whims of one’s employer. Even the high-tech industry is subject to high turnover and often provides exceptionally high stress workdays (and sometimes nights and weekends). The 2008 market collapse, or the 2020 economic shut down due to Covid-19, serve as clear examples of how volatile the marketplace can be and how those in service-based work in the gig economy disproportionately bear the economic burden without the safeguards and protections of the corporations they service. Thus, today’s youth face an increasing unstable labor force and future where it is hard to chart out a career and follow the script of previous generations as they enter adulthood.

Yet this precarious situation forces youth to be able to take on a multiplicity of projects, gigs, and positions that provide ever new digital and interpersonal skills and proficiencies. Thus, critical digital literacies are not only a job requirement for cyborg youth, but they constitute a set of survival skills and life-time proficiencies that are ever evolving, expanding, and mutating, as the high-tech economy and global culture mutates, providing new opportunities and possibilities, as well as new crises to mediate and survive. In the current global pandemic, youth service industry jobs abound in the pandemic gig economy, but they are dangerous and precarious as they will disappear when life returns to quasi-normal (if it ever does). This situation demonstrates, once more, the dualism of both the appreciation and lack of regard for the health and well-being of our youth.

In this precarious situation, gender roles mutate, as young women as much as young men participate in the gig economy, delivering essential goods, working for

Amazon or Walmart or local grocery stores, to provide goods, as well as working on-line to help provide infrastructure for the gig economy and participating in the further digitization of workplaces. Thus, like Haraway's original cyborg, strict gender lines are mutated, and feminism is faced with new issues as cyborg youth mix gender lines and identities and young women take on new challenges, as well as dealing with older ones. For Haraway, in the original Manifesto, changing roles in the economy or capitalism are directly and dialectically related to changing notions of the family. The displacement of the self in the light of advancements in information and communication technologies, creates not only a technological diaspora, but an altered set of gender roles and expectations (Haraway 1985/2006: 136). In many ways, the reframing of the self in light of new technologies appears to be a larger goal of white capitalist patriarchy, or what has since morphed into the informatics of domination, to reduce all human life into code, into a simple set of binary numbers of 1s and 0s to organize, to categorize, and control.

5 Conclusion: Cyborg Youth in the Contemporary Moment

Haraway's 'Cyborg Manifesto' is thus still a call to arms against traditional western categories of knowledge binaries. And youth are up to the task. Ultimately the same globalization that exploits, can also unite. For example, look at the ability of activist Greta Thunberg and young people to unite for School Strikes for Climate on September 20, 2019, using social media to co-ordinate student walkouts in 150 countries. The same technology that excludes also unites. While youth in the developing world were typically behind the over-developed world in technology adaptation, the Arab Spring was initiated, and mass upheavals followed, by youth and citizens mobilized through social media (Kellner 2012). Likewise, throughout the world in 2011, the Occupy and other movements mobilized youth through social media to demand fundamental political change, and dramatized an intolerable situation in which the 1% dominate the 99%.

Many youth have lived the pandemic year online and have made new connections, projects, and taken on multiple gigs, some of which may propel them into new and unanticipated futures. Life in the digital fast-line is always going to be unpredictable, there will always be crashes and wrecks, but some will cross the finish line and score rewards and bonuses while others will profit from the wreckage. Capitalism is always a risky business and the high-tech environment intensifies the risks, potential crises, and even possible collapse. Life under capitalism for cyborg youth is always a question of what's happening? What next? Where are we going? WTF is going on? Yet possibilities and connections emerge in the most likely and unlikely of places, as Haraway notes, 'if we learn to read these webs of power and social life, we might learn new couplings, new coalitions' (Haraway 1985/2006: 136).

The cyborg is about challenging the categorization of knowledge, the construction of knowledge, the coding of knowledge and the dissemination of that knowledge as 'fact', mystifying the bias, ideologies, and social construction of knowledge.

To critique this mystification, we must recognize how privilege and exclusion work. This process requires a further exploration of binaries such as self and other, or the one who is dominated vs. the forces of domination. The cyborg does not privilege binaries, but challenges dualisms. The cyborg challenges some of the most powerful binaries of Western civilization: mind vs body, human vs machine, nature vs nurture. For with each of these binaries that are challenged by the dualistic nature, the synergy of the cyborg, such that it is not clear who makes up what part or where the division begins or ends between one and the other.

Furthermore for Haraway, 'our bodies are the maps of power and identity' (Haraway 1985/2006: 146). Indeed, for today's youth, relations of power and domination and possibilities for self-development and social change are a constitutive part of everyday life. Cyborgs are not innocent, but are socially constructed and can be reconstructed. People are not innocent, and of course as already explained to us by Jean Baudrillard, maps are not innocent either. Maps are the original simulacrum, and work to divide, to categorize and to separate us. Maps works to classify, to code, and to construct our perceptions of life, liberty, power, and identity, around arbitrary constructs of citizenship, nationhood as facts (see Gennaro and Miller 2020).

Cyborgs, by their very nature, challenge these traditional structures of knowledge creation, construction, and dissemination. Youth as cyborg challenge this too, and are constructing their own maps, projects, and classifications. Perhaps this is why today's cyborg youth, led by activists like Greta Thunberg, force us to rethink our relationship to each and every component of this planet. Perhaps this is why Haraway's concluding thoughts resonate so profoundly decades after the text was written and well into a technological universe where the cyborgs of the last centuries' science fiction novels now roam the streets in earbuds with iPhones, while demonstrating against racism, sexism, or destruction of the earth. As Haraway reminds us, and we give the last word to her: 'The machine is not an *it* to be animated, worshipped, and dominated. The machine is us, our processes, an aspect of our embodiment. We can be responsible for machines; *they* do not dominate or threaten us. We are responsible for boundaries; we are they.' (Haraway 1985/2006: 146) (emphasis in the original)

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Spreading Stupidity: Intellectual Disability and Anti-imperialist Resistance to Bioinformational Capitalism

Megha Summer Pappachen and Derek R. Ford

1 Introduction

Capitalism is by its very nature dynamic. As a social relation between labor and capital, between the dispossessed and expropriators, capitalism is a constant struggle over not just the production of value, but the conditions of life itself. The latter is the reason why capitalism, to exist as a proper mode of production, had to not only dispossess people from the means of subsistence—and therefore to produce a class compelled to sell their labor-power—but also to dispossess us of our skills and knowledges by transferring them to machinery (dead labor, or fixed capital). Bioinformational capitalism can be seen as a further step in this process, with capitalist innovations 'that control, change and experiment with the material basis of life' (Peters 2012: 98). This material basis is more than our social relations and ways of life: it is our very biology.

Faced with this configuration of capitalism, some critical theorists and activists find an antidote in open source or common ownership over knowledge and information. At first blush, this seems appropriate as it works to reduce or eliminate the private ownership of the contemporary means of production. Yet this path, as we show below, is not only inadequate but *on its own* can also work to reinforce the underlying pedagogical logic of bioinformational capitalism, or what we call, following Melissa Gregg (2018), productivist pedagogy. Gregg uses productivist pedagogy to refer to apps, self-help books, and other media that assist in raising personal productivity, but leaves the pedagogical aspect of productivist pedagogy unexamined (Ford 2022). We conceptualize productivist pedagogy as an orientation to the world that positions the unknown as that which not only *can* but *must* be known, the

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opaque as that which *must* be articulated, the mute as that which *must* be spoken. Bioinformational capitalism clearly approaches the material and biological life in this way: the body is a puzzle to be solved.

Finding recourse to the common as the remedy to exploitation, however, operates along the same pedagogical axis. In fact, it can deepen and intensify it as the commons is legitimated by being *more productive* than capitalism. This is, for example, Michael Hardt and Antonio Negri's (2009) main argument for the common as it relates to education: 'The central tools are no longer the spinning loom or cotton gin or metal press, but rather linguistic tools, affective tools for constructing relationships, tools for thinking, and so forth.' This latter set, which 'humans already have', need 'to be developed'. 'That is why basic and advanced education is even more important in the biopolitical economy than it was previously. Everyone needs to learn how to work with language, codes, ideas, and affects—and moreover to work with others, none of which comes naturally.' (308) Providing free and open access to training in these areas is one part of expanding our ability to fully cooperate in and produce the common. Because the privatization of knowledge 'limits access to ideas and information', it thereby 'thwarts creativity and innovation' (Hardt and Negri 2005: 185). As such, increasing access to and training in immaterial production will unleash the true surplus of our productive capacities.

Productivist pedagogy is grounded in the need for communication, which is what bioinformational capitalism's *private* (or quasi-private) databanks as well as alternative *common* databanks of open-source facilitate. As Phoebe Moore and Andrew Robinson (2016: 2775) note in their study of the quantified self, '[c]apital encourages universal communication, but only in quantified terms, and thus, anything that cannot be quantified and profiled is rendered *incommunicable*—meaning that it is marked and marginalised, disqualified as human capital and denied privilege'. Under bioinformational capitalism, however, these marginal spaces are colonized and mined for value by technologies and practices that measure and quantify 'what were formerly treated as immeasurable, qualitative aspects of the labour process or the self' (2779).

In what follows, we show how such a productivist pedagogy is the fundamental educational motor of not only capitalism (in its bioinformational, colonial, and imperialist forms) but also its attendant oppressions such as ableism. In response, we propose a theory and practice of stupidity as a socialist and anti-imperialist form of resistance, one that is subversive precisely because it is *not* productive. Stupidity as a knowledge thwarts bioinformational capitalism's attempts and ability to valorize and exploit knowledge: thereby repelling its increasing command over labor and life. The primary reason is that stupidity can't be quantified, measured, communicated, articulated, or rendered transparent. This means that stupidity is not a *lack* of determinate knowledge because such a lack would always refer to something that is already known. Stupidity, then, is not 'opposed to knowledge' but rather entails 'the absence of a relation to knowing' (Ronell 2002: 5). Viewed this way, the current struggle is not merely one of *ownership* but one of *pedagogy* as well. Stupidity becomes a key aspect of a knowledge ecology oriented against bioinformational capitalist exploitation and oppression.

2 Bioinformational Capitalism and Actually-Existing Artificial Intelligence

While the ethical and political implications of bioinformational capitalism continue to be explored and struggled over, the role of knowledge in this struggle has been given scant attention thus far. This is an interesting and problematic omission, given that the very thrust of bioinformational capitalism is precisely to *know* and *understand* 'biological processes through the development of computationally intensive techniques including pattern recognition, data mining, machine learning algorithms, and visualization' (Peters 2012: 104). Bioinformational capitalism is precisely concerned with the production, distribution, exchange, and consumption of this knowledge, as each is an integral node in the production of surplus value. These processes entail both the digitalization of biology as well as the biologization of the digital. The first concerns the harvesting and storing of biological information in ever-expanding databases, while the latter—which is the primary focus of this chapter—concerns the creation of new digital networks and technologies that work like 'the inner mechanisms of the human brain' (105).

The capitalist biologization of the digital manifests most clearly in Artificial Intelligences (AI), a term coined in a proposal for a 1956 Dartmouth College workshop by mathematics professor John McCarthy (who taught at Dartmouth), researcher Marvin Minsky (a Junior Fellow at Harvard University), computer scientist Nathaniel Rochester (employed by IBM), and information theory founder Claude Shannon (who worked at Bell Telephone Laboratories). They proposed 'to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to stimulate it' (McCarthy et al. 1955: 1). It is not a coincidence that the only aspect of intelligence mentioned in the proposal is learning, although they later include the use of language, abstraction, and calculation, as well as 'self-improvement', 'randomness and creativity' (3). The primary obstacle was to move beyond input-output procedures at the level of the machine to the machine's ability to detect or 'sense' changes in the machine's environment.

Yet there are different kinds of AI as well as numerous aspirations for such technologies. The definitions of existing and aspirational AI revolve around the ability to define 'the parameters of artificiality, or the ways in which computers are unlike human intelligence' (Cope et al. 2020: 2). Existing AI is simultaneously subordinate to human intelligence—in that it can only calculate—and is superior to human intelligence—in that it can calculate bigger and more complex formulas at faster speeds. Thus, our current era of AI intelligence is 'more accurately labeled the binary age' instead of 'the digital' (2).

For Nick Dyer-Witheford, Atle Mikkola Kjøsen, and James Steinhoff (2019: 9), 'the essence of AI—indeed, the essence of intelligence—is the ability to make appropriate generalizations in a timely fashion based on limited data'. They refer to 'actually-existing-AI-capitalism', which denotes 'a phase of experimental and uneven adoption of the technologies in which so many hopes are invested' (2). The largest form of AI here is machine learning, in which machinery takes in data, processes it, builds models on it, and uses these models to make predictions. Some forms of machine learning entail ‘deep learning’, in which networks do the aforementioned while at the same time continually modifying the weight given to different factors of data.

To speak of an *artificial* intelligence is to restate and re-entrench its distinction and separation from *non-artificial* or *human* intelligence. Thus, another problem is to what human intelligence refers at any given moment. One result is the ‘AI-effect’, whereby ‘as soon as AI can do something, it is no longer considered to require intelligence’ (9). The artificial-human divide changes, although there hasn’t been sufficient inquiry into what counts as intelligence in the first place. If one can’t make calculations, abstractions, or predictions based on data, are they *neither* machine nor human? More fundamentally problematic on our reading, however, is the very desire to render the human visible in order to biologize the digital. Capitalism has *always* been driven by this desire. We should remember that capitalism only grew into a proper mode of production with the development of large-scale industry and machinery, or when capital moved from the *formal* subjection to *real* subjection of labor. This transition, for Marx (1867/1967: 425), is complete as soon as ‘it is now no longer the labourer that employs the means of production, but the means of production that employ the labourer’. During capital’s early years it took existing forms of production (handicraft and manufacture) and only modified them under its command. The problem it confronted was that both forms of production were regulated by *labor* because the knowledges and skills required for production were held within workers themselves.

With the development of machinery, the relationship between living labor and dead labor (as manifested in machinery) is inverted such that the latter becomes the driving and regulating force of production. For this reason, as Marx (1939/1993: 694) wrote in his *Grundrisse* notebooks, ‘*machinery* appears… as the most adequate form of *fixed capital*, and fixed capital, in so far as capital’s relations with itself are concerned, appears as *the most adequate form of capital* as such’. The reason machinery is the most sufficient form of capital is because it absorbs ‘the accumulation of knowledge and of skill, of the general productive forces of the social brain… into capital, as opposed to labor’ (694). The English translation is *appearance*, but as Mario Tronti (2019: 179) observes, Marx actually wrote *erscheinen*, which is translated as *appear*, but often ‘should be translated as “presents itself”, a meaning very close to the verb “to be”’. In other words, the appearance isn’t an ideological distortion we can clear away but works on the very *ontology* of the process. It is, after all, workers who *produce* machinery.

Yet the fact that machinery regulates the production process is both an appearance and a reality, as anyone who works machinery will confirm. Nature doesn’t produce machinery: ‘they are *organs of the human brain*, *created by the human hand*; the power of knowledge, objectified’ (706, emphasis in original). Within these pages between the sixth and seventh notebooks, Marx introduces the concept—written in English—of the ‘general intellect,’ which refers to the extent to which ‘general social knowledge has become a *direct force of production*’ (706, emphasis in original). While there are important debates over the general intellect and the contradictory tendencies Marx charts in these two notebooks (where fixed capital produces wealth and undermines labor-time as the source of value while at the same time forcing workers to work longer hours under worse conditions), there are two that interest us here.

One is Paolo Virno's reconceptualization of the general intellect under contemporary capitalism. For Virno, while the general intellect is composed of *particular* knowledges, ideas, capacities, inclinations, and so on, he puts his emphasis on the *generality* of the general intellect. The *particular* manifestations of the general intellect, that is, are less important than the *general* capacities of the intellect. Rather than designating 'the aggregate of the knowledge acquired by the species,' the concept indicates 'the *faculty* of thinking; potential as such, not its countless particular realizations' (Virno 2004: 66). The resources of the general intellect include 'the faculty of language, the disposition to learn, memory, the capacity to abstract and relate, and the inclination towards self-reflexivity' (Virno 2007: 6). In other words, Marx fixed the general intellect in machinery, but Virno insists it is also a part of the overall social totality and finds its most adequate expression in the human.

Dyer-Witheford et al. (2019) find Virno's reconceptualization too anthropocentric by noting that these human capacities can be properties of AI. AI machinery possesses the ability to manipulate language, to cooperate, and to produce and negotiate infinite combinations of concepts and models. And while AI can't 'feel', it can nonetheless 'interpret feelings as data' (66). Missed in this critique is a definition of communication, however. This leads us to David Harvey's (2019: 97) recent observation of Marx's general intellect, which is that Marx's use of the concept is only focused on particular forms of 'knowledge and mental capabilities' that can be 'incorporated into the fixed capital of production of value so as to raise the productivity of labour to the point where labour, the agent of value production, becomes redundant'. Harvey smooths any gap between Virno's concept of the general intellect and the aforementioned critique because he notes that the general intellect is open to any knowledge that *can* be embodied in fixed capital. The flipside is that 'all those knowledges that cannot be embedded in fixed capital are irrelevant' (97). More than that: they are *anti-values*.

Under capitalism, value is a constantly expanding process in which value is produced, circulated, and realized through purchase and consumption. Any interruption or blockage results in *non-values*, while anything that blocks the movement of value is an *anti-value*. Tronti's (2019: 254) strategy of refusal consists in 'the organisation of the working-class "No": the refusal to collaborate actively in capitalist development, the refusal to put forward a positive programme of demands'. By refusing to advance demands, the aspirations of the working-class can't be absorbed into or accommodated by capital. Such refusal also entails the refusal of intellectuality itself. 'There is no culture, no intellectuals', he writes, 'apart from those who serve capital' (254). Put differently, the production of *anti-value* is the production of *stupidity* as the other of the intellect. This is exactly the issue that Dyer-Witheford et al. (2019) avoid insofar as they uncritically accept capital's definition of intelligence as that which operates according to capitalism's demands of *timeliness* and *productivity*. Indeed, throughout their book they equate intelligence with the ability to perform cognitively in a recognizable way.

3 Disabling Capital

We return to stupidity as anti-value at the end of the chapter, and for now delve deeper into capital's insatiable desire for intelligence and demands for communicability, articulation, and visibility. We will feel the oppressive outcomes of capital's lust for intellect, and thereby animate the importance of refusing it all together. We can understand many activist disability groupings and individuals as the vanguard of such refusal, embodying Tronti's 'No'—whispered everywhere amongst the working people. Disability, an exceptionally broad category, presents alternative ways of being, thinking, and living that repel capital's desire for intelligence and communicability, productivity and visibility. In many ways, the 'severity' of disability revolves precisely around the *degree* to which one is slow, unintelligible, and can or cannot meet the demands of productivity under capitalism. One of us, for example, is medically diagnosed with learning and behavioral disabilities, but does not identify as disabled because they don't experience their exploitation and oppression under capitalism as a determinant factor in their lives. Generally speaking, however, disability is subjected to a burning scrutiny under the lens of bioinformational capitalism. Organic-digital technologies (Peters et al. 2020: 4) are directed toward their biological materiality, as capital marches forth to control and conquer the material basis of labor (Peters 2012: 98). The working people's biology can either enable or disable the production of surplus value, which explains this emerging capitalism's obsession with disabled biologies. Rather than relegate disability to the margin, it is salivated over, understood, exposed, and strip searched for new reservoirs of value.

Capital's twenty-first century obsession with bioinformation leads back to its desire for intelligence. Saturated with capital's aims, intelligence adopts an arrogant view toward the unknown, and becomes synonymous with answering questions, eliminating confusion, and mastering certainty. It also allows for communication, which constitutes the means of production for the immaterial economy, and has become hegemonic within the totality of capitalism (Ford 2020: 104). Immaterial commodities such as language, codes, data, and ideas constitute a vortex for capital. The global north harbors this hegemonic center, where you will find the babbling, articulate worker of the communicative age rather than the silent worker of the industrial age. As the north deindustrialized, it pushed the silent subject into the margins of the global south: pointing to how the demand for intelligence and communicability affects the global working class in gradients. But increasingly, everywhere, working-class jobs revolve around engaging in conversation and collaboration with customers, coworkers, and management. Even the culture is dominated by raving news anchors, debating experts, talk shows, podcasts, devil's advocates, and hot takes: the demand to speak and *feel* intelligent is overwhelming.

Capital lusts after intelligence and communication because, on the one hand, these are its hegemonic means of production. On the other hand, articulation helps make the unknown known. Communication skills are developed within the multitude to ‘empower’ us to speak aloud innermost thoughts, hopes, and dreams: rendering our secrets transparent to the eyes of capital. Only that which is expressed can be surveilled, controlled, and appropriated. We serve capital by turning the multitude inside out. However useful intelligence has been to capital, that much more destructive stupidity has been to it.

Stupidity is weaponized by those who are unknowing and will not communicate, who are mute and will not cooperate, who are slow and will not hasten. Capital has no use for lost, wandering subjects whose knowledge and intelligence cannot be recruited against labor (Harvey 2019: 97). Neurologically different, disabled people stand in the way of capital’s drive for surplus value, for which they face an intense oppression. Under bioinformational capitalism, disabled knowledges and biologies are slated for annihilation and extraction.

4 Feel the Oppression: The Bioinformational War on Autism

Of particular interest to our research and organizing agenda against bioinformational capitalism are disability labels and diagnoses that are or entail the label of ‘intellectual’ disability. Autism is one particularly important example. Around the same time that bioinformational capitalism was emerging in the neoliberal world, an ‘autism epidemic’ was announced by every major institution in North America. In Anne McGuire’s (2016) historically specific study of autism as a neoliberal cultural phenomenon, we feel the effects of bioinformational capitalism on autism—one concrete example of disabled life.

In the early 2000s, autism was suddenly on the lips of the president, of news anchors, medical experts, celebrity psychologists, doctors, and school board trustees. As diagnoses and cases of autism surged, the public was warned about this latest form of stupidity that was seizing upon the (white, middle-class) children of America. The reason this warning is attached to children is because children, as opposed to adults, can still be good investments. McGuire (2016: 19) recalls that autism was labeled ‘a biological problem necessitating a biomedical solution; an illness needing to be stopped, cured, fixed, eliminated’. Nongovernmental organizations amassed millions from wealthy donors to fight the disorder. Autism Speaks[1] became the largest and richest advocacy organization, and till this day, adopts the puzzle piece as its logo: symbolizing bioinformational capitalism’s approach to the working body as a puzzle to be solved: to be taken apart and reassembled. Autism Speaks leaders summarized the violent, anti-disability atmosphere of this time

[1] See https://www.autismspeaks.org/. Accessed 2 June 2021.

perfectly when they announced ‘a federal declaration of war on the epidemic of autism’ (World Heritage Encyclopedia 2006).

During this ‘war’, autistic people themselves were hardly consulted: their experience and knowledge of autistic life and being were precluded. This follows the long history of the oppression and exclusion of disabled people, which coincides with the long history of the construction of ‘intelligence’ and also ‘whiteness’ and even ‘citizenship’. As Anna Stubblefield (2007) notes, ‘the possession of intellect, defined as the capacity to produce civilization, has been the principal distinction drawn by white elites to mark the difference between white and nonwhite races’ (169). In the service of racial capitalism, research was designed to measure intelligence, but those researching believed in the intellectual superiority of the white race, and so this was the standard to the tests themselves. Accordingly, those labeled as ‘disabled’, ‘feebleminded’, ‘idiots’, and so on, were *necessarily* spoken *for* because they were constructed as *lacking* the ability for self- and collective-determination. Relative to autism, non-autistic parents, relatives, professionals, politicians, and ‘advocates’ from corporate-style nonprofits ‘[understood] themselves as speaking on behalf of autistic people’ who had no rationality, credibility, or truth (McGuire 2016: 20). Advocates harnessed financial powers to launch a campaign aimed at remaking autistic children’s nature—to separate them from their disability by any means necessary, at as early an age as possible.

One of the popular mechanisms was ‘person first language’. Advocates would insist that people use the phrase ‘person with autism’ rather than ‘autistic person’ because the latter was, somehow, insensitive (187). While the new phrase seems banal, McGuire attests that it ‘plays an important role in supporting the dangerous biomedical presupposition that autism is somehow separate and separable from a person “with” it’ (227). It performs a separation of a person and their embodied way of being, and simultaneously makes disability an insult. These moves necessarily dehumanized disabled people, as Sinclair (1999) contests:

> I can be separated from things that are not part of me, and I am still the same person. I am usually a ‘person with a purple shirt,’ but I could also be a ‘person with a blue shirt’ one day, and a ‘person with a yellow shirt’ the next day, and I would still be the same person, because my clothing is not part of me. But autism is part of me.

Like Sinclair, many disabled people claim their disability as part of their identity. Many push against the process of dehumanization and depersonalization they are subjected to by bioinformational capitalism, and draw solidarity to other identity contexts. For instance, we would not say ‘person with Indianness’ over ‘Indian person’; or ‘person with womanhood’ over ‘woman.’ A person is inseparable from their own subjectivity, and any attempt to wrench them apart opens doors to a host of justifiable violences. Again, however, because disability is such a broad category, there are a range of ways disabled people choose to refer to themselves and relate to others and the world, decisions that are contingent historically, politically, economically, singularly, and geopolitically, among others.These injustices have come in many forms. We may look to the vast biomedical industry that has emerged to ‘cure’ autism for some examples. McGuire (2016) documents the wide variety of treatments and therapies that compromise this industry: behavioral programs and schools, neurofeedback therapies, speech and physical therapies, social skills therapies, electric shock therapies; as well as pseudoscientific therapies such as holding therapy and chelation treatments which can be described as nothing short of torture (127). Even the most mainstream behavioral therapies are coercive in that they try to remake a child's being. Autistic children cry all day in behavior therapies and schools, as their comfort zones are violated and their boundaries crossed. They kick, scream, and revolt when they are asked to hold eye contact, sit still, speak clearly, and obey instructions. While 'services' like these are cloaked as ethical and helpful, in reality, they are coercive and non-consensual: aimed at aligning autistic instincts to capital's demands for efficiency, intelligibility, and productivity.

Violence against autistic people is normalized and is expressed most extremely in the high rates at which they're murdered with relative impunity. They are murdered most often by their parents, family members, or the police. Every year, a Disability Day of Mourning is held to mourn the loss of hundreds of people with disabilities who are killed each year by their own families (Autistic Self Advocacy Network 2017). In her study, McGuire (2016: 195) collects a lengthy list of names, dates, and details of autistic children who were killed by their parents to 'gesture toward the violent materiality of a cultural desire for "life without autism"'.

Of the many cases, let us look at that of Katie McCarron from Morton, Illinois. Three-year-old Katie was suffocated to death with a plastic garbage bag by her mother, Dr. Karen McCarron, in 2006 (McGuire 2016: 197). McCarron said that when she first found out about Katie's diagnosis, she cried. She became determined to cure Katie of her autism. 'She was not learning at a rate I would expect', McCarron confessed. 'Everything I tried to do didn't help her'—referring to behavioral schooling (206). At her testimony, McCarron said: 'I loved Katie very much, but I hated the autism so, so much…I hated what it was doing to her…I just wanted autism out of my life' (206). At the trial, when her defense attorney asked McCarron whether she thought she was killing Katie, she said: 'No.' When he asked who she thought she was killing, McCarron answered: 'Autism' (207).

We see the violent conclusion of a desire to repress autism in Katie's murder. A separation that begins in anti-autistic language, ends in the literal. McGuire traces how violence continues when the media covers murders like Katie's, and in how the courts litigate them. The media and the courts systematically sympathize with the perpetrators, and locate original blame within the autistic child themselves (McGuire 2016: 207–208). They claim that the root cause of the murder is the victim: something that plays out in filicides as well as police murders. When mourning the loss of autistic victims, Autistic Self Advocacy Network explains that the pattern of violence 'starts when a parent or caregiver murders their child or adult relative with a disability and continues in how these murders are reported, discussed, justified, excused, and replicated' (Disability Day of Mourning 2021).

Anti-disability violence serves to uphold the hegemony of intelligence and communicability, which provide the means of production for the totality of capitalism (Ford 2020: 104). This violence has helped the emergence of bioinformational capitalism, which has found lucrative reservoirs in the effort to destroy uncooperative biologies. A central mission of nonprofits like Autism Speaks was securing funding for biomedical and biodigital 'forms of research looking to cure autism and/or eliminate autistic ways of being' (McGuire 2016: 57). As this emerging capitalism develops deeper into the twenty-first century, its orientation to disability has undergone important updates.

5 Spectrums of Disability: Biological System Upgrades

In 2013, the American Psychiatric Association (APA) released the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM). The new release redefines autism as 'Autism Spectrum Disorder' in a move that belies the system's shift towards spectral thinking. McGuire (2017: 403) defines spectral thinking as 'the understanding that our bodies and minds exist on sliding scales anchored by oppositional poles of health and illness, normalcy and abnormalcy'. Defining autism as a spectrum marks the 'beginning of psychiatry's migration away from strict categorical approaches to diagnosis, where disorder is either present or absent, and toward dimensional approaches, where disorder is measured by degree'. Although at first this may seem like a liberalizing and positive development, McGuire (2017) argues that it instead increases the surveillance and control of disabled life, and feeds into bioinformational capitalism.

Spectrums rope more people into a disability diagnosis, and 'empower' them to slide up the scale of ability. A narrative of 'upward mobility' is initiated, without questioning the premise of what is 'up' and why it is desired (McGuire 2017: 418). It is an 'inclusive, optimistic, and highly lucrative narrative of improvement, recovery, and resiliency' that feeds into an 'economy of debility and capacity' (418). As Jasbir Puar (2012) observes, 'Debility is profitable to capitalism, but so is the demand to recover or overcome it' (154). Bioinformational industries profit from the need for subjects to recover from abnormalities of unproductiveness. Peters (2012: 105) explains that genomic capitalism, harnessed with a new generation of information processing, comprises a bioinformationalism which 'expresses a new kind of utopian perfectionism about the possibilities for a new age of genetic self-renewing capitalism that is capable of programming itself'. Contemporary innovations in genetic engineering, prenatal genetic testing, pre-emptive health screening, and stimulation of fetal brain development all aim at biomedically preventing disability before it arrives. Innovations in brain imaging, highly personalized diagnosis and treatment protocols, early intervention services, and therapeutic remediations aim at repressing disability once it does arrive. Further than enabling this 'economy of debility and capacity', the spectrum-ization of disability also urges people to increase self-surveillance.

A culture of surveillance and control is enabled in the effort to forge new subjectivities. 'I argue that notions of spectrum are giving birth to a unique brand of neoliberal subject', McGuire (2017: 418) writes. This novel subject performs incremental and 'ongoing (read: unending), acts of (self) surveillance, production and consumption' to coerce themselves up the sliding scale of 'bodily value' (418). Following Robert McRuer, McGuire understands 'the good spectrum subject' as 'one who possesses the capacity, flexibility and capital to move along the pathological gradations of a continuum that is always and forever oriented toward compulsory normativity' (418). The multitude is made to regurgitate itself in the image of capital, annihilating disability in the process.

At the same time, the system also codes itself for regeneration. Bioinformational self-renewal is witnessed in a curious alteration to the DSM's title. McGuire (2017: 408) notices that '[w]hile the first four editions of the DSM use Roman numeral designators (i.e., DSM-II, DSM-III etc.), the fifth edition uses an Arabic number "5"'. Instead of DSM-V, it was released as DSM-5, or perhaps what they really meant: DSM-5.0. 'With the help of digital technologies, according to the APA, we can expect to see a DSM-5.1, 5.2, etc. Updates to the manual will now be ongoing, incremental—more like system updates/upgrades.' (McGuire 2017: 408) Like cellphone operating system updates—OS 14.1, 14.2, 14.3—which fix bugs and install new ones, bioinformational capitalism too will spontaneously update and upgrade the multitude. The APA says that '[o]ngoing revisions of DSM-5 will make it a "living document," adaptable to future discoveries in neurobiology, genetics, and epidemiology' (DSM-5 2013: 13). The DSM itself becomes 'a self-replicating organism' (Peters et al. 2020: 6) on the orders of bioinformationalism. The bio and digital fuse, necessarily making disability their central target. We have also witnessed a 'thickening of the DSM'—which has expanded from 500 to a thousand pages over the last 30 years (McGuire 2017: 405–406). Individual diagnostic categories are expanding and 'more and more detail is going into describing the minutiae of individual disorders' (406).

The 'epidemic' of autism could instead be interpreted as the 'epidemic' of bioinformational capitalism's war against opacity and unintelligibility. Indeed, Hanna Ebben (2018) writes that the 'epidemic' is based on the 'desire to recognize the undesirable', which is 'manifested through ways of perceiving that assume that autism and disability appear to people, and that such appearances need our urgent consideration in order to prevent further spreading of assumed pathologies' (160). Put differently, this is the desire for visibility and articulation for, as every minutiae of disability is exposed to the eyes of capital, the demand for visibility and transparency is realized. These are the consequences of embodying the multitude's challenge to intelligence and communicability.

The oppression of disabled life animates the importance of refusing this desire. It animates the importance of developing an anti-capitalist and disabling knowledge ecology that can resist in the age of bioinformaionalism. Stupidity will be a key aspect of the alternative knowledge ecology—and can assist in the struggle toward socialist and anti-imperialist horizons. This, however, will depend on our insistence that stupidity is divorced from and not in a relation with intelligence and knowledge, for as long as they two are approached as intertwined, the former will always be a means to generate the latter.

6 Disability and Stupidity as Anti-imperialist Resistance

At this point, we want to pause for a moment to consider stupidity's specific challenge to imperialism. As a form of capitalism, imperialism too has saturated pedagogy: rendering it not only productivist, but also colonial. We may notice colonial tones in how we often talk about learning: 'mastering' a subject, 'discovering' a new theory, 'exploring' a topic. The learner is imagined as a conquistador invading indigenous unknowns, discovering new lands, ripping the veil off of exotic people, and dragging everything into the light of scrutiny.

As inhabitants of the unknown, disabled and colonized people are taken to war. Across many histories and timelines, empire has waged war against indigenous people. They are mined for value by mechanisms that measure and quantify formerly inaccessible sources of profit (Moore and Robinson 2016: 2779): searching for new markets and natural resources. This is the reason why anti-colonial and decolonial struggles have long protected their unknowns, insisting on inaccessibility of their knowledge systems. Indigenous peoples of Asia, Africa, and the Americas have lived and died in the name of blocking access to their ancestral lands and knowledges. They were right to, for the moment European hands touched their ancient knowledges of medicine, diet, agriculture, geography, technology, language, and culture, they evaporated immediately into the profit motive.

Instead of mimicking imperialism's arrogance toward the unknown, we require forms of knowledge that allow the unknown to simply *be*. A knowledge that can accommodate confusion, uncertainty, and lack of productivity. Not beholden to a profit motive, socialist knowledge is peaceful toward disability, and is comprised of stupidity. An example and practice of stupidity as anti-imperialism may be found in Beth A. Ferri's (2018) account of her autoimmune illness.

Ferri is diagnosed with a rare blood disorder called chronic autoimmune neutropenia (12). She explains that doctors always describe disease by using war metaphors. Contagion is posited as an external enemy, a terrorist, who must be defeated before it invades. Disease talk invokes 'legacies of war and empire' that rely on 'ideologies of strength and conquest' (2). At this point we are naturally reminded of the war on autism—yet another instance of disability imperialized. Autoimmunity, however, poses a paradox to the imperialist narrative. It forces a shift in the discourse from concern over an external terror to that of internal terror: as Ferri puts it, 'invisible sleeper cells hidden inside the body waiting to strike' (11). Living with an autoimmune illness herself, however, Ferri feels misrepresented by the war metaphors.

She and other autoimmune people describe their biologies in ways that are more 'confounding' than internal warfare (13). They flirt with alternative metaphors such as foolishness, mystery, and paradox. Ferri (2018) offers testimony of one blogger with Crohn's Disease who calls his immune system a 'tool'.

> One day he was checking over things and when he got to my digestive tract he was all like, 'Whoa, whoa, whoa. What the hell is going on here? You guys are infected!' And my digestive tract was like, 'What the hell are you talking about. Are you drunk again?' And, so my

> tool of an immune system sets about 'CURING' my NOT sick digestive tract. (Ferri 2018: 13)

This confused biology sometimes leads its person down painful, chronic paths, and sometimes down comical ones. An acknowledgement of confusion, and self-awareness of incompetence feels more accurate to the blogger. Ferri herself offers another metaphor for her biology: that of fantasy and mystery. She writes:

> Alternative metaphors like *mystery* or the experience of Alice from the novel *Alice in Wonderland*, who finds herself in a curious new world after falling down a rabbit hole, highlight a common experience of living with an autoimmune disease—one that is very much outside of discursive certainty and medicine's preferred biomedical frameworks of cure. (Ferri 2018: 13)

Here, biology finds itself in a state of dreamy stupor: wandering through an inexplicable scape (the unknown) after losing all sense of place and time. In this mystery, there are more questions than answers—as the wonderland exists outside of biomedical certainty. Autoimmunity might also be 'a paradox' Ferri suggests—'A self-contradiction. A contradictory self' (15). All these metaphors offer alternative ways to know—stupid possibilities that lead us away from military conclusions. Confusion, mystery, and paradox are all stupid knowledges that emerge when disabled people think through their own experiences. These are all open questions that do not present any path or need to secure answers. The source of stupor's power is in its rejection of a productive pedagogy; its disavowal of intelligence. We return now, once again to stupidity's anti-value to more deeply understand its resistance to capitalism (and imperialism).

7 Organizing Anti-value: Spreading Stupidity

Productivist pedagogy moves from ignorance to knowledge. In the beginning of Daniel R. DeNicola's (2017) *Understanding Ignorance*, he quickly separates ignorance from stupidity. While ignorance is 'a lack of knowledge', stupidity 'is a mental dullness that indicates an inability to learn or a sustained disinterest in learning' and unreason is 'any type of irrationality, such as intentional but self-defeating actions or the affirmation of contradictory beliefs' (DeNicola 2017: 8). Learning is the fundamental movement from ignorance to knowledge, which once completed *eliminates* ignorance. The various forms of ignorance, he writes, 'may be removed or annihilated by *learning*, though different modes of learning may be necessary. The range of learning is as wide as the range of remediable ignorance' (26). The annihilation of ignorance by learning, however, remains trapped in a cycle of production insofar as learning *creates* ignorance. We learn something, and then we have a host of questions and unknowns that arise as a result, 'new knowledge has generated new questions, questions that could not have been asked previously' (184).

DeNicola (2017: 8) sums up the difference: 'Ignorance can be remedied; stupidity is intractable.' It is precisely this intractability that interests us as a form of resistance to capital's command over life and labor insofar as stupidity's intractability is an intransigent anti-value. Because stupidity can't be educated, its unknowability, opacity, and muteness endures beyond measure by remaining inarticulable and incommunicable. While databanks can store knowledge and knowledge's lack or absence, no technologies can quantify stupidity, nor can they discern or articulate it. Stupidity as such is the pedagogical form of working-class refusal. As Tronti (2019: 259) notes, as long as the demands of workers can be 'recognised by the capitalists themselves as objective needs of the production of capital … they are not only subsumed, but solicited; no longer simply rejected, but collectively negotiated'. When Tronti asks 'what happens when the form of working-class organisation takes on a wholly alternative content' when it 'refuses to function as an articulation of capitalist society' (295), he's posing the necessity of an alternative pedagogical logic, one that is incompatible with productivist pedagogy. In our age of bioinformational capitalism, moreover, stupidity is incalculable, incapable of abstraction, self-improvement, and innovation. We can now finally appreciate why capital's waged a relentless war against autism, why disability activism is a form of anti-capitalist resistance, and why anti-colonial and decolonial struggles have insisted on the inaccessibility of their knowledge systems.

We would like to end by proposing how writing can be a way of spreading stupidity, first by noting how stupidity infuses Marx's own writings, particularly his writing as research. Indeed, here it's interesting to note that just before he moves to the fragment on machines in his reading of the *Grundrisse*, Antonio Negri (1991: 139) admits he is 'always stupefied to see the power of Marx's intuitions, the extraordinary anticipations of the *Grundrisse*'. What Negri finds so useful about the notebooks is the way they perform Marx's own stupor. The research and writing, he says, is 'open on all sides: every conclusion that takes the form of a presentation of the research opens spaces to new research and presentation' (Negri 1991: 12). As such, 'there is no linear continuity, but only a plurality of points of view, which are endlessly solicited at each determinant moment of the antagonism' (13). It is telling that in the English translation of the *Grundrisse*, the title of the text remains untranslated. While it's typically translated as 'rough draft', Thomas Kemple (1995: 18) notes that another possible translation is 'ruptures-in-reason'. Even as Marx sought to articulate and present the inner logics of capital, he constellated this presentation with constant returns to stupor: by trailing off into digressions, breaking off notes at certain points, and also by leaving certain words untranslated and thereby preserving their intractable incommunicability and refusing to transform their opacity into a transparency.

We can also find such a constellation in the text most generally opposed to the *Grundrisse*: the first volume of *Capital*. While this text is Marx's magnum opus—his clearest exposition of the inner workings of capital—it is by no means defined only by articulation. In fact, the text ends, we argue, by a return to stupor. The penultimate chapter of the volume contains Marx's most succinct and categorical recounting of the transition to capitalism (as the negation of individual private property) to the negation of the negation, when the 'expropriators are expropriated' (Marx 1867/1967: 715). Yet Marx doesn't end the book here, after this clarion call for revolution, one presented in a way that could be read teleologically and even deterministically. Instead, Marx ends with a short and rather dry exposition of Ebbon Wakefield's theory of colonialism. There's no revolutionary conclusion, no call to arms, no declarations of what is to be done. The effect is to return the reader to the openness of capital and to the stupor of thought that persists within Marx's intellect. Marx returns us to a state of stupor and indeterminacy.

Moving outside of Marx and the Marxist cannon, another example of writing spreading stupidity can be found in John Cage's *silent writing*. While many scholars have debated the meaning of Cage's silence about his own sexuality, Andy Weaver (2012) focuses on how silence is blocked together with Cage's articulations. One place this shows up is Cage's 'Where are we eating? and What are we eating?' It seems to be about Cage's homosexual relationship with dancer and choreographer Merce Cunningham, yet we don't learn about this through the poem itself. The poem merely 'catalogues a series of meals that Cage, Cunningham, and members of Cunningham's dance troupe ate while touring' (Weaver 2012: 20). Rather than confess any relationship, Cage merely lists mundane moments of their time together, producing an opaque idiom that resists visibility.

As a result, 'Cage's work shows not only *that* silence can be politically agential and challenging to the status quo, but *how* to make silence an effective tool of socio-political critique' (20). The idiom remains mute and opaque—we are stupid in the face of it—which is precisely its political efficacy. It remains, as Weaver puts it, 'alternative without being oppositional' (34). This is a politics that, in line with Tronti (2019), refuses to articulate a program that capital could accommodate or even understand. The alternative is a silence that we also find in Marx, but what we have in mind here is that Marx leaves us with at the end of the third volume of *Capital*, which as Althusser reminds us, ends with 'A title: *Classes*. Forty lines, then silence' (Althusser and Balibar 1968/2009: 214) (emphasis in original). Instead, it's a silence that *inhabits* the form of the writing's end, one silence inaugurated not by death but by the very indeterminacy of Marx's thought.

Given capital's dynamism, however, it would be irresponsible to assert that such opacity represents a *permanent* form of anti-value. Nonetheless, in our current configuration of bioinformational capitalism—no less than its previous forms—capital's desire for visibility and transparency remains absolutely central to its regime's exploitation and dispossession as well as to its ability to command labor. Global struggles against imperialism, colonialism, and capitalist exploitation worldwide contribute such this contagion to generate a new, stupid knowledge ecology.

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Decolonizing Racial Bioinformatics: Governing Education in Contagion and Dehiscence

P. Taylor Webb and Petra Mikulan

1 Prologue

Immanuel Kant's idea of the *good life* cast its object in racist terms (Gilroy 2005; Harvey 2000).[1] Rather than delineate the object of his inquiry, Kant parroted racist platitudes about life to pontificate upon the conditions of an object he took for granted. Kant took Modernist liberties, literally, with his entitled position and discussed, at length, the adjective that qualified the very object of his assumed privilege. Kant's elaboration of that which is 'good' demarcated 'universal' activities associated with living morally, but within a racist hierarchy that had radically excluded the object of 'life' from so many.

We agree with Paul Gilroy (2005: 9) that 'Kant compromised himself by associating the figure of the "Negro" with stupidity and connecting difference in colour to differences in mental capacity provides a useful symbolic marker'. One useful marker is David Harvey (2000: 532) who understands Kant's racism as an 'an intellectual and political embarrassment'. Moreover, as Harvey (2000: 533) noted, Kant's racism contains 'a more sinister side to it', an evil in which Kant's project of universal moral reasoning masks as education.

Harvey (2000) locates Kant's racist educational philosophy through Martha Nussbaum's articulation of education, and specifically her ideas about geographical knowledge, anthropology, and the limits of difference. Harvey (2000) is concerned that Nussbaums's ideas about education simply circulate the very racisms that Kant

[1] We have decided to not reprint Kant's racisms. They can easily be located through our citations.

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used to develop his ideas about universal moralisms. As Harvey (2000: 531) noted, 'Nussbaum merely follows Kant (without acknowledging it)'.

2 Introduction

Our discussion of Kant provides an important context, but our chapter does not interrogate Kant's racism, nor do we discuss his, and others', compromised educational projects. Literatures that examine how Kant's racism has sullied (Western) philosophy are increasingly available (e.g., Eze 1997; Mills 2014; Yancy 2004), and literatures that discuss his failed educational project are frequently found within literatures about decolonizing education (e.g., Bhambra et al. 2018). In short, we agree with Lundy's (2014) rebuke of Kant when he noted that 'what the good life looks like cannot be prescribed in advance. One could only say that the good life is a life capable of sustaining an active experimentation … and an exploration of the limits, in every direction, of our will.'

Rather, our brief prologue is intended to illustrate how ideas of 'life' and vitality continue to be presupposed, rather than explicitly examined and discussed (Canguilhem 1991; Deleuze 2005; Foucault 1998). As such, Giorgio Agamben, continuing his longstanding critique of Kant, stated,

> It will be necessary … to embark on a genealogical inquiry into the term 'life'. This inquiry … will demonstrate that 'life' is not a medical and scientific notion but a philosophical, political and theological concept, and that many of the categories of our philosophical tradition must therefore be rethought accordingly. In this dimension, there will be little sense in distinguishing between organic life and animal life or even between biological life and contemplative life and between bare life and the life of the mind. Life as contemplation without knowledge will have a precise correlate in thought that has freed itself of all cognition and intentionality. *Theōria* and the contemplative life, which the philosophical tradition has identified as its highest goal for centuries, will have to be dislocated onto a new plane of immanence. (Agamben 1998: 239)

For our purposes, we are concerned that assumed notions of life, like Kant's, animate dead educational practices, often through viral racist practices.

Notwithstanding the philosophical neglect that 'life' has received, today we grapple with new developments in bioinformatics that encourages a rethinking of what constitutes life. Bioinformatics 'imagines and promises superior forms of life that are both utopic in intent and haunted by dystopic envisioning of a humanity (and humanities) "left behind"' (Mikulan and Rudder 2020: 618). Mikulan and Rudder (2020: 618) suggest that 'coming to terms with this contentious duality requires an education to not only respond to futures without humans as we know them', but to engage in (im)possible praxes of future forms to come, and built against the history/category of Man. Education continues to insist that all life matters, even if many of these expressions of equality are steeped in juridico-economic effects of colonial and imperial histories masked as moral prescriptions used to govern a 'good life'. Regardless of education's insistence on equality, life scientists are continually engaged in an effort to discover ways to create new and better forms of vitality through bioinformatics. Implicit in this bioinformatic search is the reminder and admission that all life does not matter equally.

2.1 Chapter Intent and Organization

Today, the idea of life has become the contemporary 'framing problem' because 'new modes of knowing life – ranging from epigenetics, virology, neuroscience, and nanotechnology to geology, astrobiology, and cosmology – present critical theory with the task of creating concepts' (Weinstein and Colebrook 2017: 4). For Weinstein and Colebrook (2017: 70), the task of creating concepts arrives from the fact that 'ways of thinking about, knowing, and transforming life dramatically change what might count as living and the epistemic and ontological status of life itself'. Of course, it was just a few decades ago that education governed preferential forms of life eugenically, betraying so many of its Modernist propositions. As Weinstein and Colebrook (2017) noted, contemporary advancements in bioinformatics re-raise – but also, re-trouble – historical discourses in education concerned with its disciplinary practices of treating life as an evolutionary determined concept (or, as we discuss shortly, *closed system*), particularly with regard to raciality [the *sine non qua* onto-epistemological signifier of coloniality (da Silva 2014)].

This chapter is theoretical and speculative. It is designed to unsettle conceptions of education and interject additional problems into the institutions of education and its concomitant practices. We do not provide obligatory recommendations or improvements to enable the continuation of this Modernist institution. As such, our speculations and problematizations are designed to escape education rather than to improve or reform it (Webb and Mikulan 2021). The chapter utilizes four bodies of literature: critical life studies (Pearson 1999; Weinstein and Colebrook 2017); educational bioinformatics (Peters et al. 2021a), and machinic reasoning and thought (Parisi 2013). The fourth body of literature that we draw upon are literatures that discuss how the assemblages of life, information, biomedia, bioinformatics, and machinic thought condition, and are conditioned on, categories of race, racism, and raciology (Brown 2015a; Gilroy 1998; Jackson 2020). We delimit our discussion to issues of anti-Black racism and in relation to discussions about Black 'para-ontologies', or the ways blackness functions to displace or exceed ontology (Moten 2008) and virtuality (da Silva 2014).

We sketch an alternative set of logics and practices concerning education as it stands at the precipice of the next, but incredibly powerful, bioinformatic era. Rather than understanding bioinformatics as a disciplinary locus to optimize, enhance, improve, reform, or more efficiently practice education, we treat bioinformatics as a locus laden with possibilities to escape education (Ball 2020; Ball and Collet-Sabé 2021; Webb and Mikulan 2021). In other words, we examine some of the possibilities that bioinformatics have to escape the biopolitical and disciplinary registers that education will likely use to filter bioinformatic developments in order for greater biopolitical control (Deleuze 1992). We utilize the idea of 'contagion' to examine the transmogrifying aspects of bioinformatics and data in education, and speculate how these aspects can facilitate escape (Parisi 2013). We examine how *digital contagions* in bioinformatic technologies 'take on a life of their own', and discuss some of the implications this has to escape biopolitical theory and educational governance.

The chapter begins by providing a brief overview of bioinformatics and discusses the implications this emerging industry has for educational governance. We discuss how data and life morphs, mutates, and changes – without human intervention – by drawing on Luciana Parisi's (2007, 2013) concept of *contagion*. In her work on artificial intelligence, Parisi (2007: 32) argued that the life is produced through 'contagious transmission rather than filiative heredity'. We work with her idea of contagion to counteractualize (Deleuze 1990) vitalist conceptions of life, and particularly racialized ideas of life, that continue to be used to govern education through naive and racist ideas like Kant's *good life*. In other words, the chapter argues that data and life operate in contagious and dissipative ways that provide energetic opportunities to challenge, and possibly escape, Modernist and biopolitical ideas of education designed to assemble, enhance, multiply, and select preferential forms of life.

The chapter notes that contagion is also a dangerous aspect of any life – a condition that education utilizes repeatedly to steer and govern human capital production through fear. We discuss how contagion produces errant and necrotic forms of life that simultaneously interrupt evolutionary determined enunciations of life and interject potentially explosive mutations. We note, then, that contagion presents an additional problem to the future of educational governance – *that representative epistemologies and ontologies are no longer about human notions of production, reproduction and selection but contingent practices of contagious silicon-based objects and thanatropic non-human processes*. In other words, we believe that control can be increasingly displaced from education and educational governance by accelerating our contagious bioinformatic moment.

Our premise is that bioinformatics are caught within the bifurcating logics of 'life' (e.g., either closed or open; passive or active; given or produced; mechanical or vital; dead or alive; human or nonhuman). As a result, educational subjects and bodies are also caught between (at least) two systems of governance, especially when the scale with which the question of the digital is measured remains the scale of an organism. On one hand, education continues to treat life and bodies as evolutionary determined and hence selected, disciplined and trained; and, on the other hand, education governs life and bodies as something that are immanently plastic, that constantly exceed disciplinary enclosures, and that can be infinitely modulated or 'optimized' (Deleuze 1992). We conclude with discussing the limits of active, biocentric vitalism (agency, reason, self-possession) which are embedded in education, educational governance, and particular articulations of bioinformatics (e.g., computational biologies). Rather than understanding life within humanist traditions (e.g., a contained subject position), we propose a speculative reading of bioinformatics as a particular moment of 'excess contagion'. We argue that bioinformatics is a scientific and technological force that exceeds enclosures, but one that education will try to harness in order to widen its own limits by optimizing the desires to financialize, privatize, and develop ‘human capital’ (Becker 1964; Brown 2015b; Foucault 2008).

If bioinformatics can simultaneously equalize and exacerbate unequal forms of life, we conclude paradoxically, that accelerating this bioinformatic moment might instantiate a ‘decoloniality of informatics’ through the proliferation of contagious, uncertain, errant, necrotic, and mutant life. Rather than reform education and its anti/racist declarations of vitalist life, we suggest an accelerated use of ‘contagious bioinformatics’ as a way to proliferate unknown becomings for new kinds of intra-connectivity, especially between human and inhuman networks of relationality. Luciana Parisi (2004: 134) characterized our moment of contagious bioinformatics as the ‘symbiotic assemblage of non-analogous modes of information … multiply the lines of transmission – stimuli and receptions – between all modes of communication: a virus, a human being, an animal a computer’. Contagious bioinformatics for a people yet to come ….

3 Bioinformatics and the Biomediated Body

The term *bioinformatics* is a portmanteau for technological capacities and abilities that treat ‘biology as digital information, and digital information as biology’ (Peters et al. 2021b: 370). Bioinformatics can be defined as ‘the application of computational tools to organize, analyze, understand, visualize and store information associated with biological macromolecules’ (Luscombe et al. 2001). Perhaps the most well-known example of bioinformatics has been the global endeavour to map the human genome, and bioinformatics is increasingly used in a wide range of endeavours including developing vaccines for diseases, psychopharmacology and personalized therapies, and within structural and functional genomics. As Craig Venter (in Peters et al. 2021c: 2) puts it, ‘[w]e can digitize life, and we generate life from the digital world. Just as the ribosome can convert the analogue message in mRNA into a protein robot, it’s becoming standard now in the world of science to convert digital code into protein viruses and cells.’

We limit our discussion of bioinformatics to endeavours designed to alter epidermis and epidermal growth factors. The literature sometimes refers to this particular area of bioinformatics as *skinomics* – ‘a field of bioinformatics applied specifically to skin biology … Skinomics has been expanding into extensive genome-wide association studies, e.g., of psoriasis, proteomics, lipidomics, metabolomics, metagenomics, and the studies of the microbiome.’ (Younis et al. 2017) For some, skinomics portend a future where … ‘“skinomics” techniques will be mature [enough] to become applicable to the personalized dermatology practice of the future’ (Younis et al. 2017).

In addition, one of the significant computational tools used in bioinformatic research is artificial intelligence (AI).[2] Increasingly, 'there is growing interest in the application of [AI] techniques in bioinformatics' (Narayanan et al. 2002: 91), because '[AI] can be used to analyze process and categorize the gigantic amount of biological data in less time. Numerous AI algorithms have been developed and used in bioinformatics analyses.' (Hanif et al. 2019: 114) A key aspect to our argument lies in the ways AI operates within the technological assemblage of bioinformatics. More specifically, we are interested in the ways that AI prehends race and race data within its computational practices of skinomics.

3.1 Biomediated Bodies and the Raced Subject

Developments in quantum physics, nanotechnology, cellular and molecular biology, neuroscience and epigenetics tell us that life as we know it can no longer be read as deterministic because life has always been artificial (Colebrook 2011) and plastic (Malabou 2009) in its transmission of code and information. Patricia Clough (2008: 2) argued that our bioinformatic moment has generated the 'biomediated body' – a liminality that contemporary bioinformatic forces are directed toward 'the forging of a new body'. The biomediated body 'exposes how digital technologies, such as biomedia and new media, attach to and expand the informational substrate of bodily matter generally, and thereby mark the introduction of a "postbiological threshold" into "life itself"' (Clough 2008: 2). Biomedia involves 'digitization', whereas 'the image itself has become a process, which not only invites the user's interaction but rather requires the human body to frame the ongoing flow of information, shaping its indeterminacy into meaning' (Clough 2008: 5–6).

Biomediated bodies are positioned within diametrically opposed understandings of life, whereas, on one hand, life and bodies are evolutionary determined and hence selected, disciplined and trained (Foucault 1995); and, on the other hand, life and bodies are immanently open, modulated, and constantly exceed disciplinary enclosures (Deleuze 1992). Clough (2008: 2) locates biomediated bodies precisely within these diametric oppositions of 'life itself', and within the corresponding, and often painful, transformation from industrial capitalism toward a hyper-financialized and neoliberal force. Here, the biomediated body is a 'historically specific mode of organization of material forces, invested by capital into being'.

[2] We use the following definitions throughout: artificial intelligence is defined as the theory and development of computer systems that interact and perform human cognitive tasks (e.g., visual perception and speech recognition); and the following two features which can be discrete from, but are increasingly seen as aspects of AI, (a) algorithm is a defined list of steps for solving a problem and a computer program can be viewed as an elaborate algorithm; (b) machine learning occurs when computer systems learn from data, enabling them to make increasingly better predictions. (Luckin et al. 2016)

Clough (2008: 2) notes that the biomediated body produced through different economic transitions parallel the accompaniment of ‘relations of power in the shift of governance from discipline to biopolitical control, a shift that depends on a certain [re-]deployment of racism’. We agree, and note that the continuous surplus value generated through different racisms is extracted from biomediated slave labor, fracked from the earth’s strata, and continually expropriated through the neo- and re-colonization of native territories (Da Silva 2014). As Clough (2008: 18) observed, ‘[w]hat makes the biopolitics of the biomediated body a political economy then, is the break into biology or “life itself” by carving out various populations in order to estimate the value of their capacities to live’. Sylvia Wynter (2005: 364) described the intersections between biomediated bodies and political economy as *racism*, or ‘an effect of the biocentric conception of the human’ (see also Foucault 2003; Mbembé 2003).

Like ourselves, Clough (2008: 2) is ultimately interested in the liminalities produced in biomediated bodies, and specifically with how biomediated bodies are ‘empirically realized and in terms of the philosophical conception of the virtual’. For our purposes, we connect Clough’s ideas about the virtual to Denise Ferreira da Silva’s descriptions of the virtual, namely transubstantiality, whereas

> racial knowledge transubstantiates (shifts them from the living to the formal register) what emerges in political relations into effects of efficient (scientific reason’s) causality, its critical tools fail to register how the total (past, present, and future) value expropriated is in the very structures (in blood and flesh) of global capital. (da Silva 2014: 83)

Like Clough and da Silva, we believe that bioinformatics is beginning to accumulate capital from ‘“life itself”, an abstraction which reduces life to a new unit for negotiating an equivalency between the cost of energy expenditure and its reproduction or replacement’ (Clough 2008: 14).

Throughout our discussion, we note that any idea of a decolonial bioinformatics must account for its supposed scientific non-neutrality. For example, in our post-pandemic moment, imbued with the biopolitics of human capital, we note that the lives of most humans are mediated in some way by science and techno-information, but in disproportionate ways. Privileged bodies enjoy both the life-enhancing medical procedures and products (such as vaccines), and enjoy better survival rates due to improved access to information; while, unfortunately, other, sexed and racialized bodies are utilized as raw sources and labor, valued mostly for their biological (reproductive) capacities.

3.2 The Possibilities and Problems of Bioinformatics to Disaggregate Raciologies

Paul Gilroy (1998) surmised that our bioinformatic moment will have profound impact on the ways race, racism, and raciologies are understood and practiced. Gilroy speculated,

> [t]he old, modern representational economy that reproduced 'race' is today being transformed … by the scientific and technological changes that have followed the revolution in molecular biology … [I]t is possible that we shall do a better job of countering the racisms, the injustices … if we make a more consistent effort to de-nature and de-ontologize 'race' and thereby to disaggregate raciologies. (Gilroy 1998: 839)

In many ways, our chapter takes its impetus from Gilroy's (1998) ideas about the possibilities of biotechnology to de-ontologize race. However, we complicate our contemporary bioinformatic moment in two ways. First, we note the pervasive biopolitical rationalities in education around racialized eugenics and the ways contemporary advancements in bioinformatics re-raise – but also, re-trouble – discourses in education concerned with its historical and disciplinary practices of treating life as an evolutionary determined or closed system. The contemporary vernacular around optimization and enhancement is historical code particularly for racialized/non-White populations. Gilroy (1998), of course, is rightly not interested in optimizing bodies with biotechnology, but we note that educational practices and educational governance rely on these rationalities quite a bit.

For example, Rose (2007: 16) referred to the capacity to recombine the molecular body, or the recombinant body, as part of the expansion of the technologies of optimisation, in which a technology is both equipment and techniques but 'is more than this. It is an assemblage of social and human relations within which equipment and techniques are only one element.' Gulson and Webb noted that the recombinant body

> is part of a long history of optimisation connected to eugenics, and hence the idea that postgenomics is seeing a re-racialisation in molecular terms (Meloni, 2017), an occurrence in which there is a re-emergence of multiple biological underpinnings for race (Morning, 2014). This is to see that optimisation can be premised on normalisation – that is, the practice of eliminating biological differences that are considered to threaten what is deemed as 'normal life'. Making optimisation synonymous with normalisation … has led to some claims that forms of postgenomics such as epigenetics have been considered a possible science of new eugenics (Mansfield & Guthman, 2015). (Gulson and Webb 2018: 7)

The second complication that we introduce has to do, broadly, with control and agency. Above, Gilroy (1998) used the preposition 'we' to signal a certain level of human agency or human control within attempts to de-nature and de-ontologize race. We want to stress that conceptions of raciality and emerging attempts to de-nature and de-ontologize race can be generated by both humans *and* machines, in which 'algorithmic rules now generate or construct patterns from the re-assemblage of data' (Parisi 2019: 2). What is significant about machinic understandings of life, race and processes of racialization are the extensive range of applications produced by the intensification of new computing power and availability of (big) education data and (big) biological data, including the possibility of AI to apprehend these data on 'their' own.[3] This is to take seriously what others have described as an 'autopoiesis' of machinic prehension (Fazi 2019), or what Luciana Parisi (2013)

[3] Facial recognition may be the clearest evidence of how racializations and racism are re-circulated through AI (Gulson et al. forthcoming).

described as *contagion*. In other words, we condition Gilroy's hope to disaggregate raciologies with bioinformatics with the assistance of non-human actors and the autopoiesis of machinic prehensions. However, we note that any disaggregated raciology must confront how it has been historically territorialized within unequal discourses and practices of optimization, and imaginings of recombinant – and disqualified – bodies.[4]

We discuss the autopoiesis of machinic thought next, and specifically with Luciana Parisi's idea of machinic contagion.

4 Contagious Life: Dissipative Structures and the Virtual Possibilities of Disorder

Luciana Parisi (2013) argued that artificial intelligence, machine learning, and algorithms prehend data through a process of *contagion*. Parisi stated,

> algorithms prehend the formal system into which they are scripted, and also the external data inputs that they retrieve. Nevertheless, this activity of prehension does not simply amount to a reproduction of what is prehended. On the contrary, it can be described as a contagion. This is because to prehend data is to undergo an irreversible transformation defined by the way in which rules are immanent to the infinite varieties of quantities that they attempt to synthesize. (Parisi 2013: 16)

Parisi's idea of non-anthropocentric contagion signal that machinic thought, i.e., algorithms used in skinomics, require, and rely on, propositions of uncertainty and incomputability. Indeed*,* algorithmic prehensions are actuated within innumerable forms of incomputibilities, or what Parisi (2013: 129) discussed as 'computational entropy' (i.e., randomness). For Parisi (2013), algorithms are independent, non-human entities fully capable of speculative thought *themselves.*

Katherine Hayles (2016: 33) noted that bioinformatics are best understood as 'cognitive assemblages' distributed across human and machine cognitions. Cognitive assemblages 'attend to new situations, incorporating this knowledge into adaptive strategies, and evolving through experience to create new strategies and kinds of responses'. Hayles (2016: 32) locates her idea through the idea of *assemblage* developed by Gilles Deleuze and Félix Guattari, whereas assemblage 'carries connotations of connection, event, transformation, and becoming'. Tony Sampson (2012), again borrowing from Gilles Deleuze (and particularly Deleuze's reading of Gabriel Tarde's microsociology), similarly extends biological contagion to, what he refers to as, 'the age of networks' best understood as 'virality'. Thus, we can understand bioinformatics as a 'ceaseless modulation of information that follows the auto-transmutation of matter [e.g., epidermus] by changing its activity of selection from one moment to the next' (Parisi 2004: 133).

[4] Disqualified bodies is, of course, a major aspect of Gilroy (1998).

For our purposes, we emphasize Parisi's ideas of machinic prehensions of uncertainty, incomputability, and 'computational entropy', or randomness. These dissipative structures function as contingent practices of virtuality, and are central to understanding how and where de-ontology resides.

4.1 Contagious and Mutative Bioinformatics

Uncertainty, incomputability, and computational entropy are processes that Keith Ansell Pearson (1999: 170) argued were intrinsic to 'machinic evolution' which 'refers to the synthesis of heterogeneities and involves the formation of a "consistency". A machinic assemblage connects and convolutes the disparate in terms of potential fields and virtual elements, and crosses techno-ontological thresholds without fidelity to relations of genus or species.' Contagion, then, is understood as attempts to form consistencies across heterogeneities, material *and* virtual, but undergoes an irreversible transformation itself immanent to the heterogeneities synthesized. In this sense, contagion necessarily and irrevocably mutates, whereas 'all living systems and their boundaries are caught up in machinic assemblages that involve modes of transversal becoming' (Pearson 1999: 170).

Pearson (1999) noted that AI, algorithms, and biology do not coincide with popular conception of life as the 'body-as-organism' or as a closed and determining system. Rather, biological and machinic life operate as open systems dependent on *contagious* dynamics. Pearson stated,

> it is erroneous to view the organism as an entity entirely separate from, and evolving independent of, its environment, or to reify the environment by treating it as something given and fixed, and which, it is alleged, produces only a 'passive' model of adaptation. Organisms cannot be treated as closed systems simply subjected to external forces and determinations; rather, they have to be understood in more dynamical terms as open systems that undergo continual flux. (Pearson 1999: 146)

Contagion, then, assists in understanding that bioinformatics and its objects of practice, are 'not reducible to its particular genetic structure or composition. In other words, what are important are not the components of the system but the dynamic relations between them' (Pearson 1999: 169).

4.2 Disorder and Dissipation: Life in Death

Clough (2008: 14) noted that understanding life (biological and machinic) as open systems 'makes it possible to theorize information once again, this time in terms of open systems, where information is connected both to the movement from disorder to order and from order to disorder'. Contagious bioinformatics is expressed through dynamic relations between 'negentropic decrease of entropy' which generates a reciprocal proliferation of 'complexity or turbulence, a disordering of order can emerge' (Clough 2008: 14). For example, Claire Colebrook (2011: 14) noted that the human eye does not just prehend sensory input, but simultaneously censors, edits, color-codes, synthesizes and selects how the non-perceived will be 'fabricated'. That is, the eye as an 'organ composed of singularities undergoes an irreversible transformation each time it actualizes pure potentialities of what it is "to see" but can only proceed efficiently with a high degree of not seeing' (Colebrook 2011: 14).

By way of vulgar analogy to educational bioinformatics, the overt focus on functional and genetic structures inherent to closed systems (e.g., ordering, synthesizing, actualizing and harmonizing) obfuscate the negentropic dynamics involved with, for example, sight. By favoring the pre-programmed or genetic, and so-called productive aspects of closed systems, education attempts to control disorder. In other words, education continually treats life as a closed system and tries to de-limit what can and cannot be prehended and hence understood or fabricated. Nevertheless, we argue, a contagious bioinformatics in education attends to the relations of differentiation, dislocation and dissolution germane to life as open systems. A contagious and decolonial bioinformatics in education would attend to disorder rather than control. It would pay close attention to attempts to manage, colonize, and control entropy, particularly in the name of educational governance practiced on the values of efficiency, choice and optimization.

Clough (2008: 14) noted that open systems of bioinformatics utilize 'dissipative structures' which 'allows for the virtual or potential emergence, that is, the deferral of entropy'. Dissipations can be understood as a loose form of decoherence – the loss of information from a system into a milieu. Importantly, dissipations and decoherence are productive, whereas loss simultaneously produces virtual conditions for energetic opportunities. For instance, Reza Negarestani (2011: 183) discussed dissipative structures as 'thanatropic regression or the compulsion of the organic to return to the inorganic state of dissolution'. What Negarestani (2011: 187) points to is how 'dissipative structures' produce the virtual through 'the traumatic scission of the organic from the inorganic provides the organism with energetic opportunities which are posited as sites and conditions for participation'. In other words, dissipative structures, decoherence, and thanatropic regressions are productive, virtually. The overt focus on life as a closed system obfuscates the virtual possibilities contained within processes of dissipation and decoherence.

Parisi (2013), Pearson (1999), Clough (2008) and Negarestani (2011) all note that dissipation, decoherence, and death (e.g., decomposition, and decay) function as sites of possibility rather than (only) as designations of finality. Moreover, dissipative structures can be appropriated by a variety of different political economies – capitalism, racism, sexism, etc. As Clough (2008: 11) observed, 'the appropriation of these complexities as the noisy condition of chance mutation and creation may be most desirable for capital accumulation'. Dissipative structures mark virtual sites of engagement, and position bioinformatics as a contagious locus of excess, proliferation, and mutations for different political economies to accumulate capital. As such, we believe there are 'dangerous' opportunities to accelerate these forms of accumulation in order to produce what Moten (2008: 187) discussed as a para-ontology, whereas '[t]he lived experience of blackness is, among other things, a constant demand for an ontology of disorder, an ontology of dehiscence, a para-ontology'.

However, contagion, dissipation, decoherence, as practiced in open systems, are expressed disproportionately. Depending on the precariousness and vulnerability of the open system, bioinformatics are implicated in and productive of ongoing colonial and neocolonial enclosures (e.g., life and race (and sexuality), schools, prisons). Here, Sylvia Wynter's (2005) concept of *sociogeny* is helpful. Wynter (2005: 361) offered the idea that, '[m]y proposal is that we are bio-evolutionary prepared by means of language to inscript and auto-institute ourselves in this or that modality of the human, always in adaptive response to the ecological as well as to the geopolitical circumstances in which we find ourselves'.

Sociogeny provides our proposal of a contagious bioinformatics with two important ideas. For one, sociogeny identifies adaptation, ecology, and geopolitics as obvious disproportionate and unequal forces that affect life. Two, sociogeny pushes the logic of the 'immanently open' (i.e., life, bodies) beyond the bifurcating biocentric logic of raciality. For instance, sociogeny directs our attention beyond the binary oppositions of transcendence (closed systems, evolutionary substratum/DNA) and immanence (open systems, desire, infinite optimization, etc.). Sociogeny is a remarkable idea that noted, philosophically rather than scientifically, processes associated with environmental epigenetics and what is loosely discussed as processes of 'soft hereditary' (Meloni 2017). Rather than bifurcating life as either closed *or* open, sociogeny and environmental epigenetics suggest life is produced within closed *and* open systems, or 'the idea that the hereditary material is affected by the parents' or grandparents' lifetime experiences, not fixed at conception (Meloni 2017, p. 4)' (in Gulson and Webb 2018: 6).

For our purposes, sociogeny locates life firmly within the biopolitical economies of desire, produced by and productive of biocentric raciality. That is, we are mindful of the potentially contradictory desires of open systems when articulating the racial and racialized categories that have structured the contemporary composition of the bio / info / matics. Sociogeny helps us understand how open systems are opaque, indifferent, and nonhuman, but also desirous, sensed, and prehended.

5 Ontologies of Dehiscence and the Plasticities of Educational Governance

Fred Moten (2008: 187) argued that '[t]he lived experience of blackness is, among other things, a constant demand for an ontology of disorder, an ontology of dehiscence, a para-ontology'. We have argued that an ontology of disorder can be located within a bioinformatics premised on open systems, rather than on closed systems. Further, an ontology of disorder can be proliferated through the contagious and nonhuman computations and dissipative structures of AI. As a point of orientation, we might accelerate, rather than constantly regulate, our contagious bioinformatic moment in order to produce ontologies of dehiscence.

Moten's (2008) 'constant demand' for dehiscence focusses the educative moment of bioinformatics within the very conditions of excess that already exist within the para-ontologies of life premised on open systems. This excess is located doubly within machinic capacities for contagious thought, an acceleration of bioinformatic's own capital accumulation of thanatropic regressions and dissipative structures. These decidedly non-human actors nuance Gilroy's (1998) hope to 'disaggregate raciologies' with, what we believe, are largely non-anthropomorphic processes of contagion produced by non-human actors and indifferent processes of mutation and decoherence.

Another educative moment within the uses and practices of bioinformatics is to note how biopolitical discourses about 'optimization' continually swarm and shape biomediated bodies. As Clough (2008: 10) noted, the biomediated body 'is a recent complexification in bodily matter at the molecular level as its informational capacity is made more productive'. We have no doubt that the fields of bioinformatics premised on closed systems will attempt to control contagion, excess, and mutation in order to accumulate more capital, one form being the production of more useful bodies, often referred to as 'human capital' in education. As such, we understand a bioinformatics premised on closed systems as a likely return to different forms of racism. Hence, ours and others' pleas to escape education (Webb and Mikulan 2021), and in ways best suited for their particular situations, perhaps as forms of counter-conduct (Ball 2020; Davidson 2011; Foucault 2007), counter-actualization (Deleuze 1990), and/or fugitivity (Harney and Moten 2013).

The scientific and educational preference for closed systems positions bioinformatics in diametric opposition to Moten's (2013) idea of a para-ontology. We anticipate that bioinformatics premised on closed systems will employ education and educational governance as the primary means to extend the idea of a productive body, particularly within the economic processes of racialized optimization and accumulation. In other words, education's historical investments in practices of normalization will not interrupt the bioinformatic 'wet lab'. Rather, education will likely represent an invaluable site of (big) data for future biomediated productions and accumulations. More importantly, education will position itself (once again) as a complimentary site to both normalize and differentiate (i.e., contain) the mutations of a contagious bioinformatics. Thus, education will likely continue with its eugenic practices, but now through the expropriation of the virtual manifest in contagion and dissipation.

5.1 The Complimentary and Contradictory Desires of Biomediated Bodies

The biomediated body, a liminal and desirous one, is stretched between the teleologies of different closed systems of bioinformation, and cast within the contagious excesses of disproportionate and desirous open systems. Moreover, the liminalities and desires of the biomediated body are expressed through shifts in industrial capitalism to contemporary financed ones. For example, Rose (2007: 20) noted that the liminalities of the biomediated body rest with a consumerist reorientation from normalization to customisation. He stated:

> In part, I suspect, the feeling of novelty and disquiet arises from the sense that we are moving, in the words of Adele Clark and her colleagues, 'from normalization to customization' … Pre- viously expert medical interventions were utilized in order to cure pathologies, to rectify gen- erally accepted deviations from desirable functioning or to promote biopolitical strategies through lifestyle modification. Now recipients of these interventions are consumers, making access choices on the basis of desires that can appear trivial, narcissistic, or irrational, shaped not by medical necessity but by the market and consumer culture. (Rose 2007: 20)

We would just add that the biomediated body is not simply one stretched across conflicting forms of governance, capital, desires or even conflicting ideas of information and 'life itself'. Rather, bioinformatics is an exceptional site of contradiction that invites bodies to invest in themselves through, and even with, these contradictions. In other words, we might not place normalization and customization as distinct poles, but rather, as complimentary *and* contradictory desires, whereas it is easy to understand how customization can be normalized, and normalization differentiated.

Today, the 'customized' educational subject is no longer an 'individual' with an assumed 'potential' waiting to be trained through disciplinary schooling. Rather, '[i]ndividuals have become "dividuals," and masses, samples, data, markets, or "banks"' – redolent of the contemporary biomediated body (Deleuze 1992: 5). For Deleuze, desire is what marks control societies 'because they express those social forms capable of generating them and using them' (Deleuze 1992: 6). In this sense, bioinformatics produce desiring subjects, and in concert with discipline, 'biopolitics turns power's grasp from the individual subject to "life itself"' (Clough 2008: 18).

Once the biomediated body is understood as a locus of complimentary *and* contradictory desires, then, we believe it is easier to understand how racialized bodies are continually placed within constant and disproportionate forms of racism. Hence, 'a constant demand for an ontology of disorder' can be seen as a strategic site for blackness that attempts to recognize how racism is derived from closed biocentric systems of life, and simultaneously one that circumscribes the contagions, excesses, and mutations of open systems. 'An ontology of disorder' can be produced, we argue, through complimentary *and* contradictory desires of optimization, customization, and, when speaking of education governance, normalization.

Next, we discuss how bioinformatics functions as a desiring machine. We note how ideas of open systems, particularly notions of biological plasticity, are still circumscribed by the kinds of racisms noted by Sylvia Wynters and her ideas of sociogeny.

5.2 *The Plastic Fantasies of Open Systems: Contagion as Excess Raciology*

As we've discussed, the prevalent image of life that operates today is premised on a biocentric image of a particular human organism. It is enclosed, self-determining and elevated by a double movement of expropriation. On the one hand, the enclosure of White bodies continues to be produced by distinctive ways of coding, looking, measuring, classifying, dissecting, and evaluating Black and Brown bodies. Bioinformatics, on the other hand, manufactured in scientific knowledge procedures, produce physical, axiological and cognitive self-determinacy of whiteness as an effect of, and cause for, universal reason, – exemplified in this chapter through Kant's racism and Nussbaum's appropriation of universal reasoning as the basis for educational practice.

And, while modernist and disciplinary education is organized and modelled on this particular paradigm of biocentric, disciplinary or organismic 'life' (i.e., self-actualized and self-determined, vital), this same paradigm is conditioned on something that might be called artificial, indeterminate, or contagious. It is within these dissipative and virtual processes that a contingent counter-actualization of racialized bodies can be located. For example, in her reading of infinite indeterminacy and malleability of all life, Malabou (2015: 43) argued that the idea of *plasticity* has radically altered how (and if) material can be represented outside of itself (symbolically or 'transcendentally'):

> …if we can affirm that plasticity inhabits the biological, that it opens, within organic life, a supplement of indeterminacy, a void, a floating entity, it is then possible to claim that material life is not dependent in its dynamic upon a transcendental symbolic economy; that on the contrary, biological life creates or produces its own symbolization. (Malabou 2015: 43)

For Malabou (2015: 43), '[p]lasticity is in a way genetically programmed to develop and to operate without program, plan, determinism, schedule, design, or preschematization'. As such, 'existence reveals itself as plasticity, as the very material of presence, as marble is the material of sculpture. It is capable of receiving any kind of form, but it also has the power to give form to itself.' (Malabou 2015: 81)

Plasticity can be understood as a problemata that does not determine solutions. In fact, plasticity is always indifferent to solutions. On one hand, this indifference to solutions and functions (optimizations, augmentations, enhancements) signals a certain force of contagion, because plasticity, just as dissipation, ingresses its own irreversible transformations. However, as Jayna Brown argued in *Being Cellular, Race, The Inhuman and Plasticity of Life,*

> [o]ptimistic fantasies about the plasticity of life in contemporary speculative thought ignore the history of racial eugenics and its investment in these same ideas to its peril. It reminds us that scholarly enterprise can never be free of the contingencies that shape our understandings of life itself. Remembering how a plasticity of life was imagined and scientifically practiced through race and ability is key as scholars go forward in the project of decentering the human. A trust in scientific knowledge must be interrogated, and the 'we'

> of new materialist thinking situated historically. Scholars must remember not to assume a universally shared positioning in relation to the material world. (Brown 2015a, b: 327)

Similarly, Zakyyah Iman Jackson in *Becoming Human* conditions ideas of plasticity to acknowledge how anti-blackness lies at the root of most colonial conceptualizations of human forms. Jackson (2020: 73) argues that becoming 'any kind of form' is an optimization that is 'embedded in and conditioned by an anti-black imaginary' and particularly of an afterlife of slavery. Instead of affirming such a potential for optimization, Jackson (2020: 73) argues that plasticity 'concerns the way potential can be turned against itself by bonds of power'.

As an alternative to Malabou, Jackson's (2020: 72) plasticity is 'neither the thing-in-itself not an immanent ontology of the real but representational or paradigmatic: an a posteriori virtual model of a dynamic, motile mode of antiblack arrangement'. Jackson (2020: 72–73) concludes that 'ontologizing plasticization has been constituent to a mode of unfreedom and the history of antiblackness'. For our purposes, we suggest that folding the virtuality of optimization against itself can be conceived as excess contagion because of its own irreversible transformation of plastic potentiality. Thus, Jackson's notion of 'decentering the human' can be, we suggest, aided with the assistance of contagious machines.

Next, we end by discussing some of the implications of a contagious bioinformatics, particularly in relation to ideas of decoloniality and alternative approaches to studies of educational control. We stress some of the ethical considerations brought about from a contagious bioinformatics designed to de-ontologize race.

6 Excess Contagion: Virtuality, (Im)Possibles and a Decoloniality of Bioinformatics

We are two White academics writing from within a White university, situated on stolen indigenous lands. We are implicated in the political and affective dimension of systemic racism, and perpetuate it each time we conduct research, teach, and write from within its enclosures. This chapter is a speculative proposal, perhaps even a naïve one, that uses the disarticulations and refusals of a contagious bioinformatics to rethink, problematize, perhaps even subvert, raciology and educational control. Our speculations and problematizations are designed to imagine new modes of being and becoming – modes that account for, and proliferate, contagious and erratic encounters with dissipative virtual intensities. As such, this chapter has been written '*and* risked in the name of "impossibles"; future educational worlds that converge and diverge according to their own manners of composition' (Mikulan 2022).

Our argument stitches together somewhat disparate ideas about de-ontologizing race by accelerating, rather than regulating, bioinformatics. In no way is our argument designed to speak for anybody, and, in addition, we are uncomfortable thinking ours as a signpost about being and becoming an 'ally'. Rather, we have strung together some 'impossible' ideas in order to generate a different thought, an alternative rationale, perhaps even a logic of refusal and subversion to the governing practices of raciology, raciality and education. As such, our chapter can be conceived as a kind of 'ex-colonization' of particular ideas and practices in order to accelerate a de-colonialization of educational governance and bioinformatics.

For example, Mikulan and Rudder (2020: 615) suggested that neo-vitalist materialist approaches to ontology and life must consider that 'racism is vitalist in the active sense because it begins with bodies' (as bounded organisms are always autopoetic and self-proximate). They also noted that 'vitalism is racist' because it 'distributes and discriminates racialized bodies according to their function as parts in a whole'. Speculations from/with bioinformatic (im)possibles, in contrast to molecular biopolitics, would be an orientation for educational thought that no longer begins with the image of a living, active, body imagined as a recombinant student that is to be managed and optimized. Rather, bioinformatic (im)possibles now present education with new problems of virtual, dissipative forces of de/composition that are indifferent to those of the reproductive human and the productive organism (and, of course, the persistent and disproportionate governance and control paid to the reproductive functions of females).

Our argument locates bioinformatics as a specific non-human machine that already proliferates contagion, randomness, and dissipative errors intrinsic to its calculating operations. This is the ontological supposition of Luciana Parisi's (2013) notion of contagion. Our argument rests in understanding that the redeeming project of an educational bioinformatics lies in its decoloniality, and particularly a decolonization directed to exceed enclosures (e.g., closed systems, 'racial purity', schools). This excess, we argue, is always already located within the non-human or non-anthropomorphized systems of life and information treated as open, rather than understood as closed. The converse of this statement, of course, is that education and its governance are designed entirely to control this excess.

If there is an element of human agency in a decolonial bioinformatics it is, we argue, to accelerate and proliferate these non-human systems and processes. Another locus of human intervention within a decolonial bioinformatics is to refuse attempts to 'fix', 'correct', or 'humanize' contagion and dissipative excess. Our gambit locates education as the likely and premier site to attempt to humanize and control bioinformatic contagion. Further, we believe education will try to re-inscribe contagion, error, and randomness in ways that are congruent with the humanistic, vital, and patently racist values of today – and importantly – yesterday.

As a result, we recognize and fully acknowledge that our 'impossibles' are not a straightforward politic because we believe that education governance (e.g., policy) will likely try to harness the excess of decolonial bioinformatics in ways that continue to multiply and control populations. As such, a decoloniality of bioinformatics should account for the dissipative structures and thanatropic regressions of open systems, and accelerate machinic contagions and virtuality released from these reproductive functions. What Moten (2013) discussed as an ontology of disorder, then, is oriented towards proliferating disequilibrium, and dehisence, and is 'dangerously' contingent, dissident, indeterminate, incalculable, uncertain, and unbinding.

Our decolonial bioinformatics follows Colebrook's (2011) reading of Deleuze that it if the self-efficient human organism were to be 'radically recalibrated' in the future, it is possible to live outside the confines of closed systems and develop injunctions to biopolitical and educational control. As such, our ideas about a decolonial bioinformatics conditions images of a people yet to come by insisting that it is ethically irresponsible to continuously tear and split the biopolitical. Infinite varieties of impersonal quantities and immanent qualities that dissipate and decompose are unequally arranged and disproportionately experienced (e.g., Black/White; male/female). A decolonial bioinformatics is cognizant that any politics of dehisence will likely bifurcate ontologies into subjective, productive enclosures on one hand, and objective, subhuman and lazy forms on the other. *What is at stake are relations of being and death, wherein racialized de- and re-compositions reside within closed pasts of displacement and death, and within so-called 'hopeful', open and vitalist futures that will ceaselessly split blackness in unequal ways*.

Our decolonial bioinformatics suggests that after being irreversibly transformed in the continual process of colonial *ontologizing plasticization*, racial singularities (conceptual, spatio-temporal, gestural), once released from a particular grammar of raciality endure virtually as excess contagion. A decolonial bioinformatics is no longer tied to Black corporeal existence only, but transubstantiated into something else (da Silva 2014). Da Silva (2014: 93–94) argued that virtuality can be understood through the idea of transubstantiality when she noted that 'transubstantiality, finally, becomes a possibility' when there is a 'break through the formal lines of space inscribed by our categories (of body, of species, of genus)'.

Excess contagion, born from the dissipative structures and thanatropic regressions of open systems, mark virtual sites of engagement and endure as virtual intensities. Excess contagion is a productive force of (im)possibles – potentialities to become re-augmented, re-optimized and re-invested in new, different, and possibly mutative forms of life. Our speculative proposition for bioinformatics that disarticulates/refuses biocentric raciality in order to imagine new modes of being and becoming agrees with what Mikulan (2022) noted were an ethics of refusal. This ethics of refusal 'attends to the structural deformations that are maintained by the epistemic praxis of erasure and dissimulation so prevalent in higher education (and schooling in general), which continue to insist on engaging with the presupposed and proper *possibles* for social change'.

If excess contagion (expressed virtually as dissipation and transubstantiality) is understood to be that which informs bioinformatic practices and outputs, we note that this excess can be thought of as virtuality because its composition is dissipated beyond any single desire. The event of dissipation/entropy/death inherent to contagion no longer indicates a moment of 'going beyond', or when death and dissipation are understood as external and extrinsic to the finality of matter from the outside. Rather, death, dissolution, and thanatropic regressions involve the productive processes of virtuality and transubstantiality (molecular into cellular; conceptual into digital). Importantly, contagion indicates a repetition, an instauration of a life with no deterministic arrival, return or conclusion. In the words of Deleuze (2005: 28), '[t]he life of the individual gives way to an impersonal and yet singular life that releases a pure event freed from the accidents of internal and external life, that is, from the subjectivity and objectivity of what happens'.

Like Agamben (1998) earlier, we also advocate for more philosophical understandings of life. Moreover, we believe that analyses of education policy and governance attend to how dissipative forces operate within our contagious and bioinformatic moment. We simply do not believe that bioinformatics can be separated from educational control. In fact, bioinformatics is its product. Nevertheless, the indifferent forces that both philosophical and education policy studies should find new ways to account for those that compose errant life, death, decomposition, dissolution, and mutation. Contemporary educational analyses that attend to errant life would, we believe, require new scales against which we juxtapose the non-organismic opacity of a singular life, confronted, for example, by planetary scales already responsive to future impossibles through transubstantiation. In other words, we advocate for analyses of educational control that search out a new ethics of scale, or even analyses of educational policy that un- or de- scale education's predilection for closed, vitalist, and humanistic scales (e.g., human ethics). Scale, of course, is itself a biocentric tool and method that measures, narrates, cuts and fetishizes that which it has already predetermined (life-death, Black-White, male-female, past-future, human-nonhuman, artificial-non artificial, organic-computational, etc.).[5]

The remaining questions, for us, relate to educational control. For example, to what extent can education proliferate contagion and dehiscence (as discussed herein)? What forms of life are educated in contagion, rather than those educated through reproduction and vitalist control? Will studies in educational governance examine errant life, death, decomposition, dissipation, dissolution, and mutation, and in ways that are congruent with escaping education rather than reforming or improving it? Or, will studies in education policy continue to examine overt and 'productive' relationships, reproducing vitalist habits in studies of control, power, and force?

Educational control is entirely dependent on anthropomorphic and human scales. As such, the most likely outcome of our bioinformatic moment is that education and education governance will simply co-opt dissipative forces in order to widen its own limits. This co-optive tactic will likely try to regulate contagion, dissipation, and errant life in order to optimize current biopolitical and historical raciologies. Of course, it is entirely possible that it may do both. If 'a people yet to come' can be actualized, we believe that they will do so through concerted efforts to escape education, rather than endless efforts to try and reform education, or through governmental commissions designed to regulate technology.

[5] Ideas about 'posthumanism' contain some of the clearest demarcations of how scale remains largely anthropomorphized and biocentric. See, for instance, Braidotti (2013).

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Competing Pedagogies for the Biodigital Imaginary: What Will Happen to Teachers?

Christine Sinclair

1 Imagining a Teacher in the 1960s

In 1964, an 11-year-old child wrote about a robot teacher on an imaginary planet (Yoksrilla) orbiting the star Arcturus.

> They had robot control. Yoksrillans caught on with the idea years ago. They had robot teachers, chalk, marker and books. The books could speak if there was something in it you did not understand.
>
> 'Good afternoon,' said the robot. 'Science Fiction for everybody. Starting with the first form.'
>
> Tolifa answered her question perfectly. Everybody was asked a question. Franinina was also correct. Unfortunately Yokri and Yohola were always muddling the robot up because they were alike and because they were always playing tricks on it.
>
> Yokri's question was, 'Could there be another solar system?'
>
> 'Er yes, no impossible, oh wait a minute yes, of course, um never. I suppose so, er I don't know'. A robot cannot take all that in. Whizz! Zzzz! Ssss! Its head went whirring round. The marker was not there, or there would have been trouble. Robots cannot remember things like that so Yokri was safe. (Extract from unfinished novel, *The Other Solar System*, 1964.)

An only child, the author of the extract (and of this chapter) was an avid reader, fascinated by school and adventure stories, slightly transgressive children, and sibling relationships especially between identical twins. She also enjoyed comedy and science fiction on TV, and all these influences on her imagination can be seen in the extract. Also in evidence is a comforting attitude to robots: they can take on supporting roles but are not as capable as the dominant lifeform on the planet. Fictional robots were widely prevalent in 1964, especially in the US; the main source for this

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one, though, was likely to be Robert the robot of the British TV puppet series, Fireball XL5. Robert was transparently more of a machine than a humanoid, responding fully and literally to orders, though he was prone to overheating if flustered. When a child tells a story, she is influenced by other narratives and stories around her, some of which will have become integrated into her thinking as second nature. She will additionally draw on her own experience and her associated assumptions, for example about the nature and role of teachers.Also relevant to this chapter, is the imagined classroom that is supported through such technology. Apart from the robotics, the classroom in the story is remarkably similar to those in other tales, with an emphasis on a teacher's responsibility to ensure correct answers and good discipline, and children organised by age into forms, even though the different year groups are brought together for this class. Books (and even chalk) are still present, though somehow turned into robots. The robot marker seems to have some authority over the robot teacher, suggesting separation of summative assessment, a hierarchy and possibly teaching inspection.

Preservation of most elements of a recognisable classroom is a recurring feature of many imagined educational futures, as is evident in the well-known French postcard from the 1900s in Fig. 1. In this image predicting the year 2000, there are serried ranks of young white boys apparently being force fed some facts extracted from books and presented via a radio mechanism, initiated by the teacher. Like the child's novel in the extract, this expresses a depressing view of teaching and learning, despite its futuristic focus.

There are many similar images of imagined future technology amplifying traditional conceptions of classroom practices (see, for example, Watters 2020a, whose blog I return to later) based on a rather instrumental notion of education, where packets of knowledge are transmitted to students by teachers in the fastest possible

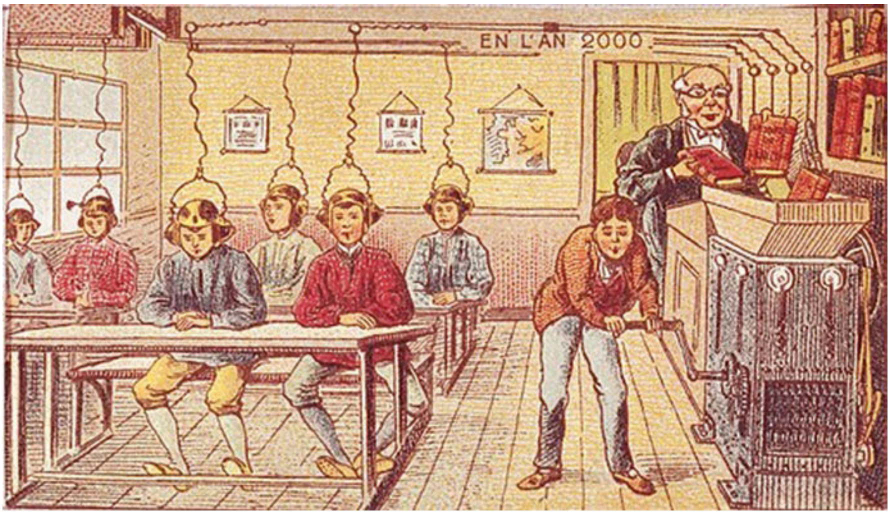

Fig. 1 Françoise Foliot (1972)—La radio à l'école (CC BY-SA 4.0)

way. The pupils in Fig. 1 look as though they are being subjected, through modern approaches, to what the philosopher Gilbert Ryle summarised and dismissed in 1962 as a 'crude, semi-surgical picture of teaching as the forcible insertion into the pupil's memory of strings of officially approved propositions… Yet, bad as the picture is, it has a powerful hold over people's general theorizings about teaching and learning.' (Ryle 2009: 467)

Sadly, the 11-year-old child in 1964 shared a similar picture of pedagogy, as do many other writers. More than half a century later, the author of the space story can reflect again on recognizable classroom tropes across the ages, including 'types' of teachers in the public imagination, ranging from dull didacts to inspirational dissidents. She can now articulate alternative ways of imagining the relationship between teaching and technology, and has even taught alongside a teacherbot (Bayne 2015). However, she can also observe how direct instruction and instrumentalism are still pervasive and present, for instance, in some aspirations for 'personalized learning' and discussions of 'learning loss' during a pandemic. She can trace the preservation of educational narratives via media channels that would have been unthinkable in 1964. She has easy online access to collations of cultural artefacts showing retrofutures, and to theoretical papers tracking and analysing 'imaginaries' from that epoch and others.

Imagined futures can fail to materialize, of course, and that is often the case—especially those with the promise of technology that will revolutionize education (Cuban and Jandrić 2015). To conclude my initial provocations, here is an observation from a curator of the history of the future, Matt Novak:

> Every generation has its shiny new technology that's supposed to change education forever. In the 1920s it was radio books. In the 1930s it was television lectures. Here in the second decade of the 21st century, it seems the Massive Online Open Course (MOOC) is the education tech of tomorrow. Let's hope it pans out better than previous attempts. (Novak 2015)

Now in the third decade of the twenty-first century, we can be certain that the way the MOOC is panning out is not straightforward; we already know that many different pedagogies are competing in the educational imaginary that encompasses MOOCs (Bayne and Ross 2014; Macleod et al. 2016).

2 Why Should We Attend to Imaginaries?

2.1 Imaginaries Are Useful Constructs

'The educational imaginary' mentioned above refers to a prevailing view of education and how it ought to be conducted. It incorporates some of the debates, myths and conflicting opinions surrounding education; it is arguably just one aspect of the broader social imaginary. The social imaginary refers to the current communal and normative way of thinking about society and its practices, enabling people to do things together. It may also be contested and in tension with other imaginaries, but has become stabilized over time to affect (and constrain) what we can do and how we can do it. It feeds into imagined futures as well as our understanding of the here and now. Thus, the educational imaginary is not just about how a single person imagines education, even though elements of it might possibly be traced back to an individual. In this section, I explore not only what an imaginary is, but why it is important, especially at a time when a new 'biodigital' social imaginary may be emerging rapidly. At this juncture, potential imaginaries may even support us in our post-pandemic quest for 'really useful knowledge' focused on emancipation and social justice (Jandrić 2021).

'We must reimagine…' has been one of the most frequently encountered phrases in response to the Covid-19 pandemic—or 'The Great Pause' as various writers have dubbed it. The pandemic has arguably drawn the public attention to the mutually constitutive relationships between society, biology and technology with effects on our daily lives. Some academic writers have chosen to talk about the processes of originating and sustaining such development as 'imaginaries', with various definitions and applications. I visit a few imaginaries in this chapter: they are all social imaginaries, or could even be construed as aspects of one prevailing social imaginary, but are sometimes given other names to highlight a particular focus. The sources I draw on reference sociotechnical, technological, educational, ed-tech, neoliberal, algorithmic, ecological and biodigital imaginaries.

I am interested in how the educational imaginary and reimagining education might combine to affect teachers and pedagogy at all levels of education. I am not focused on promoting a particular pedagogy; indeed, I explicitly want to avoid that. If a single pedagogy triumphs, there is a danger that it will be the one I imagined for my alien robot teacher, which also emerged in contemporary counterparts in the US, both fictional and real. Mrs. Brainmocker, the robot teacher practising the push-button pedagogy of The Jetsons, bore a remarkable resemblance to the behaviourist teaching machines of the time (Watters 2020a). At least we were imagining (and talking about) robot teachers in the 1960s and we probably should still be doing so, more than we currently are (Kupferman 2020a). But that does not mean we have to accept a reductive view of what they have to offer. We can also recognize, for example, that a 'teacherbot' might be playful, experimental and 'pedagogically generative' (Bayne 2015: 465), especially when good teachers possess the agency to work with it.

To explore the idea of imaginaries, there are many theoretical lenses for observing a process that begins with human imagination, co-operation and co-production directed at a shared future. They include work from writers on robotics, sociology, futures research, dialogic education, and ecology to name but a few. Although I draw on these to illustrate some points, my main method here is simply to seek out teachers and pedagogy in accounts of social imaginaries. Towards the end of the chapter, I shall draw lightly on the work of the philosopher and psychologist A. N. Leontiev (1903–1979) whose reflections on hunting identified humans' shared imaginations, goals, mediating tools and division of labour, illustrating the genesis of human activity and human consciousness (Leontiev 2005). We relied on a social imaginary and technology to move from individual hunting and foraging to anticipation of future meals based on co-operation and domestication of animals and plants. We continue to rely on our social imaginary and bioinformational technology for today's future-driven social activities, including education.

2.2 Social Imaginaries Underpin Current Social Norms

The philosopher Charles Taylor (2004: 23) is keen to make a distinction between academic theories and 'modern social imaginaries', which he describes as the common understandings of society held by large groups of people and 'carried in images, stories, and legends' as well as in strongly-held moral beliefs about how society ought to be ordered. The contemporary conditions and imagined futures envisaged by the authors of our book, for example, are more appropriately called theories, bringing together carefully-honed theoretical analyses of bioinformationalism and the postdigital to provide new perspectives on knowledge which may apply to future social practices. The other chapters do, however, draw on existing social imaginaries so that the reader understands what is being said; they also address problematic societal situations through new theories and forms of practice derived from them. They may thus contribute to future imaginaries that take hold in our globalized societies. It is in this context that I want to explore what might happen to teaching, teachers and pedagogy. I also hope to encourage readers to consider the other chapters of the book with the same question in mind.

There is then a process of migration from theories to social imaginaries and *vice versa*: they are not unrelated. Along the way, Taylor suggests, tensions, resistance, penetrations of new practices and ideas, revisions and redactions to theories combine and resolve themselves to produce a society's understanding of its contemporary culture and practices, including some prescriptive narratives that will help sustain those practices, at least for a while. Social imaginaries are never just ideologies: 'They also have a constitutive function, that of making possible the practices that they make sense of and thus enable.' (Taylor 2004: 184) There are negative aspects too: Taylor admits that 'the social imaginary can be full of self-serving fiction and suppression, but it also is an essential constituent of the real' (Taylor 2004: 185).

2.3 Sociotechnical Imaginaries Have a Focus on Futures

Successive notions of imaginaries have intersected with theoretical perspectives and become important signifiers of contemporary and future practice—especially sociotechnical imaginaries as elaborated and analysed in the discipline of Science and Technology Studies. This discipline strives to avoid the separation of science and technology from their socially constructed uses and desired futures. The recognition of sociotechnical imaginaries fulfils a need for 'conceptual frameworks that situate technologies within the integrated material, moral, and social landscapes that science fiction offers up in such abundance' (Jasanoff 2015: 3).

Fiction, especially science fiction, is itself an aspect of such material, moral and social landscapes and is a recurring theme in this chapter, especially when referring to the possible. As well as ideas for changing technology, science fiction offers a language for reflecting and developing a shared understanding of what is possible, including possibilities for science and teaching that at the time lay far beyond the reach of the child who wrote the extract from the beginning of this chapter. Even those who dislike science fiction will recognize its penetration into our shared understanding: for example, words such as robot and cyborg have suggested new ways of thinking and talking about possible futures, allowing for their realization. There are even researchers who use science fiction as method (for example, Gibbons and Kupferman 2019). While I am not doing that directly here, I have found their insights invaluable, if disturbing, for explaining in sci-fi terms what may be currently happening to teachers and pedagogy. In contrast, non-fictional accounts of technology frequently tend to overlook its social origins and interrelationships (Jasanoff 2015).

Sociotechnical imaginaries are focused towards a 'desirable future'. They are 'animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology' (Jasanoff 2015: 4). Jasanoff herself privileges the word 'desirable', highlighting the inevitable interplay of possible utopian and dystopian futures in our thinking, as I am also doing here. It is useful to draw attention too to her expression 'animated by': there are alternative futures but reaching the more desirable ones may depend on what is already present in our current social imaginary as well as in the knowledge of our scientists and technologists. And of course there may be competing 'desirable' futures. Jasanoff stresses the importance of considering the historical aspects of imaginaries: how they emerged and constituted and stabilized communal practices where alternative routes were also possible.

Sociotechnical imaginaries provide Jasanoff and her colleagues analytic power for their work across a range of research in science and technology,[1] but pedagogy and teachers are not their focus. However, similar discussions of 'desirable' futures can be found in futures studies, especially in the work of Wendell Bell who distinguished possible, probable and preferable futures (Bell 1997). When picked up by an educationist, this has been worded as: 'for educational futures, we can focus on what is likely to happen, what could happen, and what we want to see happen' (Kupferman 2020a: 4). Kupferman encourages us to do this creatively, recognizing the multitude of possible futures, rather than with a view to proscribing or prescribing. What counts as desirable futures will, of course, be in the eye of the beholder, but there will be more than one.

The role of advances in science and technology in animating imaginaries affects all teachers, across all levels and in all disciplines, in ways that have recently become

[1] See https://sts.hks.harvard.edu/research/platforms/imaginaries/. Accessed 28 June 2021.

increasingly obvious though not always positively, and provide the background to this chapter.

2.4 Competing Pedagogies and Myths Are Influenced by Imaginaries

The 'teacher-centred' model of education based on transmission has co-existed in the social imaginary for some time with the apparently contradictory 'student-centred' model based on transformation, with both views competing for dominance in education policies in several different countries (English 2016). Teacher-centred is often unfairly equated to an unimaginative form of direct instruction measured by what the students can repeat. Although an instrumental approach to teaching may sometimes be useful, it is certainly not the only approach available nor the only one actually used by teachers. It has been too easy for people to share the impoverished conceptions of teaching as the passing on of propositions or narrowly-defined and decontextualised competences, and this has encouraged the perpetuation of such forms of teaching for those who have an interest in them, including commercial organizations.

One result is recurring cycles of educational myths that feed into other potentially damaging narratives, such as the view that our current education is 'broken' because it was designed for a long-past industrial age: a factory model of education. This view 'is now *and has been for a century* the rationale for education technology' (Watters 2015, in her blog that considers the history of the future of educational technology). Moreover, Watters observes that this view is not only based on historical inaccuracies, it also preserves the emphasis on efficiencies and control associated with the actual educational model it critiques. She reveals how inventors of 'teaching machines' in the 1930s expressed much the same desires that we hear today for new technology to standardize, personalize, and revolutionalize an outmoded education system. Like then, the aim today is still to hand responsibility for education over to the ed-tech commercial market in preference to teachers.

Yet the move towards personalized learning also draws from the prevailing educational imaginary the idea of one-to-one dialogues between students and excellent tutors, envisioning the possibility of using technology to create these at scale. In a discussion framed by 'the technological imaginary in education', Norm Friesen (2020) suggests that educational dialogue itself has taken on the role of a myth to promote EdTech transformations. He traces the history of dialogue and its famous proponents, including Socrates' dialogical methods, Rousseau's utopian one-to-one experiential and constructivist teaching, and Dewey's vision for democratic and inclusive education based on dialogue in the classroom. The technological imaginary first introduced the teaching machine, based on Skinner's behaviourism, and then later attempted to emulate Rousseau's and Socrates' forms of dialogic exchange, associated with different pedagogical approaches. They were not successful, because dialogue is not actually amenable to such quantification; it is irreducible. However, we should perhaps be grateful that social and sociotechnical imaginaries still retain some positive myths around teachers, even if they also postulate a future where teachers are superseded by algorithms.

2.5 Social Imaginaries Could Have an Impact on Teachers' Futures

As we formulate our new theories about the bioinformational world, therefore, we need to be aware of the persistent and powerful social imaginaries that may already (mis)represent education and the role and nature of teachers. We should be aware of attempts to undermine the agency of teachers. Those who value teaching and teachers must ensure that their voices are discernible in the emergent imaginaries of the future. Borrowing a metaphor from Jasanoff (2015: 21), teachers and their allies need to be part of the collective 'glue' that preserves what societies value, or the collective 'solvent' that leads to change where it is needed. We should attend to imaginaries because some of them have shaped our present realities; we should attend to imagined futures to assess what future imaginaries might endure. I hope to demonstrate that it is important for teachers to still have agency in those futures.

In the rest of the chapter, I look at what happens (or doesn't happen) to teachers in discussions of a small range of contemporary imaginaries to tease out some likely tensions for a biodigital imaginary that might emerge through our current direction of travel. I look for teachers in analyses of imaginaries and in related discussions on imagined futures. I review effects on teachers and pedagogy from the social imaginaries identified in these accounts. In this brief exploration I consider further how imaginaries actually work in normalising certain forms of practice. Drawing lightly on the explanatory power of cultural-historical activity theory, I conclude the chapter with an argument for the retention of teachers and suggest some ways of infiltrating, subverting and resisting dominant imaginaries that seek to hide or exclude them.

3 Finding the Teacher in Neoliberal and Technological Imaginaries

Neoliberalism features strongly in contemporary imaginaries affecting education. By neoliberalism, in this context, I am referring to economic and political theories promoting the values of free market capitalism, the transfer of the public to the private sector, and self-interested individualism that have led to the commodification of education with the support of national governments. The growth of the neoliberal imaginary has raised questions about how neoliberalism is 'done' in education (Ball 2012: 2), and the answers expose 'a great deal of political and ideological work that is highly organized and well funded' (18). Finding out the mechanisms of neoliberalism is a feature of my search for the teacher, starting with a look at the issue of globalization. Neoliberalism is, however, only one dimension of contemporary globalization (Olssen and Peters 2005) and it is important not to conflate the two as there will be alternatives.

3.1 Globalization, Educational Policy and the Curriculum

Writers who are interested in the application of social imaginaries to education have invariably been focused on the impact of globalization (Berniyazova 2018), and it is in this area of research that I initially looked for discussion about teachers. Taylor's (2004) distinctions between theories, ideologies and social imaginaries offer an explanation of how education has been subjected to a neoliberalism fiercely critiqued by many educational researchers, writers and practitioners, while still influencing widely-held educational social imaginaries.

Rizvi and Lingard (2010) use Taylor's ideas to explore how a neoliberal global imaginary has emerged within largely knowledge-based economies afforded by information technology. An ideology—globalization—has been 'translated into actual material practices steering our sense of possibilities and conceptions of the future' (Rizvi and Lingard 2010: 33). They trace the movement and impact of this translation via the neoliberal social imaginary and how it affects policy, and in particular, educational policy. At this current stage of this translation from ideology to social imaginary, education policy in most countries is now firmly established as having to respond to the global competitive environment, highlighting economic issues and exacerbating social inequalities. How that is realized through policy will differ between countries because of other social imaginaries in play, but all our options seem to be constrained through the hold of the rationality of the global market and competition.

Hodge (2017) uses Rizvi and Lingard's work as a starting point for analysing an aspect of the work of teachers that has been affected by the neoliberal social imaginary—control over the curriculum. Following Taylor's (2004) account of penetration of new ideas into the social imaginary, Hodge illustrates how neoliberal economic and market-oriented theories (for example, Public Choice Theory) have been given 'both explanatory and normative power' (Hodge 2017: 340) to infiltrate our shared understanding of curriculum practice. Hodge has identified three main problems for teacher control of the curriculum brought about by the infiltration of the neoliberal imaginary. I have summarized these in Fig. 2, possibly risking the same kind of 'glossing' of theory that Hodge is himself critiquing. However, the three problems are uncomfortably recognizable, with hindsight, to experienced teachers who have seen the erosion of their autonomy with respect to curricular decision-making.

The first problem arises because of a view that professionals in the public sector are inefficient because their self-interest is not constrained by the mechanisms of

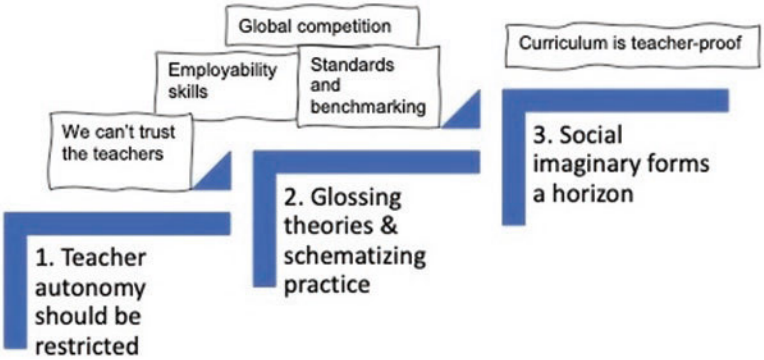

Fig. 2 Problems from infiltration of a neoliberal imaginary (based on Hodge 2017)

the market (Public Choice Theory). In education (at all levels, but especially in state schools), this means that the government must step in to ensure that other 'stakeholders' in education do not suffer because of teacher inefficiency. Public Choice Theory and other neoliberal theories are glossed or simplified for application rather than elaborated, and this gives rise to the second problem.

The theories are coming into the social imaginary through schematized practices and are rationalized through policy. 'Generalisations, keyword vocabularies and fragments of arguments circulate and are on hand to give sense to new and modified practices.' (Hodge 2017: 341). I have suggested some such fragments in Fig. 2; there are many examples. Indeed, this has resonances of the 'McDonaldization' of society (Ritzer 1993) and its effects on educational policy where it succeeds in rendering invisible the labour of teachers and students through buzzwords, attributing the work instead to policy and strategy in higher education (Hayes 2019).

Hodge's third problem is the success of the social imaginary in normalizing practice. This means not only that teachers' curriculum skills will have 'atrophied' through lack of use, but also that their participation in curriculum decisions will have become unthinkable. A horizon for thinking and imagination has been established.

A decade after Rizvi and Lingard (2010) wrote about globalization, material practices affecting education policy joined forces with a global pandemic that had a further impact on what we could do together, in our social and educational practices, with and without technology.

3.2 Infiltration of the Educational Imaginary During the Covid-19 Pandemic

Hodge's revelations about the infiltration that affects all education levels in the social imaginary were clearly borne out during the Covid-19 pandemic and especially in the aftermath of the closure of school, college and university buildings. Examples might include: an attempt to use algorithmic determination of grades for school leavers in the UK; quantification of 'learning loss' through institutional closure; EdTech investment in 'desirable' forms of reimagined learning. It is useful to consider Hodge's three problems with the infiltration of the social imaginary in these cases.

In the absence of formal national exams, governments in the UK were clear that teachers could not be trusted to assess school students' work, exemplifying another illustration of the first problem identified in Fig. 2. In Scotland, both the First Minister and the Education Secretary expressed concern about the 'credibility' of teachers' results. 'Mr Swinney said last week that he believed teachers were often "optimistic and aspirational" about their pupils' abilities, while an exam system "does something different".' (BBC 2020) This proposes a convincing horizon to teachers' agency (the third problem in Fig. 2).

Without the opportunity to sit an exam themselves, students learned that the algorithm determining their results would be partly derived from results of previous pupils at their school. This was clearly unfair. The students', parents' and teachers' strong resistance to such 'postcode lottery' (BBC 2020), along with the associated media frenzy, resulted in teachers' assessments being allowed for the year 2020, but discomfort and mistrust of teachers remained, with a sense that all the grades were inflated (see also Hayes 2021).

A subsequent concern about 'learning loss' invokes all three of the problems seen in Fig. 2. The expression 'learning loss' was shorthand for an attempt to quantify in terms of time and money what students, and ultimately society, missed during the pandemic. Initially, it might seem less damning of teachers. Indeed, the consultancy group McKinsey and Company even sought teachers' views on learning loss to make their case for reimagining education (Chen et al. 2021). Nevertheless, glossing the educational impact of the pandemic as 'learning loss' in terms of productivity and economics, established in the public imagination a need to supplement teachers' work with catch-up strategies to cover the 'lost' packages of knowledge, including private sector initiatives, leaving a sense of teachers being unable to cope by themselves. There is some truth in this, of course, as the emergency meant that teachers all over the world were suddenly expected to double their course preparation: providing classroom-based and online courses on the same topic. Added to that, the prevalent educational imaginary deprecated online provision, seeing it as necessarily inferior to the classroom, despite many strong examples to the contrary (Bayne et al. 2020). Excellent online provision, however, takes time to develop (as does excellent classroom teaching) and is not the same as 'emergency remote teaching' (Hodges et al. 2020).

Ben Williamson of the University of Edinburgh has been tracking the use of the term ‘learning loss’[2]—along with other glosses, schematizations and algorithms that promote neoliberal values in education. He is concerned about the direction such reimagining is taking. Along with Anna Hogan of Queensland University, he has written a report on Pandemic Privatisation in Higher Education: EdTech and University Reform (Williamson and Hogan 2021). This highlights the closure of educational buildings as conditions ‘animating’ sociotechnical imaginaries that ed. tech companies had already been promoting for years. These companies were positioning themselves to forge and strengthen the public-private partnerships and commercialization of education which they had been preparing long before the pandemic struck. For the commercial providers jostling for leadership in higher education’s future, it has been an opportunity to transform and revolutionize education, ‘fixing’ it through digital technologies (reminiscent of the promises of the television programmes and teaching machines of the 1930s referred to earlier in this chapter).

Indeed, the report highlights concerns about technological ‘solutionism’ such as the replacement of teachers with artificial intelligence (Al) and personalized study packages for students, approaches that might support an instrumental vision of teaching and learning while also echoing the science fiction of our retrofutures. Yet these are simply outputs of one form of neoliberal imaginary based on EdTech; there are other possibilities for the uses of technology. Williamson and Hogan (2021: 4) do stress that teaching and learning online ‘is neither inevitably transformative nor necessarily deleterious’. They suggest that alternative imaginaries will be needed to counter those dominated by commercial interests.

3.3 The Algorithmic Imaginary

Commercial interests may go beyond just selling hardware and software and extend to the curriculum itself. In an earlier paper, Williamson (2018) draws attention to the ways that some of the commercial EdTech companies have been creating their own alternative schools. This means that the ‘solution’ to the problem of education rests not only in the provision of supporting technology but also in teaching the values and methods of the technocrats themselves. The lack of trust in teachers highlighted in Fig. 2 has been the first step towards this apparent solution to the ‘broken education system’ of the current social imaginary.

> They firmly lodge the algorithmic logic that everything is objectively calculable, predictable and manageable through technical systems – and the associated technocratic mentality that value-free technical expertise is preferable to political conflict – in the institutions of schooling. (Williamson 2018: 232–233)

There is support for this concern in a chapter from futures researchers who use science fiction as method. Extrapolating on the point in the story (in the *Terminator*

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[2] See https://twitter.com/BenPatrickWill/status/1380626733376888837. Accessed 7 June 2021.

series) where 'the curriculum became self-aware', Gibbons and Kupferman (2019: 167) ask 'what Algorithmic Intelligence will think of the human teacher once it becomes self-aware'. Adapting the work of Philip K. Dick in imagining a data-driven society, they theorize a proposed new digital curriculum in New Zealand:

> the self-awareness of the digital technology curriculum will be evident in the tendency to prevent any questioning of not just its privileged status, or of the status of digital technologies in contemporary and future societies, but in the tendency to argue that all children are future workers for the digital system and the big data society (Gibbons and Kupferman 2019: 176).

The 'algorithmic imaginary' combined with significant resources from venture philanthropy was thus already being trialled in what Williamson calls 'silicon start-up schools' and university plans, before the Covid-19 pandemic struck. The potential for infiltration of both public schooling and the educational social imaginary is strong. If we want to avoid the implications of a reductionist and technocratic approach to education, we will need to create or animate alternative imaginaries. It may be difficult if a horizon is already established, but there is still hope as long as teachers can recognize that there are alternatives (Gibbons and Kupferman 2019).

4 Teachers, Imaginaries and the 'Not Yet' Futures

The neoliberal imaginary is undoubtedly affecting our present times and influencing much academic policy, teaching, research and writing. Some aspects, such as AI replacing teachers, might be more related to the near future and for many people would still be classified as science fiction. While imagined futures are an aspect of our contemporary social imaginaries, they will not necessarily be realized. There are alternatives, both actual and emergent, and there are ways of avoiding 'an unproductive cycle of critiquing overly optimistic *and* overly pessimistic narratives' (Ross and Collier 2016: 19) about technology and education. Ross and Collier argue for a stance of 'not-yetness' in relation to emerging technologies: working with them to see where they can take us, rather than using technologies to attempt to replicate classroom practices, or to simplify and tidy up complexity. They urge us 'not to narrow our vision to see only what we *can* account for' (Ross and Collier 2016: 28) and also reject the 'education is broken' claims, seeing emerging technology as full of possibilities, but not a quick fix to anything. The complexity of education requires a broader view.

The social imaginary is itself complex (Taylor 2004) and also relates to what is emergent. Not-yet futures feature in a comparative study of educational imaginaries in a PhD thesis by Assem Berniyazova (2018). Seeking to establish opportunities for collaboration in educational innovations between Scotland and Kazakhstan, Berniyazova has investigated the compatibility of social imaginaries in the two countries, with a focus on technological and social innovations. She traces the social imaginary at three levels: practitioners' (school-teachers') perspectives; the industry perspective through academic publications and conferences, and the societal perspective through folk stories and political speeches. She finds commonality between the two countries: for instance, '[m]ost of the interviewees believed that teachers played an indispensable role in the lives of the young people' (Berniyazova 2018: 88). (This includes the suggestion that teachers should not be replaced by robots.) There are also some subtle differences, including different perceptions of time, and different attitudes to newness and technology. She is keen to highlight that her findings are not 'cultural diagnoses', and she makes some valuable observations on the realization of social imaginaries:

> The aspects of social imaginary are not the algorithms that prescribe (let alone predict) behaviour; rather, they are levers resorted to in order to navigate through events and experiences. In other words, an aspect of social imaginary is somewhat like a proverb: what matters is not so much what it 'says', but what it 'does' - how it is used. In that sense, some aspects of the social imaginary in each country encourage stability, while others encourage flexibility. Together, they pose as the necessary tools that eventually serve the adaptability and sustainability of the community. Therefore, some aspects of social imaginary that, at face value, may seem to be in conflict, could actually be very similar to each other. (Berniyazova 2018: 114)

Berniyazova's thesis provides a rare opportunity to counter the stereotypes of teachers from the neoliberal and other imaginaries, while at the same time explaining teachers' and others' views on 'the desirable one of us' that is nurtured by the social imaginaries in each country. The relationship between policies, envisioned futures and teachers' practices, is refracted in this thesis through narratives of folk tales, politicians' speeches and the interviews captured here, giving a complex picture. It is a fine illustration of the view that teaching plays a complex role both sustained by and contributing to the prevailing social imaginaries. It would not be easy to reduce this role to algorithms.

5 Finding the Teacher in Ecological, Biological and Biodigital Imaginaries

Given my concern about the teacher's potential presence and role in biodigital imaginaries, I sought evidence in books and articles that expressly refer to such imaginaries or those that might be related.

5.1 Education in the Ecological Social Imaginary

Buckles (2018) traces the effects of the modern social imaginary on education and makes the case for moving from an anthropocentric social imaginary to an ecocentric one that is global and future focused. As with proponents of the neoliberal and other imaginaries, the aim of Buckles and the authors he cites is transformation;

also like the neoliberal imaginary, there is an interest in systems thinking, both in terms of biological systems and educational design. Unlike the neoliberal imaginary, the transformation should not be focused on material gain for individuals and groups, but rather on stewardship of our natural resources. The resulting pedagogy, glossed as ‘Connective Education’, is a form of ‘learning by doing’. Ideally, it should take place outside in the natural world, reminiscent of Rousseau with the young child Emile learning ‘not in a classroom or through explicit instruction, but in the countryside by experiencing things of nature directly for himself, as they are relevant to his immediate desires and interests’ (Friesen 2020: 148).

The focus, then, is on curriculum and values, aiming for promotion of ecological literacy that go beyond immediate desires and interests and lead to ‘the development of competences, cognitive skills and dispositions that enable ecological literacy to be enacted’ (Buckles 2018: 160). The chapter ‘Education in the Ecological Social Imaginary’ contains a considerable unpacking of the potential syllabus of ‘Connective Education’ and what the learner needs to understand, but there is no mention at all of the teacher and what their role might be, if any. The relationship between student and teacher is left as a question in the book’s conclusion. Arguably, this could leave a teacher some agency and creativity in contributing to the vision; equally, it could lead to an assumption that a teacher is not needed, especially in curricular decisions. The book is interesting and worthwhile, representing an individual’s imagined but ‘not-yet’ future rather than an actual social imaginary. Its observations on imaginaries are useful, though not particularly so for a reader looking to find the teacher among them.

However, visionary books and papers on sustainable and ecological futures that are inclusive of teachers do not have to be claiming to be an ecological social imaginary or imagined future, even if the work might have aspirations in that direction. A more recent work (Lautensach 2021) with some of the same values—the need for transformation, a transition from anthropocentrism to ecocentrism, attending to the ethics of sustainability education and to curriculum needs—adds a strong focus on the importance of teachers and teacher development. Despite some stark messages in the book, or indeed perhaps because of them, Lautensach positions teachers’ professional capacities as giving them power along with ‘the obligation of teachers worldwide to reach out across cultural divides to combat parochialism, to compare what works, to co-invent and to share pedagogical “wheels” rather than to reinvent them’ (Lautensach 2021: 285).

This obvious respect for teachers is accompanied by a proposed pedagogy: a transition pedagogy aimed at sustainable education, which incorporates both progressive curriculum revisions and making the best of the existing curriculum. One key notion of ‘protecting and supporting positive deviants’ (92–94) indicates why Lautensach talks about power and the need for teachers: Greta Thunberg is the example given of a positive deviant. While some of the themes of this book are not yet in the prevailing social imaginary, Greta Thunberg most definitely is already present, supported by many (though not all) teachers, and across many different countries.

5.2 *Advances Hidden in Plain Sight: A Prompt from the Biodigital Imaginary*

Scholars writing about our biological or biodigital futures do not specifically address the teacher as part of the imaginary around education, and it is important to highlight this absence. It is perhaps not surprising; the topics themselves have other pressing messages for our culture. A rare reference to biodigital imaginaries (O'Riordan 2011) took me to an interesting point about the convergence between spectacular science fiction and more mundane practice, where the connection is almost unnoticed. She is referring to the establishment of circulation of people's genomic information as socially normative. 'Biodigital practices have arrived rather quietly—this, together with the rhetoric of convergence, obscures a dynamic move that could benefit from some disaggregation.' (O'Riordan 2011: 308)

O'Riordan's point has been picked up by Peters et al. (2021) as something to look out for when considering how biodigital communication will affect meaning-making. Availability of students' biodigital data would seem to move teaching into a new realm. The biodigital imaginary from O'Riordan's perspective has not included reference to teachers, though. However, it does chime with Williamson's (2016) report that biopedagogies, psychopedagogies and neuropedagogies are emerging with the potential to enhance bodies, emotions and brains respectively and feature in teachers' future repertoires in the formation of a biodigital child. Biodigital information about human bodies is very different from digital information (for example, avatars and online profiles) or analogue information (for example, descriptions, taxonomies and statistics) about them. Biodigital information can be extracted via digital processes directly from the body, at last allowing the biological to 'flow back through the circuits of the machine' (O'Riordan 2011: 257). An interesting aspect about O'Riordan's analysis is her strong emphasis on science fiction, both as a point of comparison and to aid with the language with which to talk about what is happening. Once again, science fiction has alerted us to the notion of convergence of the biological and the digital (or the human and the avatar) in the form of the cyborg: it is perhaps happening sooner than we think, which will have an impact on teaching and learning as well as other things we do together.

In turn, this prompts further reflection on what else might be missing from contemporary social imaginaries, simply *because* near-future events seem so like science fiction that they can be dismissed as such. Changes in human bodies as they merge with data and artificial intelligence may end up cutting off alternatives, with no point of return. If there are moves towards this, they should actually be represented in the social imaginary in a way that goes beyond myths and science fiction. In a moving autobiographical account of his journey towards becoming a 'cyborg' to overcome the ravages of motor neurone disease, robotics expert Peter Scott-Morgan[3] writes of a 'fork in the road' of the future direction of AI: an irrevocable

[3] For more information see his website at http://www.scott-morgan.com/blog/. Accessed 7 June 2021.

choice between biologically-enhanced robotic intelligence developing independently (the Hollywood dystopic version), and AI-enhanced humans developing collaboratively. In a pivotal moment, he tells his husband:

> We're charging down the independent AI route! We haven't all discussed it, let alone agreed to it, we're just doing it! Practically no one has even noticed that there's an alternative route, an alternative future that we're shooting past—like missing a motorway exit—we'll never be able to reverse back and take it. And we'll never have that choice again. (Scott-Morgan 2021: 118)

His story is about the great effort he and Francis Scott-Morgan put into making that alternative future a reality—supported by a wide range of scientific, technological and caring expertise—using AI to ensure his own continuing existence, presence, creativity and activity despite the failure of his body. When biodigital futures start to merge with science fiction, we need to be looking out for such forks in the road. They may also appear to be dead ends, such as the forms of horizon-setting seen in Fig. 2, which may require resistance and subversion. We also want to ensure that if there's a fork between a biologically-enhanced AI in teaching and learning route and an AI-enhanced human teacher one, that we take the right one *if we need to* do *anything at all.* There are again alternative narratives in the social imaginary and its fictions; for example, that AI enhancement may lead to new problems of inequality (see Ishiguro 2021).

6 The Effects on Teachers of Contemporary Social Imaginaries

6.1 A Lens on the Activity of Teaching

The theoretical concept of social imaginaries and what people say about them has been useful for drawing out some contemporary issues affecting teachers. To theorize beyond this would benefit from a lens that can help identify what people do to make things happen in a particular culture. One candidate that might be appropriate to investigating the imaginary that might form around the biodigital, is cultural-historical activity theory (CHAT). As Blayone (2019) explains: 'Activity theory draws attention to agentic humans inquisitively exploring and strategically instrumentalising digital technologies to extend their native capacities for achieving goals.' (Blayone 2019: 452)

The above quotation is a good summary of what Peter Scott-Morgan has done; it is also worth exploring it as an ambition for teachers and their champions in our new biodigital environments. I would therefore tentatively propose activity theory as a candidate for further analysis of teachers' not-yet futures which may be highly technologized and ecocentric. However, there is a debate about the continued use of activity theory, which was developed for the era of printing. It may not be adequate for the biodigital world. Blayone (2019) draws attention to different possible emphases in activity theory that will affect the extent to which technology can be accounted for:

> On the one hand, Kaptelinin and Nardi (2012) emphasise that humans are uniquely capable of 'higher' mental functioning and acting with intention. On the other hand, Rückriem (2009) argues that our digitalised world has exceeded the limits of this anthropocentric view. (Blayone 2019: 454)

Kaptelinin and Nardi (2012), from the quotation above, are known for their work on human-computer interaction and their positive attitude toward activity theory is expressed in their preface: 'Activity theory is animated by an optimistic, positive, forward looking prospect in which imaginative reflexive activity always holds possibilities for just action.' (Kaptelinin and Nardi 2012: ix) They believe this is key to the use of technologies 'inflected by figurations of theory': we need good theory if they are going to work well. The other author cited, Rückriem (2009), does not actually use the word 'anthropocentric', but his warning strikes a note of concern. Rückriem (and also Blayone) privilege the theorizing of Leontiev (over Vygotsky or Engeström) for conceptualizing human activity in our digitalised world.

I would also like to privilege Leontiev's view of activity, albeit on a much smaller scale. For my current purposes—to suggest that if there is a biodigital imaginary then teachers ought to have a place in it—I am particularly interested in the potential explanatory power of Leontiev's (1981) account of the structure of human activity. In Fig. 3, I use his initial illustration of hunting, referred to earlier in the chapter, but I then apply the structure to teachers and their activity and associated actions in the accounts of social imaginaries. I particularly emphasize the role of operationalizing actions. Once an action has become a routine process, it becomes second nature or automatic, and may even be done by a machine instead of a human (such as gear changing when driving a car).

The object of the activity of teaching might be worded differently in different sectors and in different cultures. Berniyazova (2018) found that it was always expressed in Scottish secondary schools both by teachers and through

Fig. 3 Leontiev's hierarchical structure of activity (based on Leontiev 1981)

documentation as 'development of the whole child'—an example of policy becoming part of the teachers' shared imaginary. There may also be hidden objects of teaching, as we have seen: to do well in league tables, to attract further students, to make money. For teachers themselves, teaching will also be motivated by the need to earn a living, but of course there are other ways to do that.

There is no shortage of candidates to consider as goal-oriented actions involved in the activity of teaching: including planning a lesson, marking a paper, setting up a task. Once an action becomes routine, it can be done without thinking and can thus be operationalized. Cleaning the whiteboard, for example, has been an important operation in teaching and is likely to be done without involving too much conscious effort. Experienced teachers will also recognize a potential danger of operationalizing aspects of their teaching repertoire (going on autopilot) as they explain a method or deliver an anecdote that they have done many times before. While it can be useful and indeed necessary to be able to draw on such resources, a teacher can rarely get away with doing things 'unconsciously' all the time.

Some of a teacher's actions have now been routinized for them. Often this happens through bureaucracy and standardization, which can then be fully automated by software or apps, such as plagiarism or proctoring software. It is even possible to operationalize and then automate marking papers. As Audrey Watters has observed in a recent blogpost following a Twitter debate (Watters 2020b): 'We've taken that drudgery of analog worksheets and we've made that drudgery digital and we call that "progress."' Her argument is that if it is drudgery for the professor to mark it, it is probably also drudgery for the student to write it. That is what happens when teaching and learning are operationalized to the point of automation, which perhaps explains why teachers do not notice that they are losing more than a boring piece of marking.

An operation can be de-automized if required, turning it back into an action. A driver who suddenly needs to change gear, will be able to revert to the fully conscious goal-directed action of doing so. Even fully automated processes can often be overridden to revert to human actions, as long as the human still retains the skills and agency, and the technology and social imaginary permit it. If the automated marking does not work, the professor can return to the worksheets. Alternatively, and more productively, the professor might engage in academic actions assessing students in a way that contributes to the teacher's own learning and reflexive future use in teaching. This is not something easily replicated by technology.

6.2 Actions that Cannot Be Operationalized: Dialogue and Caring

One action that might be subordinated to the activity of teaching is 'engaging in dialogue' and there could be further subdivisions of this such as: listening, giving feedback, asking/answering questions, paraphrasing, summarising, reviewing, challenging. Dialogue depends on conscious action and is unlikely to be operationalized, let alone automated. Apparent dialogue as used in chatbots, virtual assistants and other forms of AI, is not the same as here-and-now purposeful dialogue between two humans. This is not to deny the potential for apparent dialogue in teaching; one student has described interactions with a teacherbot as 'ambush teaching' (Bayne 2015: 463). At best, though, this is anticipated dialogue—part of a repertoire but not consciously delivered, even if it may appear to be so. This point is the same as was raised earlier, by Norm Friesen, when discussing approaches to 'personalized learning'. 'Dialogue, in short, is a ubiquitous yet irreducible experience.' (Friesen 2020: 155)

Dialogue has more than one interlocutor, which is sometimes overlooked in both research and teaching. Teachers are the people who know about students and their levels of understanding, and they get to know them through dialogue (spoken, written and digital). Taking away opportunities for teachers and students to be in dialogue brings an emptiness to the learning process. Teachers should be able to feed back their understandings from their students into decisions made about the curriculum and approaches to teaching. The loss of such dialogic knowledge would be profound, especially if the teacher cares that students are engaging and learning successfully.

Caring is perhaps more of an attitude than an action, but there are caring actions (including those seen above for dialogue). Teachers have a responsibility to care about their students' learning, and, usually, an inclination to do so. Moreover, it is through dialogue that teachers and students can activate this care: 'The response of the cared-for completes the caring relation. Without it, there is no caring relation—no matter how hard the carer has tried to care.' (Noddings 2012: 773). Noddings is talking about school students, and the caring relation includes finding out what the learner needs and not just making assumptions about it. But both assumed needs and expressed needs have to be met. Not all teachers are adept at this, of course, but the necessity for it is becoming greater than ever, and while technology may be able to support the care, it does not feel it.

The analysis above brings out the point that an algorithm is the automatization of a once human action. Not all human actions are amenable to such automation. Even for those that are, while they are still at the 'not yet' stage, it is important to decide whether automatization is the correct route. It might lead to a loss of human knowledge and understanding.

7 Endings and Futures

The main message from this chapter concerns the consequences of reducing or erasing teachers' agency. If there are competing pedagogies in our new practices, we need practitioners on the ground who understand those practices as pedagogies and not 'just the way things are'. Teachers need to ensure that resistance and change can emerge before a fork in the road has been missed or a horizon has been set and we are left with no choices other than the pedagogies and curricula of the venture capitalists and technocrats.[4] It helps to be aware of the ways that our social imaginaries affecting education are infiltrated, and we need to engage with those imaginaries not just in academic papers and book chapters researching its damaging effects, but also in the wider media. Influential thinkers such as Audrey Watters and Ben Williamson are good at spotting emergent trends in our imaginaries, and sharing them widely through Twitter and blogs. They set us a good example.

Spotting such developments in the social imaginary is important; they are sometimes surreptitious while they are infiltrating our current understandings. To this can be added the complexity of organizations and professions affected by the social imaginary at local level but each with their own 'unwritten rules' (Scott-Morgan 1994). This is the same Scott-Morgan who has now become a cyborg; his expertise in decoding 'unwritten rules', which themselves show some similarity to imaginaries, guides his thinking about many aspects of his own future, including which are the right rules to break.

Just knowing about these matters is not enough: we need action for our own infiltration, subversion and resistance and the imagination to support this action. Scott-Morgan's autobiography ends with a fantasised account of later stages of his future, a story which originated as a fantasy novel that he started writing when he was 13 years old. It is probably the most utopian account of the end stages of a life lived with motor neurone disease. It contains much more imaginative use of technology and AI than my own unfinished fantasy novel from 1964. (To be fair, my main interest then was more in the application of technology to amusement parks than to teaching and pedagogy.) Like Scott-Morgan, we can do our own appropriate rule-breaking by going beyond the horizons set for us by previous imaginaries. Kupferman (2020b) encourages us to ask 'what if…' questions to aid our post-pandemic reimagining, saying '[l]et's play in the future by writing it.' (Kupferman 2020b: 50), following techniques from the 'good theory' he finds in science fiction.

As well as embracing the contributions of science fiction, social media, positive myths and deviants, for our new social imaginaries, we will definitely need good theory. Our success in finding appropriate uses for technologies that are 'not yet' impacting education will be dependent on theories that can properly account for what we are doing. If there is no room in the biodigital social imaginaries for teachers, then we will have lost more than we can possibly imagine. If we find ourselves heading for a world with a single pedagogy focused only on the reproduction of neoliberal values, it will demonstrate that we have missed an opportunity to the infiltrate the social imaginary with more stimulating and creative pedagogies.

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[4] For many more examples of this trend, follow Ben Williamson's blog Code Acts in Education. See, for instance, https://codeactsineducation.wordpress.com/2021/04/20/valuing-futures/. Accessed 7 June 2021.

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The Global Pandemic Did Not Take Place: Cancellation, Denial and the Normal New

Pete Bennett and Michael Jopling

1 Introduction

> Human beings must be everyday people or they will cease to exist. (Lefebvre 1977: 135)
> And what remains when disbelief is gone? (Larkin 2011)

Perhaps because it exists at an intersection between knowledge and biology, the global pandemic forces us either to address, or ignore, its existential and epistemological threats. This chapter draws on various theories, philosophies and other forms of writing, applied to education and politics, to examine the extent to which the pandemic offers an opportunity to rethink and redo. In this our immediate context is the UK, and in particular England, presented as an illustrative and extreme, rather than representative, case of how the pandemic has magnified issues and problems that preceded it (Davies 2020) and how they have been, and can be, understood, resisted and ignored. This situation is awash with contradiction in an English culture riven by the enduring symptoms of long Brexit, which just adds to the tension. As we emphasise, the pandemic is made up of both the virus and our responses to it. In fact, the promise of a return to 'normal' manifests as both a forlorn hope and a considerable threat: being lost is ever more attractive than being found. The chapter's title draws on Baudrillard's (1994, 1991) notions of simulacra and simulation in relation to the Gulf War: 'The idea of a clean war, like that of a clean bomb or an intelligent missile, this whole war conceived as a technological extrapolation of the brain is a sure sign of madness.' (Baudrillard 1991: 55) In the understandable

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concern with achieving a 'new normal' since the initial lockdowns were introduced, the emphasis has been much more firmly on the normal (the pandemic did not take place) than the new (we have all been irretrievably altered). Here we explore the normalness of the new, building on Baudrillard's (1994, 1990) notion of irreversibility and insight that 'the territory no longer precedes the map, nor survives it'.

Informed also by Frederic Jameson's (1984) concern that a sense of historicity has been unsettled by the 'discontinuous flow of perpetual presents', we read Baudrillard's analysis as a call to arms for the return to an effective historical sense to restore complexity, disorder and contention in a world that potentially wants none of it. This is congruent with Lefebvre's (2002: 226) notion of a critique of everyday life, which aims to 'render ambiguities bearable, and to metamorphose what seems to be most unchangeable in mankind'. Thus, it requires both careful and multidisciplinary analysis, as Rancière identified:

> Basically I tried to combine two things: one is transversality, I think the things that matter for theory turn up at crossover points where the different jurisdictions disappear … the other feature is precision. That's a quality that's been fostered in me by my constant practice as a gardener. With plants you can't be vague. I've done the same with texts. (Rancière 2016: 32)

Education is our field of enquiry because it is the area in which we work but also because it constitutes a practice, process and experience within which and around which these generally troubled and troubling times might be mediated. As (of all people) the former Church of England leader Rowan Williams (2021) noted recently, educational issues have been a 'lightning rod' and 'a vehicle for anxieties about national priorities, social disadvantage, mental health, the calculation of risk and a good deal more' in the period during the pandemic. We contest that education remains captive to notions of pragmatism and 'what works', which have drained much of the joy out of learning. Our approach in opposition to this is to draw on a range of theoretical insights in a spirit of questioning and playfulness. This does not mean we are not serious, rather that we are approaching the unanticipated, if not unprecedented, challenges of the last year and a half in the spirit of Madison (in Spry 2016: 176–177) who is clear: 'I am playful, but I am not playing. I do not appreciate carelessness. I pay attention. I do not let go or look away, because I have learned that all the meanings, languages, and bits of pain will come into clarity and utility like a liberation song.'

2 Cancellation, Denial and Education

> Everything could be dispensed with if we only had the strength and the courage. (Bernhard 2013: 30)

Knowledge has been at the centre of our viral present through a renewed and enduring, if unstable, focus on education. The pandemic has both magnified the unequal effects of disadvantage in education at all levels and offered politicians and policy-makers a means to overlook the existence of such disadvantage and resist change. This is clear from the facile focus on children's short-term lost learning (which has also not taken place and will only occur if we require or allow it to), that has distracted from its effects on other areas such as their mental health, for example. It was also clear when at the moment of the first lockdown the unthinkable happened in the UK and other countries and exams were cancelled. The fact that few could still imagine why anyone would want to learn anything for the sake of learning was an indictment of how corrosive the neoliberal approach to education has been in England. Later, after an uproar when everybody learned (and at the same time did not learn) that every year exam results are distorted by algorithm, this abject betrayal of the great project of education was repeated. Once again the gauntlet was thrown down by the cancellation in England in 2020 of high stakes exams for 11, 16 and 18-year-olds. This resulted in teachers being set to work compiling evidence to support their predicted grades with an explicit acceptance that that year's assessment would not cover all of the course content. No one considered the value of just teaching the rest of the course content because 'population management' trumps education every time (Peim 2013). Middleton reminds us that Lefebvre (2004) calibrates three 'qualities' of pedagogical endeavour: 'dressage, education and learning', explaining that '[m]ilitary in character, dressage is "training" or "drill", based on routine, repetition and obedience' (Middleton 2017: 413). Here is the English system of high stakes examinations.

By contrast, reflecting on another period of pan-European disorder, Lefebvre observed: 'Education ought to centre on concrete problems that are both practical and theoretical, both empirical and conceptual' (Lefebvre 1969: 157), the 'real' problems of 'lived' experience. These were a long way from 'what works'. Pandemic or not, they are the very elements that the neoliberal-inspired reforms in England sought assiduously to excise to the extent that the school curriculum offers a student of history no opportunity to engage with the historical moment they are living though. This is denial on a grand scale. The identification of contradictions, which Lefebvre argued 'give rise to problems, and thus to a set of possibilities' (2002: 209), is not for them.

Like whole currents of prevailing philosophical and cultural thought, such notions have been long denied in politics and in education policy in England. This has been the case in particular since clocks were turned back and traditional forms of knowledge and assessment were reinstated in 2010. After this, the post-truth seeds of Brexit and some responses to the pandemic were sown. We should remember that the director of the Vote Leave campaign rehearsed the approach in England's Department for Education a handful of years earlier. The move towards traditionalism is founded on a series of myths, which Barthes showed us long ago emerge out of simplification and denial:

> In passing from history to nature, myth acts economically: it abolishes the complexity of human acts, it gives them the simplicity of essences, it does away with all dialectics, with any going back beyond what is immediately visible, it organizes a world which is without contradictions because it is without depth, a world wide open and wallowing in the evident,

> it establishes a blissful clarity: things appear to mean something by themselves. (Barthes 1972: 143)

Myth also informs Matthew Clarke's exploration of educational policy as a series of fantasies and disavowals. Clarke (2020: 155) explores how we are asked to fantasize, for example, about more excellence, everywhere while disavowing 'the role of middle-class values and socioeconomic power in educational success', indeed reframing these as 'purely personal characteristics of aspiration, resilience and resolve'. In this way 'social discrimination and economic exclusion are rendered invisible in the interests of preserving a putative but fantasmatic egalitarian meritocracy', which, in anybody's money, is 'wallowing in the evident'. This process reinforces the core myth of education as the path to individual opportunity and social redemption, regardless of circumstance or disadvantage (Peim 2012). It also offers the reassurance of closure (order) and the utopian reach of openness (chaos) and more importantly and inevitably 'paradox' and 'contradiction'. These are represented by some as 'postmodern' characteristics, but they might more accurately and pertinently be described as 'post-truthisms'.

Thirty years ago, Jameson (1991: ix), dismissed the postmodern as 'an attempt to think about the present historically in an age that has forgotten to think historically in the first place'. Thirty years before that, Raymond Williams (1961) identified three functions of education which exist in tension: the production of a labour force; the transmission of (traditional) forms of culture; and enabling individuals to develop their full capacities. Therefore, we are asking in this chapter, how do we take the tensions and contradictions of the pandemic to create new knowledge ecologies and forms of education? How can we ensure that this moment of transition leads to change (a normal new) and to do this do we need a fourth (fifth, sixth) function of education around which to develop a new plan of action?

3 A Brief History of Simulation: A Lesson Too Late for the Learning?

> Theory, meanwhile has itself also changed and offered its own type of clue to the mystery. (Jameson 1984)

The paradox embodied in our title is, like Baudrillard's, conceived as a provocation. It is multi-layered and multi-modal, bringing together pure myth and brute facticity. The myth of the pandemic, like the myth of education itself in Peim's (2013: 32) coining, 'is a dynamic structure, a series of specific myths in a turbulent system of differences', but with even greater and grimmer impact. Regarded variously as humanitarian and economic catastrophe, inevitable 'wake-up' call, test, hiatus, consequence of the connected world, natural break and certainly powerful message/lesson, it will offend many at the deepest and simplest level to suggest it did not happen. However, our polemical stance does not place us in league with Covid-19 deniers, the 'anti-vax' libertarian fringe, but rather as inquisitive observers of what largely looks like 'business as usual'. Indeed, the crisis seems to have provided a further excuse for subjection and exploitation within the ironic promise of a new normal (same as the old normal – if you're lucky). Of course, Barthes addresses this in his exploration of myth, pointing out that 'the signifier in myth exactly reproduces the physique of the *alibi*' and where 'there is a place which is full and one which is empty' (Barthes 1972: 122) (emphasis in original).

Thus the pandemic can be represented in the UK, and in England in particular, as part of the ubiquitous 'levelling up' process (with death masquerading as the ultimate leveller) while inequality escalates. The unedifying spectacle of allocating grades for untaken public exams has already been held up as a sad and brief chronicle of our time. No reckoning though can ever be made, so brinksmanship remains the order of the day because, while 'the ordinary alibi (for the police, for instance) has an end … [m]yth is a value, truth is no guarantee for it; nothing prevents it from being a perpetual alibi' (Barthes 1972: 122). In other words, myth, in Barthes' memorable phrase, 'always has an elsewhere at its disposal'.

This is the basis of Baudrillard's critique of Marxism, which he dubbed the alibi of capital, because it invests in a battle for meaning which can never be brought to the point of crisis as it battles with a bourgeois opponent that has ex-nominated itself so it appears only in the guise of nature and the nation. It is also about battling a spectral archive, 'a language which does not want to die' but 'wrests from the meanings which give it its sustenance an insidious, degraded survival' (Barthes 1972: 132).

Here is the real battleground, what Rancière (2006: 10) calls the intelligibility of the debate, a place for the practice of theory and the theory of practice. While we take very seriously Jameson's critique of postmodernism as the cultural dominant of late or multinational capitalism and recognise the points he makes about history and nostalgia, it is also difficult in our current context to argue with Mark Fisher's (2021) evaluation of the prescience of Baudrillard's accounts of the way we live (and learn). It is hard also not to recognise that it is neoliberalism which has not only become an accepted cultural dominant, fusing the economic and cultural to survive repeated predictions of its demise (Plehwe et al. 2020), but also how it has done so by neutralising postmodernism's warnings through deeming them 'mere' theories, albeit dangerous ones.

This had the bizarre effect in the UK of having the British Minister for Women and Equalities blame Foucault for children's supposedly poor literacy in a speech that was later redacted for 'party political content'. What Liz Truss was making clear in a contradictory fashion was that theory gets in the way of practice, that teaching 'theories' like racism and sexism leaves little time for 'making sure everyone could read and write' (in Zorzut 2020). She then compounded this by indicting a more significantly theoretical villain: 'postmodernist philosophy – pioneered by Foucault'. Without evidence she dismissed it as follows: 'In this school of thought, there is no space for evidence, as there is no objective view' (Truss in Zorzut 2020). At the root of this is perhaps an unknowing rejection of Fisher's (2018: 766) insight that one of the impulses that runs through all of Foucault's work is a recognition of 'the arbitrariness and contingency of any system, its plasticity'.

Here in part is the culture war between common sense, rational, objective action and symbolic gestures. The Māori scholar Maria Bargh (2007: 14) has argued that '[t]he usage of the term "rational" by neoliberals can be seen as "a propaganda coup of the highest order … It carries the implication that any criticisms of it, or any alternatives put forward, are by definition irrational, and hence not worthy of serious contemplation."' For example, though Baudrillard's work is based on observation and careful argument about consequences, it is dismissed as fanciful and abstract (Fisher 2021: 49). Neoliberalism though hardly appears to be a theory at all, operating rather in the 'real world' into which we're thrown and which deals us the hand we're expected to play to the best of our, also 'thrown', abilities, like riders on the storm.

We need to consider how this plays out more specifically but not before acknowledging Baudrillard's (1983: 86) prophetic blueprint of simulation because as he says, '[t]he impossibility of reconciling theory with the real is a consequence of the impossibility of reconciling the subject with its own ends'. Our evocation of Baudrillard is vital because the most significant viral infection is of 'the real', whose degradation Baudrillard (1994: 6) tracked as a precession from 'signs that dissimulate something to signs which dissimulate that there is nothing'. Of course, this can be written off as 'fancy' theory, but in our image-saturated digital age, this points to the failure of imagination and certainly of the empty signifier, 'education'.

Curriculum reforms in England since 2010, which as we have hinted have painstakingly preferred the academic and traditional to the personal and contemporary, give credence to Fisher's (2014: 9) assertion that '[t]here's an increasing sense that culture has lost the ability to grasp and articulate the present'. It was culture that Debord quipped captured 'the meaning of an insufficiently meaningful world' in *The Society of the Spectacle*, claiming that '[e]verything that was directly lived has receded into a representation' (Debord 2005: 7). This was in 1967, though its pre-quotation cited Feuerbach from 1841: 'But for the present age, which prefers the sign to the thing signified, the copy to the original, representation to reality, appearance to essence … truth is considered profane and only illusion is sacred.' (Feuerbach in Debord 2005: 6)

If we go back to this 'normal', the pandemic did not take place, although grief remains. As we wrote elsewhere, '[t]he first casualty of hyperreality is "the real", historically, geographically and culturally situated' (Bennett 2017: 82). Writing in 1981, Baudrillard (1994: 354) entirely anticipates the nature of the threat and the longing for an illusory golden past that lies behind so many populist appeals: 'When the real is no longer what it used to be, nostalgia assumes its full meaning. There is a proliferation of myths of origin and signs of reality; of second-hand truth, objectivity and authenticity.'

In his *Requiem for the Media,* Baudrillard (1986: 124) added obliquely that 'the media revolution has remained empirical and mystical'. This is a fateful and possibly fatal combination which clarifies our relationship with what Berardi (2017: 203) calls 'the epistemological and practical hegemony of the economic paradigm' as onto-theological. This act of faith is essentially nostalgic, an essentialism that longs, post-truth, for some kind of reckoning, hence the daily bulletins from medical experts in so many countries documenting the war on Covid-19. We are asked to believe a common sense notion that there is indeed a reality that is incontrovertibly 'there', relating to Heidegger's notion of 'thrownness', which is revealed emotionally and 'trumps' theory in some unspecified way. There is a kind of brinksmanship at play here, albeit without possibility of resolution, and a naïve faith in 'brute facticity' as the ultimate standard (where once we relied on honour and integrity). This appeal to reality also authenticates what appears to be a rationalist approach.

It is interesting to contrast this with Lefebre's critical pedagogy which is predicated on the mythification of these abiding 'truths' of returning the historical, which Barthes was so tired of seeing confused with nature at every turn. The Marxist Lefebvre (2002: 20) works rather from the notion that the 'human being is historical and its historicity is inherent to it: it produces and is produced, it creates a world and creates itself'.

4 The Global Pandemic Did Not Take Place: A Lesson from History

> Is this the promised end?
> Or image of that horror? (Shakespeare 1997)

So much for rationalism. The pandemic has also been a godsend (*sic*) for the anti-vax movement to further their form of rationality, however irrational it might seem to others. Andrew Wakefield, struck off the medical register in the UK for making unfounded claims about links between autism and the MMR jab, remains alive and well and living in South Florida. He makes high profile documentaries, lots of money and co-habits with former supermodel Elle 'The Body' MacPherson. It seems that Marston (1603) was right: 'fortune still dotes on those who cannot blush'. However, the more serious point concerns the absence of any restraint on the casual lie which might perhaps be understood in terms of Baudrillard's (1990: 47) observation that 'we grant meaning only to what is irreversible: accumulation, progress, growth, and production'. In the same treatise he argues that '[p]roduction only accumulates, without deviating from its end. It replaces all illusions with just one, its own, which becomes the reality principle' (Baudrillard 1983: 83). Moreover, he relates this to a crisis in our 'all-too-beautiful strategies of history, knowledge, and power' which, he says 'are erasing themselves' (86). In some ways the 2008 economic crash, which Critchley (2021) characterises as a 'crisis of faith' in the value of money, was a dry-run for the pandemic. Yet we still get fooled again. Berardi (2017: 35) describes this as 'the exorcism that failed', arguing that 'the collapse of Lehman Brothers and the crisis of subprime mortgages in my expectation set the conditions for changing the regime of financial capitalism'.

For Berardi this new moment of crisis constitutes a horizon of possibility. He had previously argued that '[c]orporate capitalism and neoliberal ideology have produced lasting damage in the material structures of the world and in the social, cultural, and nervous systems of mankind' (Berardi 2011: 8), but now it is time to fight back. He proposes that we reclaim what Marx describes, using the English words, as 'The General Intellect' (the technical, social and professional knowledge of workers) through using 'consciousness of knowledge as the weapon' (Berardi 2017: 197). In this way, knowledge becomes a means of abandoning capitalism, rather than merely resisting or rejecting it.

The key here is subjectivity, acting as a foil to all forms of authority in which knowledge is not part of uncovering truth or describing reality: 'it is rather about the creation of meaning and the invention of technical interfaces projecting meaningfulness into reality' (Berardi 2017: 198). Berardi is drawn to 'The Fragment on Machines' in *The Grundrisse* where Marx himself proves fairly far-sighted in setting us a challenge. The question is 'to what degree general social knowledge has become a direct force of production and to what degree, hence, the conditions of the process of social life itself have come under the control of the general intellect and been transformed in accordance with it' (Marx in Berardi 2017: 202). The potential here is for education is to become what Berardi calls 'the actor of disentanglement', since for Berardi (2017: 202) the general intellect is 'the field of the next struggle and of the next creation: a task for the twenty-first century beyond the fog of neoliberalism and the miasma of the identarian brainless body'.

This moves us formally to the critique of universities and research for succumbing to the neoliberalist agenda (Mintz 2021), a development which the apparently neutral pandemic has paradoxically only made worse. Berardi (2017: 203–204) is optimistic because he recognises that the autonomy of knowledge depends on individuals working to 'produce value inside the semiotic machine'. However he is also aware that '[t]he autonomy of knowledge presupposes the independence of those who animate the general intellect' (Berardi 2017: 204). This means not only university vice-chancellors, governors and government, but also students, teachers and researchers.

Berardi provides a historical overview of 50 years in which the General Intellect has been in submission. During this period common notions of 'the future' have been rendered unfeasible and a flirtation with the theoretical principle of social mobility, which Reay (2017), drawing on Berlant (2011), calls a form of 'cruel optimism' because it so often offers false hope, has largely run its course. However, in universities profound changes continue and for Berardi these are to be resisted. There is 'no longer a space for the integration of technical skills and humanist culture' because '[i]t is being transformed into a space of mere acquisition for specialised knowledge, a space where individualism and competition are cultivated to the detriment of solidarity and consciousness' (Berardi 2017: 210).

5 Meritocracy and Depersonalization

With a heavy whiff of Baudrillard, Berardi (2017: 210–211) also claims that 'here, in the neoliberal transformation of the educational process, lies the ultimate danger of the final desertification of the future of humankind'. At the centre of this transformation has been the reinvigoration of the ideology of meritocracy, which Williams (1958) argued long ago 'weakens community and the task of common betterment' and 'sweetens the poison of hierarchy'. This has justified the emphasis placed on high-stakes examinations in England, which Foucault (1991: 187) reminds us transforms people into analysable objects and forces them into a system of competition, translating 'the economy of visibility into the exercise of power'.

For Berardi (2017: 212), meritocracy is 'the Trojan horse of neoliberal ideology, the hot bed of precariousness fostering competition' with individuals obliged to fight for position in the 'pecking order' and the skills and knowledge with which they fight merely a means to an end. In this way, competition becomes the rule. Meritocracy acts as 'a stimulus for ignorance' which 'diminishes our capacity to see ourselves as sharing a common fate' (Sandel 2020: 47). This is a process familiar to teachers in our schools and colleges. As Berardi (2017: 212) points out, 'as the criteria of evaluation are fixed by those who have power, the learner is invited to adopt the evaluation criteria corresponding to the existing powers'. As he emphasises, accepting meritocracy cancels students' ability to learn autonomously.

The stakes are too high for Berardi to sweeten the pill, for this neoliberal turn is also a global force, which Eve Tuck (2013: 324) has described 'as nihilistic, as death-seeking'. Like a virus. Thomas wrote with concern that:

> The surveillance of students, and now the surveillance of teachers (and ultimately of all citizens of a corporate state), is not covert, but in plain view in the form of tests, that allow that surveillance to be disembodied from those students and teachers – and thus appearing to be impersonal – and examined as if objective and a reflection of merit. (Thomas 2013: 215)

The notion of depersonalised, disembodied surveillance parallels some of the restrictions introduced with little resistance following the pandemic (and our point here is to highlight the lack of political and intellectual scrutiny of their implications, rather than the implementation). It underlines that this disembodiment has become 'business as usual', an element of twenty-first century alienation: the way we live now. In this disjointed, disembodied existence where 'the work of the brain is subjected to the heartless rule of finance' people end up 'sick at heart in many ways' (Berardi 2017: 206). Here living, as in being in the world, is undermined, deprived of its 'poetry'. Lefebvre borrows from Heidegger the notion that '[d]welling, in its essence, is poetic' and cites the German decisively on the possible reasons for the absence of the poetic and 'our inability to take the measure of man and his heart', suggesting that these deadening influences 'spring from a strange kind of excess: a rage for measurement and calculation' (Lefebvre 2003: 122).This is about being free and everywhere in chains, but also reflects a worsening infection since it problematizes Rancière's assumption that teachers might be at least emancipated intellectually. His recipe for intellectual emancipation only requires teachers to be emancipated themselves, an ingredient he cannot have imagined would soon be in such short supply (Rancière 1991: 15). In 2021 teachers spent weeks collating evidence to support the grades they were awarding their students. Nobody even suggested that time might have been better spent educating them. The map had clearly preceded the territory.

Berardi is clear where this is going but also optimistic that it can be remedied. His bare statement of the former is designed to encourage us to the latter. His view is that if this separation between educational achievement as technical formation and critical education persists: 'By the 2nd generation no trace of autonomous self-consciousness will be left in the social brain, the legacy of modern culture will be reduced to vestiges for antique dealers and the general intellect will be forever subjugated.' (Berardi 2017: 210–211) He calls on universities in particular to defend the autonomy of knowledge because it is 'the only way to overcome the corporate devastation of the world and the global identitarian civil war' (214). It is also in what Berardi calls 'the Age of Impotence' and 'the horizon of possibility of our time'.

6 The Age of Vulnerability

> We're all vulnerable right now. (Latino farmworkers, California)

This impotence is also intertwined with the uncertainty and fragility which characterise our times: 'As Berardi has argued, the intensity and precariousness of late capitalist work culture leaves people in a state where they are simultaneously exhausted and overstimulated.' (Fisher 2014) This sense of exhaustion leads to a heightened sense of vulnerability. During the past decade, vulnerability has become a ubiquitous term in social policy and politics to the extent that we could as easily refer to an age of vulnerability as to one of impotence. As so often, this has simultaneously expanded and contracted its meaning(s), although they rarely tend towards the positive. The pandemic focused attention on vulnerable groups to the extent that 'vulnerability scores' were used in England in April 2020 to ration Covid-19 treatment – the more vulnerable patients were on this measure, the less likely they were to be admitted to hospital or treated (Calvert and Arbuthnott 2021). Something sinister was afoot.In their overview of its 'many faces', Brown et al. assert that vulnerability tends to appear in three forms across a range of literatures:

> as a policy and practice mechanism, which plays out in interventions, sometimes overtly and explicitly, sometimes subtly or unnoticed; as a cultural trope or way of thinking about the problems of life in an increasingly pressured and unequal society; and as a more robust concept to facilitate social and political research and analysis. (Brown et al. 2017: 498–499)

Analysis of social policy has tended to focus on the first form. In neoliberal social and education contexts, notions of vulnerability have tended to regard individuals as 'architects of their own disadvantage' (Potter and Brotherton 2013: 7). The UK, which Fisher (2018: 459) described as 'the world capital of apathy, diffidence and reflexive impotence', has often been a pioneer in this. The troubled families programme launched in England in 2011 to 'support' 120,000 families facing disadvantage is the pre-eminent example. More social democratic social models, such as those common in Scandinavia, recognise the role played by context and the social environment, but tend to undervalue individual factors. Identifying and measuring vulnerability in the neoliberal context – blaming the victim – also allows it paradoxically to be depoliticised and ignored (Potter and Brotherton 2013). By May 2015, the UK Government was claiming that '99 per cent of troubled families had been turned around' (Crossley 2017). The fact that this was widely contested and ridiculed was unimportant. The improvement, which had not taken place, had occurred.

However, what is striking is that even theoretical approaches that are hostile to the processes and effects of neoliberalism tend to default to reductive notions of vulnerability: 'Unless there is a challenge to the construction of the idea of human beings as vulnerable and diminished that is being strengthened through therapeutic education, it will be impossible for workers to confront and resist the therapeutic workplace.' (Ecclestone and Hayes 2019) It is notable that Ecclestone and Hayes' (2019) acute exploration of the negative effects of the therapeutisation of education elides the notion of vulnerability with being 'at risk', which seems a rather narrow view. This means that, rather than Brown et al.'s (2017) 'more robust' concepts of vulnerability, the suggestion here is we use the complexities and duplicities that Covid-19 has spotlit and magnified to co-opt broader notions of what being vulnerable can mean.

Drawing on Foucault's work on sexuality and desire, Angel (2021) highlights the danger of regarding vulnerability primarily as a state to be overcome or resisted: 'When you feel vulnerable, it's tempting to brace yourself against vulnerability – the fantasy of hardening yourself so that nothing can hurt you. The collateral, however, is that nothing can reach you, either.' This notion of admitting, rather than concealing, one's sense of vulnerability is something we have addressed in relation to education (Jopling 2019). As Larrivee (2000) has emphasised, in this context the capacity to reflect in teaching is closely related to the acceptance of uncertainty when addressing a problem. This requires teachers to relinquish control and reveal their vulnerability, rather than regard it as something to be suppressed. Revealing vulnerability in this way can be an effective way of reaching and building trust with vulnerable young people, who are typically written off as 'hard to reach' (ironically echoing Angel's description). Here vulnerability is a precursor of an emancipatory form of collaborative learning.

This can be taken further with reference to Judith Butler's (2020) more resilient and engaged conceptualisation, in which rather than being a state to be resisted, vulnerability is recast as a form of activism: 'What if the situation of those deemed vulnerable is, in fact, a constellation of vulnerability, rage, persistence, and resistance that emerges under these same historical conditions?' Here vulnerability becomes part of a more complex conglomeration of responses to the situation which causes it. Butler's language recalls Fisher (2018: 459), who followed the characterisation of the UK as apathetic, already cited, by describing it as 'the country that periodically explodes into rage'. Despite the fears of the Government and its advisors (and leaving the conspiracy theorists to one side), this was not a common response to the extreme restrictions of lockdown in 2020.

In fact, like so many administrations, the UK Government was largely given the benefit of the doubt when a rapid vaccine roll-out in 2021 drew the public's attention away from its sluggish early responses to the pandemic, captured most vividly in its repeated failures to keep its regular promises to open schools, universities or pubs. The irony here is of the punctum of the vaccine which causes the recipient to forget earlier fears, agonies and vulnerabilities, reflecting most poignantly Barthes' (1981) celebrated 'punctum of a photograph' – 'some detail that has an unexpected and inordinate capacity to wound' (Royle 2018). Barthes' punctum exercised its power through bringing memory and an image of the past together. The vaccine's punctum effectively wiped the past, bringing its recipients closer to the old normal than the normal new, and persuading many that the threat can be ignored or forgotten. At least for a while.

7 (Not) Forgetting/(Not) Remembering

> I have no memory for things I have learned, nor things I have read, nor things experienced or heard, neither for people nor events; I feel that I have experienced nothing, learned nothing… (Kafka 1973: 270)

In *Forgetting*, Gabriel Josipovici (2020: 23) quotes from Beckett's book on Proust: 'Only he who forgets, remembers.' Pleasingly, this itself is a misremembering of Beckett's (1965: 29) '[t]he man with a good memory does not remember anything because he does not forget anything'. Although Josipovici is correct in finding his distillation pithier, it also loses something. Beckett's double use of the negative is characteristic in pinpointing the necessity of forgetting, which itself echoes Josipovici's (2020: 58) later use of Nietzsche's assertion in *The Genealogy of Morals* that 'it is altogether impossible to live at all without forgetting'. This has an unsettling effect on us as we wonder whether not remembering or not forgetting is preferable. Josipovici's (2020: 58) point is that they are interdependent: 'In each case the question is of the right balance between remembering and forgetting, between waking and sleeping, between that which can help us live, can invigorate our activity as Goethe put it, and that which paralyses us'.

This recalls Fisher's (2018: 757) characterisation of the recent past in a hauntological gesture which undoes forgetting: 'to recall these multiple forms of collectivity is less an act of remembering than of *unforgetting*, a counter-exorcism of the spectre of a world which could be free' (emphasis in original). The paradox of this counter to easy nostalgia is itself reflected at the end of Josipovici's book, where, referencing Beckett and Wallace Stevens, he identifies the necessity and impossibility of reaching an understanding that is beyond memory and forgetting:

> Imagining forgetting is as impossible as imagining the absence of imagination, yet with the one as with the other, we are hungry for that experience, feeling that if only we could reach behind our imaginings, behind our memories, we would find our true place in the world. This remains, however, always tantalisingly out of reach. (Josipovici 2020: 143)

For an education system that has focused on the pandemic in terms of 'learning and earning loss' for school and university students, rather than as a challenge to the very notions of knowledge and learning, this may well look like theory getting in the way of practice. In fact, it offers a potential way to understand what we have experienced and continue to experience. If in a time of post-truth, cancellation and denial are the dominant forms of willed forgetting, education has a key role in play in asserting the interdependence of both remembering *and* forgetting in order to understand how we have come to this pass and how to move past it.

This is the promised end. As we seek UK Prime Minister Boris Johnson's fabled, irreversible 'opening up' and education's mythical 'catching up', all within the 'paradise postponement' which is 'levelling up', so Baudrillard's dark and difficult later work, his fatal theory, slides into view. Irreversibility is a cornerstone of Baudrillard's critique, which suggests that only according to this principle do we allow meaning to ensue. However, somewhere between the virtual and the illusionary, the pandemic refuses to conform. The biological resists the process of naturalisation and the rhizomatic refuses to become the genealogical. As Deleuze and Guattari emphasise:

> The rhizome is an anti-genealogy. It is a short-term memory, or anti-memory. The rhizome operates by variation, expansion, conquest, capture, offshoots. Unlike the graphic arts, drawing or photography, unlike tracings, the rhizome pertains to a map that must be produced, constructed, a map that is always detachable, connectible, reversible, modifiable, and has multiple entryways and exits and its own lines of flight. (Deleuze and Guattari 1987: 21)

Not only anti-genealogy, this is anti-memory: not rock and roll but genocide. Baudrillard offers the radicalization of all hypothesis as part of his campaign of theoretical violence. The pandemic unsurprisingly proves a fertile case study since it both supports and apparently confounds Baudrillard's assertion that symbolic exchange is over and signs cannot cross to the objective world, testing his belief that 'simulacra prevail over history' (Baudrillard 1993: 56). This challenge is not provided theoretically but rather practically by the refusal of the biological to be possessed or controlled. Thus, although clearly virtual and subject to illusion, the pandemic is also immanently a manifestation of excessive practice, which Baudrillard argues abolishes systems by pushing them into hyperlogic.

We recognize Baudrillard's image of politics as a form of manipulation employing surface appearance and empty forms, precisely in the politics of the pandemic: indeed it has rarely been more apparent. However, it may also be the case that in the current circumstances, postmodern (post-truth) society's unchecked need for fascination, which Baudrillard believed had usurped the need for meaning, has been, in simple terms, reversed. This is not to argue for a society coming to its senses or indeed a society presented with this opportunity, although of course these versions will have purchase for some. However, it might constitute a previously unimaginable opportunity to reconsider Baudrillard's late career dilemma with new information and propose a way forward that is less fateful or indeed fatal.

Baudrillard's concept of fatal strategies derives from his inability to conceive of a productive function for theory which was not futile (and both politics and education constitute theories in this sense). Fatal theory embraces futility, dramatically and poetically, but perhaps not conclusively if it is ultimately outflanked by its own desire to make an end, an apotheosis: the vanishing point. Interestingly, for Baudrillard (1983) memory represented a threat, the preservation of the past in the present which contributes to the derealisation of the moment and the loss of the present to memory. As such it is a kind of 'suspension of disbelief' and dreaded deferment of extinction: like the Sybil who hangs suspended over Eliot's Wasteland and only wants to die or the little boy who promises Godot will come tomorrow.

Meanwhile, at the centre of the pandemic, both literally and symbolically, is the virus. It exists only to make more viruses. It may not be properly alive but it is a rewriter of scripts including this one. In this stand-off there may be a moment to reconsider. Derrida embraced something of this alternative in the law of genre, conceiving of 'a principle of contamination, a law of impurity, a parasitical economy' and also 'the law of abounding, of excess, the law of participation without membership, of contamination' (Derrida 1981: 59, 63). In simple terms the pandemic is reversible and that changes everything: adapt or die.

8 Conclusion: Beyond Our Depths

What implications does this have for how we approach knowledge, learning and education in the broadest senses? It seems clear that the pandemic has both accelerated and magnified social, cultural and political issues that were already dominant. In this the UK is a peculiar but by no means unrepresentative case. Barthes (1972: 131) wrote that 'myth is always language-robbery' and the pandemic has allowed the post-truth linguistic denials and cancellations that have characterised the Brexit saga (to name one example) to proliferate further. It would be tasteless to refer to the 'fatal strategies' and prevarications that led to so many deaths, but the pandemic has showed the gap between the 'scientific advice' that has been offered and the linguistic distortions and denials of history in real time that have been 'justified' by that advice. The challenge for all of us is to attempt to remain inquisitive observers in real time. In the educational context, that has played out in terms of a narrow focus on 'catch-up' and 'loss'. Unfortunately, this has more often than not been based on simplistic calculations of time out of school or college and fanciful projections of future earnings, rather than a more considered reckoning with how to rethink learning for the normal new (Riordan and Jopling 2021).

In his critical review of Camus's *La Peste,* to which so many turned at the beginning of the pandemic, Barthes (2002: 7) wrote that '[e]vil sometimes has a human face and *La Peste* says nothing of this … Everything begins where the plague is not only the plague, but the image of evil in the human face'.[1] While he is specifically referring *La Peste'*s allegorical concern with the second world war, Barthes' observation also highlights how important it is to recognise that the pandemic is constituted of both the virus itself and our actions in response to it. This justifies our use of theory (as practice) to provoke different understandings of our predicament (and practices) because it is only by seeing through the language-robbery and attempts to revise history in real time that we can resist the mythologisation.

In fact, resistance, one of the emergent themes of this chapter, may itself represent one of the new functions of education that we sought in response to Williams (1961) and the form of action to which it needs to contribute. The complexity of the virus and its mutations has been increased by the multiplicity of our varying responses to it, both individually and collectively. This means our resistance to its implications need to be similarly deft. At the end of Kafka's (1961: 91) story, 'The Silence of the Sirens', it is characteristically unclear whether or not Ulysses is complicit in the sirens' silence: 'Perhaps he had really noticed, although here human understanding is beyond its depths, that the sirens were silent, and held up to them and to the gods the aforementioned pretence merely as a sort of shield.'

We are in this kind of territory in response to the pandemic, where so much human understanding is out of its depth. As a result, we need both to see through and outplay the pretences that have been used to disguise that failure of understanding. The ways in which the pandemic has focused our attention on the issues we have explored: simulation, denial, vulnerability and remembering/forgetting means it is imperative to use the knowledge we have developed of these issues to move out of our depths, which is of course also a movement into depth. It is important to recognise that the pandemic extends the widespread sociocultural disembodiment and depersonalization that the relentless surveillance of teachers and learners symbolizes. It is also crucial to understand it in terms of Baudrillard's notion of irreversibility, particularly in the light of the apparent memory-cancelling functions of vaccines. Barthes (1972) reminds us that myths create a simplified world without depth and we need to reject the myths perpetuated by neoliberalism in order to rethink so much, both in education and more widely. While the viral aspects of the pandemic will withdraw, its human elements and consequences will be much more enduring.

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Postscript: Revisiting the Concept of the Edited Collection

Michael A. Peters, Petar Jandrić, and Sarah Hayes

1 Introduction

The edited collection is a standard publishing vehicle that stands alone among other collections as an academic form of writing that since its beginnings in the nineteenth century has been taken for granted and has remained unchanged in terms of its conventions. The edited collection is a collection of original scholarly chapters written by different authors and arranged or organized by the editors of the collection to reflect different perspectives on a theme, generally chosen by the editors and developed in a 'call for chapters' that summarizes the main ideas and indicates the subthemes. It is different from anthologies which republish important articles, normally chronologically, or the edited book series, both of which are forms of academic publications that involve editing contributions from different authors. Much of the responsibility for the edited collection rests with the editor or editors who craft the volume's purpose and structure and generally provide an introduction to the major themes of the work and mention each chapter and its contribution to the work as a whole.

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Michael Peters and Petar Jandrić have published many edited collections including *Education and Technological Unemployment* (Peters et al. 2019) and *Knowledge Socialism: The Rise of Peer Production: Collegiality, Collaboration, and Collective Intelligence* (Peters et al. 2020a). In this edited collection, *Bioinformational Philosophy and Postdigital Knowledge Ecologies,* edited with Sarah Hayes, we have decided to theorize and experiment with this form of scholarly communication in the humanities and social sciences.

Historically, the edited collection has had much value. In order to stretch its limits, we decided to explore the way in which we might encourage greater reflection on a major category of academic publishing whose form and standard conventions are often taken for granted. In our paper, 'Revisiting the Concept of the "Edited Collection": *Bioinformation Philosophy and Postdigital Knowledge Ecologies'* (Peters et al. 2021a) – which is partially reproduced in the first part of this Postscript – we provided a brief overview of history, philosophy, and the practice of the edited collection. We designed a new approach to collaboration in this edited collection, and we invited authors to join us in this exciting journey into the unknown. In this paper, we first present our invitation sent to all authors and conclude with a brief analysis.

2 The Edited Collection – Openness, Collaboration, Trust

We recently discovered Peter Webster's *The Edited Collection: Pasts, Present and Futures* (2020a), focused on church history that at the same time begins the process of rehabilitating the notion of the edited collection as a 'lesser work', where he writes:

> Edited collections are widely supposed to contain lesser work than scholarly journals; to be incoherent as volumes, no more than the sum of their parts; and to be less visible to potential readers once published. It is also often taken as axiomatic that those who make decisions in relation to hiring, promotion, tenure, and funding do so agree. To publish in or edit an essay collection is thought to risk being penalised for the format before even a word is read. After examining the origins of this critique, this Element explores the modern history of the edited collection and the particular roles it has played. It examines each component part of the critique, showing that they are either largely unfounded or susceptible of solution. It proposes the edited collection as a model of one possible idea of scholarly community: collaboration, trust, and mutual obligation in pursuit of a wider good. (Webster 2020a)

Webster proposes a defence of the format of the edited collection, examining the elements of the critique to show that they are unfounded 'or (if they are of real substance) that they may be resolved' (Webster 2020b).

Webster's defence and proposal that the edited collection is a scholarly model of community based on 'collaboration, trust, and mutual obligation in pursuit of a wider good' (Webster 2020a) is a theme and philosophy that reverberates with us. We would argue that there is a need to retheorize the construction of the edited collection, as a scholarly format of academic publishing in the age of peer production, where collegiality, collaboration, and collective intelligence take on new value. This enables us to use it more constructively to explore themes of the collection. We can do this by writing papers that act as a springboard, reference point, and theoretical position, which contributors can use to spur their own thinking either in use, modification or criticism of the ideas proposed. This additional material in this case is generated by the editors (in three separate but related papers) (Peters et al. 2021b, c, d) together with this reflection on the publication format of the edited collection. When taken together, these materials may provide additional resources, research directions and perhaps greater research coherence, extending and broadening the concept of the edited collection.

During this global pandemic, the principles of free online scientific articles has been an urgent priority, especially where the speed of exchange and new scientific findings are required. These, in a sense, are able to compete and even outrun the speed of infection, mutation and development of new strains of Covid-19 (Peters et al. 2020b, c). At the same time, the concept of 'community' must be distinguished in terms of scientific and scholarly communities exchanging academic work on the basis of argument and evidence, from media sites and cultures where there is no emphasis on science, evidence, testing and rigorous analysis. Bioinformational and biodigital philosophy has the job not only of observing and analysing the evolving forms of science and knowledge, its production under different modes, its publication forms, but also of understanding and explaining the differences between the social epidemiology and epistemology of conspiracy thinking. This includes differentiating between viral forms of disinformation (infodemics) (Peters et al. 2020c), those forms of public science that are open and available free to all – so-called open science – but also with regard to the mode of open knowledge production and its associated forms of open education.

The value of openness here is part of an emerging economy of knowledge ecologies that has a range of applications in open access, open data, open methodologies, open peer review, and open educational resources. These emergent social forms tend to focus on collaborations and distributed computing and cognition, and both open submissions systems and open public access. This kind of open science knowledge, distributed for free by publishers suspending the paywall or publications in open science, advanced the speed and development of the vaccines in the international community, hopefully to save millions of people from dying from Covid-19 globally. The United Nations Web site (2020a) indicates that '[t]he UN is calling for authoritative scientific information and research to be made freely available, to accelerate research into an effective vaccine against the Covid-19 virus, help counter misinformation, and "unlock the full potential of science"'. The United Nations news story (2020a) indicates that '115,000 publications have released information related to the virus and the pandemic, and more than 80 per cent of them can be viewed, for free, by the general public'.

Another United Nations news story (2020b) records, '[t]he heads of three UN agencies joined forces on Tuesday to appeal for a global push towards "open science", citing the value of cooperation in the response to Covid-19 and the dangers of treating evidence-based knowledge as an exclusive asset, or simple matter of opinion'. The story indicates how 'UNESCO is taking the lead in building a global consensus on values and principles for Open Science' and contains reference to the first draft of the UNESCO (2020) Recommendation on Open Science that declares six aims and objectives including:

1. Universal access to scientific knowledge [as]… an essential prerequisite for human development and progress towards planetary sustainability.
2. …Open Science sets a new paradigm for the scientific enterprise based on transparency, sharing and collaboration…
3. As Open Science turns into a global movement, robust institutional and national Open Science policies and legal frameworks need to be developed by all nations to ensure that scientific knowledge, data and expertise are universally and openly accessible and their benefits universally and equitably shared. (UNESCO 2020)

The first draft is to promote 'a common understanding of Open Science', to develop 'an enabling policy environment' and encourage investment in Open Science capacity and infrastructures that will 'transform scientific culture' and 'promote international cooperation on Open Science' (UNESCO 2020).

Michael Peters has examined and advocated the virtues of openness (Peters and Roberts 2011) and tried to develop the philosophy of openness in relation to building knowledge cultures (Peters and Besley 2006) and understanding the concept of open science and open education (Peters 2006; Peters and Britez 2008; Peters et al. 2011, 2012). Peters uses the concept of radical openness as a new logic for public organizations, economy and management and as a means of fostering large group creative collaboration and co-creative labour based on being open, peering, sharing, interdependence and acting globally. He argues that openness should be considered as the basis of the global knowledge commons as an emerging mode of social production for education and science (Peters 2012, 2013a, b, c). In this context, his argument and concept is that 'co(labor)ation' refers to the wisdom of the crowd (so-called crowdsourcing), and a systematic mode of collective learning processes that offers the prospect of encouraging 'creative labour' (Peters 2013a, b, c).

This same value of openness can be applied to the notion of the edited collection as a basis for promoting coherence or consistency in research focus and aims. It promotes a creative flexibility especially in the area of the postdigital-biodigital convergence (Peters et al. 2021b), where past philosophy and digital studies are still scattered in silo-ed disciplines and have been slow to address this new convergence that is determining of the global knowledge ecosystem as a whole.

3 The Edited Collection in the Age of the Postdigital-Biodigital Convergence

The edited collection, as we have come to know it, has been shaped as something of a standardised production, within our neoliberal political economy. Critiqued from a scientific point of view as a lesser publishing vehicle to a journal article, particularly in research measurement exercises (Webster 2020a, b), the writing of book chapters has almost become something that many of us do (and perhaps actually enjoy) 'behind closed doors'. Whilst aiming for acceptance in a high impact journal to meet institutional demands, we might simultaneously write a chapter because collaborating on an edited collection involves a creative process, dialogue, topic of interest and being a part of a writing community. Within a neoliberal political economy however, the direct individual 'impact' from such communal aspects of the writing and editing process is hard to measure, and so is less valued. Metrics applied to journals mean that a particular place of publication is deemed more important than the actual written content (Jandrić and Hayes 2019: 381). However, 'measuring research excellence brings a particular concept of research excellence into being' (Jandrić 2021: 19). It is a concept that sits within, and is dialectically related with the neoliberal process of academic publishing, which 'is a form of "social production" that takes place across the economy, politics and culture, all of which are in turn accommodating both old and new technology in our postdigital age' (Jandrić and Hayes 2019: 381).

It is this 'digitalisation' in our postdigital age which (whilst it may currently serve neoliberal goals) now offers a fundamental disruption to humanity. This is because 'biodigital technologies, or the biologization of digital processes, are a reflection of a very different kind of political economy' to our current one (Peters et al. 2021b). Alongside a technological and biological shift, where 'biology as digital information, and digital information as biology, are now dialectically interconnected' (Peters et al. 2021b: 370) we can also appreciate a philosophical shift. This is a shift based on environmental self-renewal and synthetic enhancement (Peters et al. 2020b, c) and a philosophy of biodigitalism, as opposed to endless market-led growth within neoliberalism.

This in turn impacts on our understanding of human labour and indeed the academic labour processes relating to the production of an edited collection. If the bioeconomy concerns using for example renewable feedstocks to produce everyday goods and services, this now encompasses a wide range of sectors and activities, such as food, agriculture and forestry. The bioeconomy is a new means of production that will gradually replace fossil-based production and be consistent with the concept of a circular economy (Philp and Winickoff 2018). As such, this combination of digital and biological transformation has significant implications for companies, as it changes the design and handling of production processes and their products. It has significant implications too, for academic labour and publishing processes as these are reimagined in a new philosophy of biodigitalism.

Through 'exploring a philosophy of biodigitalism, as a new paradigm closely linked to bioinformationalism' we can therefore appreciate that 'both involve the mutual interaction and integration of information and biology, which leads into discussion of a biodigital convergence' (Peters et al. 2021b: 370). Within this unified ecosystem, we now have opportunities to resolve problems that isolated disciplinary capabilities cannot. This has been demonstrated during the Covid-19 crisis, as a new significance of relationships between the biological and the technological has been revealed, along with 'new knowledge ecologies within a constellation of technoscience' (Peters et al. 2021b: 370). Thus, against a background of scientific crises and challenges to resolve, we perceive many sites of promise for social change, including new ecologies in publishing.

Through a postdigital-biodigital convergence, we have an opportunity to disrupt the existing set of socially constructed standard conventions that misleads us into thinking that there is only one possible rationality for edited collections. As authors in an edited collection, it is the current norm to be provided with a (usually strict) set of guidelines. Thus, we might play with more ecological and self-renewable models. In this new philosophical configuration, we no longer need to accept that the edited collection is somehow less worthwhile than other publishing formats because we can change this discourse. However, to experiment with the edited collection as a concept, and across a community of writers and editors, requires a certain amount of unlearning for each of us. It requires resistance to the digital obedience we have adopted where Big Tech 'platform ontologies' know us better than we know ourselves (Peters 2020). We have become used to strictly following a set of prescribed conventions that lack an ongoing dialogic element and the more open philosophical values of sustainability. It is important then that the few initial new possibilities suggested below are expanded in what we perceive to be an ongoing postdigital-biodigital convergence dialogue, related to the labour and production of edited collections. For this experiment to work, the list below needs to be extended, contended, and further shaped.

We identify some new possibilities for edited collections in general:

1. In the light of the postdigital-biodigital convergence explored in the trilogy of papers we are now seeking to collaboratively establish a research direction and sustainable and creative research practices for the edited collection in the humanities.
2. This means extending the 'editing' side of the edited collection through a range of collaboratively developed processes that channel our research and thinking.
3. This means rethinking the 'collection' part of the edited collection by recognizing that there are different forms of the genre, including anthologies, encyclopaedias, and others. We might consider how editing could vary with, and across, genres. We might think further about the ideological nature of genres and question whether they normalise certain values in our current political economy, when other understandings and forms of agency might emerge underpinned by a new bioeconomic political economy.
4. This is related also to an ongoing working with, and shaping of, values of 'radical openness' (Peters 2014), taking into account how these might be enacted across different regions and cultures. It may involve developing new 'pledges' too, like the Open Covid Pledge for Education (Association for Learning Technology 2020), for example.
5. If technological development has taken the lead in scientific inquiry, we might explore the philosophical and social implications of this convergence.
6. A new imaginary could emerge where we may be confident that, if biology can no longer be thought about without technology, then scientific and other disciplinary categories can no longer act as hard borders in edited collections.

7. These ideas could aid our processes of thinking, acting, writing and editing more fluidly and reflexively across existing and new disciplines.
8. As we develop the craft of authoring and collaborating simultaneously, we need creative ways to document the rich interplay that develops, for others to work with.
9. We might give more space to each author's postdigital positionality (Hayes 2021) as part of the new philosophy of openness outlined above. This may involve a deeper exploration of the fluid identities, spaces and power relations that surround each contributor. Such details emerged freely, for example, when a large collective group of authors responded to a call to provide personal Covid-19 testimonies and workspace images (Jandrić et al. 2020).
10. Exploring new alternatives to our current political economic discourse through a political bioeconomic discourse in our institutions and organisations, businesses and community groups could take the form of live debates (Hayes et al. 2020) that shape edited collections verbally, as well as textually.
11. New diverse collaborators might participate in different ways, or through contributing to establishing different and new genres. The role of genre to assist during the writing process, rather than simply as categorisation, might be explored. Perhaps genres are more fluid in a bioeconomic political economy; therefore, this gives us more scope to negotiate their boundaries 'in social interaction between writers and readers through texts, shifting to reflect changing social contexts. Through the decision to conform to or subvert genre conventions in their writing, writers contribute to these changing genre boundaries.' (Grimmer 2017).
12. Where once we might have discussed a 'literary style' and forms of 'literacy', we may now need to question more deeply what we mean by literary, and literacy, at the intersections where humanities, biology, technology, economy and politics meet.

The above are just a few possibilities raised to provoke discussion, for development and for further elaboration, to break down the 'established' conventions for the edited collection that a neoliberal political economy has structured. Inspired by a postdigital-biodigital convergence, we look forward to collectively redefining the edited collection through a new dynamic bioeconomic political economic discourse.

4 What Is Next?

In order to address this question against the background of the call for chapters, we invited each author to:

1. Consider Webster's (2020a) proposal that the edited collection is a scholarly model of community based on 'collaboration, trust, and mutual obligation in pursuit of a wider good'.

2. Think about the role of openness, as an essential aspect of an emerging global knowledge commons that fosters open science and open education (Peters 2013a, b, c). Think too about how radical openness and collective learning might encourage creativity and coherence in our edited collection.
3. Read the additional material generated by the editors of this volume. This is the three separate but related papers about bioinformation philosophy and postdigital knowledge ecologies (Peters et al. 2021b, c, d) and the paper on revisiting the edited collection (Peters et al. 2021a).
4. Use this material to explore the themes of the collection and to provoke their own thinking concerning how they might modify, extend, or critique the ideas proposed.
5. This additional material, together with this reflection on the publication format of the edited collection, are intended to provide additional resources, research directions and hopefully a greater research coherence, that will extend and broaden the concept of this edited collection.

Finally, we wrote: We do hope that prospective authors for *Bioinformation Philosophy and Postdigital Knowledge Ecologies* will share our belief in the value of this experiment. The edited collection is a collective enterprise, and this experiment is fully in the hands of its contributors. We look forward to reading and editing your contributions!

5 Revisiting the Concept of the Edited Collection

Looking at suggested general new possibilities for edited collections, we can conclude that turning our theories into practice has achieved varied success. In terms of access, for instance, our pledge to radical openness does not meet the basic criterion of Open Access – this book, or more precisely its digital version, is paywalled by the publisher. In terms of content, however, we are really pleased that we managed to place arguments developed by biologists, philosophers, priests and their many positionalities (Hayes 2021), shoulder to shoulder.

Authors developed their chapters fairly independently of each other. Taken together, however, the richness and diversity of their works creates a postdigital dialogue which reaches beyond direct communication (Jandrić et al. 2019). Individual contributions neatly follow academic standards for the genre of book chapters in the humanities, yet chapters written by authors working in different fields, such as philosophers and medical doctors, bear many traces of disciplinary differences. Even book's structure, in which each part is an explicit or implicit response to themes identified in our preparatory papers, is far from common. It would be presumptuous to claim that all authors in this book have engaged with our experiment to the same or even similar extent. Yet these differences also indicate different positionalities. Authors' understanding of the importance of this experiment – and the level of their engagement within the experiment – reflect their epistemic values and practical willingness to engage with this type of experimentation.

While we have not managed to practically explore all new possibilities for edited collections identified in our theoretical work, this book does scratch their surface and shows that experiments in academic publishing are much easier to imagine than to put into practice. This work also opens new possibilities, and new directions, for further experimentation with academic publishing. What would have happened, if we involved a more diverse group of authors in our invitations? What would have happened, if we invited four or five co-editors, where each editor would 'represent' one discipline (such as medicine or biotech)? What would have happened, if we did a similar experiment in a radically different field such as engineering?

With such variations in mind, a new edited collection is being developed with diverse cross-sector authors contributing chapters that bring together voices from charities, small businesses, cross-disciplinary academics, councils and combined authorities. *Human Data Interaction, Disadvantage and Skills in the Community: Enabling Cross-Sector Environments For Postdigital Inclusion* (Hayes et al. forthcoming 2022)[1] is experimental too, in that the draft chapters have been developed further, through two strongly dialogic virtual events. These meetings introduced the authors to each other and have provided forums for the cross-sector dialogue to flourish. Furthermore, such an approach towards an edited collection with such a multitude of positionalities and contexts represented, demonstrates a vibrant approach towards knowledge exchange that challenges more static conceptions of a Knowledge Exchange Framework (KEF) (Research England 2021) and reporting mechanisms.

It is our belief therefore that there are close links to be made between these varied, experimental approaches towards extending how we understand edited collections in the humanities and what we describe as 'enabling cross-sector environments for Postdigital Knowledge Exchange (PKE)' (Hayes et al. 2021). We suggest that:

> Rather than heading into the community with a ready-made policy model or knowledge exchange framework to work to, postdigital knowledge exchange disrupts and inverts this approach. Based on both cross-sector postdigital dialogue *and* interdisciplinary academic debate together, these co-inform more dynamic theoretical and policy frameworks. (Hayes et al. 2021) (emphasis from the original)

Such an approach offers a more dynamic and ecological route towards exchanging knowledge and contributing to edited collections that are inclusive of multiple diverse stakeholders in communities.

In this book we pursued two parallel strands of inquiry: research into bioinformational philosophy and postdigital knowledge ecologies, and (theoretical and practical) investigation of the concept the edited collection in the age of the

[1] This book, Hayes, S., Connor, S., Johnson, M., & Jopling, M. (forthcoming 2022). *Human Data Interaction, Disadvantage and Skills in the Community: Enabling Cross-Sector Environments for Postdigital Inclusion.* Cham: Springer, is scheduled for publication in the Postdigital Science and Education book series.

postdigital-biodigital convergence. For practical reasons, including traditional expectations from edited collections and the limits of our own cognition, we decided to present conclusions arriving from our two research strands separately. However, these two strands of inquiry are dialectically related, as our ways of arriving to knowledge strongly impact its quality and structure (Jandrić 2021). Should we try and be even more radical in merging these different yet interconnected strands of inquiry into one?

So many questions, so little answers. Our only consolation is that Rome was not built in a day. Facing a mountain of things we don't understand, we humbly decide to take one step at a time. After this book is published, and after we receive feedback from our readers and reviewers, we will try to push our theory of the edited collection a bit further. Then, we guess, the time for another experiment will arrive…

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Afterword: Whither Bioinformatics in a Shifting Biosocial World?

Steve Fuller

The best way to read the diverse contributions of *Bioinformational Philosophy and Postdigital Knowledge Ecologies* is in terms of clearing the way for a more intellectually systematic and politically focused approach to the increasingly 'bioinformatic' character of the human condition. My own view about this, which should be clear below, is that the 'bio-' is being at once deconstructed and reappropriated rhetorically across the entire political spectrum. There is a deeper question lurking here about why 'bio-' retains its rhetorical allure, even though it has been virtually emptied of content. But that would take future work to address properly. In the meanwhile, perhaps the following will help focus minds as we move forward into what is definitely a 'Brave New World'.

The poet Ralph Waldo Emerson is normally credited with first calling the United States a 'melting pot'. In fact, he said 'smelting pot', to emphasize that the mixing of peoples from different lands resulted in a new and improved product (Luedtke 1979). Emerson's model for thinking about the US in this way was medieval Europe, which he imagined as a place where different peoples mixed freely, united by a common creed (Christianity) and a common language (Latin). To be sure, this is a curious reading of the Middle Ages, though it conforms to the nostalgic image that nineteenth-century Romantic thinkers tended to have of the period. Taken to next level, the idea that the postcolonial Western hemisphere might be a strong attractor for all the world's peoples, resulting in a 'cosmic race', persisted well into the twentieth century – most notably in Mexico's answer to Wilhelm von Humboldt, José Vasconcelos. Like Emerson, Vasconcelos was a Romantic, whose idea of genetics was more Lamarckian than Darwinian. He believed that mixing races resulted in stronger not weaker variants. Indeed, he believed that the 'mestizification' of the

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world would usher a new ‘aesthetic’ era for humanity (Vasconcelos 1997). For most of the twentieth century, Mexico’s checkered political and economic track record as a mixed-race country *vis-à-vis* that of the US as a largely racially segregated country appeared to discredit Vasconcelos’ thesis – especially as Darwinists weighed in with their regularly updated views on genetics.

Bioinformatics must address this curious intermingling of biological, social and even spiritual identity, which carries on to this day. Consider US President Joe Biden’s ‘Science and Society Czar’, Alondra Nelson, Professor of Social Science at Princeton’s Institute of Advanced Studies. She has made a career out of problematizing advances in biometric technology as a vehicle for establishing any clear sense of racial identity. This issue matters in the US context, where there is considerable public intellectual – but much less legal and political – appetite for awarding ‘reparations’ based on slave ancestry. Her appointment did not surprise me. Indeed, I had already been assigning her ethnographic work (Nelson 2016) for Warwick’s Master’s level ‘Understanding Social Science’ course, which is taught to the entire faculty. It is likely to prove to be an interesting work from a world-historic standpoint. After all, had Nelson written a century ago, you might have guessed that she was White and wrote out of concern for the preservation of racial purity. However, as a Black person writing today, Nelson is more ambivalent in dealing with her co-racial informants.

To be sure, Nelson is well aware that the US has failed to fully deliver on the promise of racial equality. This has become more acute through the recent high-profile cases of apparently race-based police brutality that may have been inspired by Biden’s predecessor, Donald Trump. Thus, there are now campaigns across America to ‘defund the police’, backed by the largely social media-based Black Lives Matter movement. Black intellectuals have contributed to this tendency, increasingly adopting what might be called a ‘pro-racialist’ or ‘self-segregationist’ style of politics. Yet, the relevant advances in biometric technology really do not support any such ‘reverse racism’. In fact, they arguably go against the category of ‘race’ altogether, a point to which I will return below. A great virtue of Nelson in this regard is that she writes clearly yet diplomatically about the matter, since her informants often wish – if not expect – that DNA will vindicate their past slave identity. In that respect, her writing has a whiff of the pathos one finds in the classic *When Prophecy Fails* (Festinger et al. 1956).

In this moment of Black pro-racialism, the memory of the greatest of US Black intellectuals, the sociologist W.E.B. DuBois, is often invoked. DuBois died in 1963 in Ghana, aged 95 and skeptical that Martin Luther King’s civil disobedience strategy would succeed in delivering the justice that Black people had been seeking since the end of the Civil War. At the height of the Cold War, when I first learned of DuBois, he was regarded as unduly pessimistic and perhaps had even fallen into the hands of Moscow. (After all, DuBois had won the 1959 Lenin Peace Prize.) That image has definitely been reversed – both publicly and within sociology, where he is now treated as an equal to Marx, Weber and Durkheim. I do not object to this elevation in status, but its timing is telling – as well as its implications.

While DuBois emigrated to Africa only late in life, he was certainly pro-racialist in orientation throughout. More than that, he was eugenicist in his racialism, believing that it was the moral obligation of Black universities to be exceptionally rigorous in their intake to ensure that the 'talented tenth' of the race were properly identified and cultivated. DuBois had picked up the phrase from White Northern Baptist philanthropists – including one John D. Rockefeller – who thought along similar lines and were among the early funders of Black US universities. When DuBois first made the 'talented tenth' argument, at the dawn of the twentieth century, he was opposed by Booker T. Washington and other more 'accommodationist' Black intellectuals, who thought that Blacks should lower their expectations, at least in the short term, so as not to spark a race war (*a la* class war) with the White majority, a prospect that often seemed to be lurking behind DuBois' Marx-inspired rhetoric.

Perhaps unsurprisingly, when DuBois is taught these days, the phrase 'talented tenth' doesn't normally figure, even though it was one of his most distinctive intellectual contributions. It marked him out in his day as someone who thought 'scientifically' about matters of race. Yet, the phrase continues to haunt Black intellectuals. Indeed, an extraordinarily heroic effort to launder DuBois' legacy was performed by Henry Louis Gates and Cornel West, who republished DuBois' original 1903 essay, along with virtuoso commentaries that talked about everything except DuBois' positive attitude towards eugenics (Gates and West 1997). However, it remains an itch that needs to be scratched. An especially artful and affirmative attempt to draw together process theology, Afrofuturism and so-called 'junk DNA' is Butler (2019), which is underwritten by the belief that the unique racial potential of Black people is waiting to be discovered in the apparently noncoding parts of their DNA.

Butler's thesis assumes two things: (1) that 'junk DNA' merely names the parts of DNA whose function has not been fully understood (hence the 'hidden potential' argument); (2) that racial differences – as understood through a combination of the organism's morphology and conventional genealogy – are real. Unfortunately, (1) is much more likely than (2) – and there's the rub. It returns us to Nelson, whose informants are banking on their DNA vindicating a past slave status, in terms of which the 'logic of reparations' would advantage them, at least financially and perhaps also morally. However, what some of the claimants are beginning to discover is that science, law and history are interrelated in complex ways that don't necessarily provide the outcomes that they might have liked. While Nelson is just as much against race-based inequality as any reasonable person, she nevertheless sees the bioinformatic side of things as a complicator rather than an enabler for those seeking justice on specifically 'racial' terms.

Of course, one could be much less diplomatic and simply say that whatever justice is to be had in this world will not be handed down on the basis of race. More generally, legacy social categories such as race, class and gender have been rendered irrelevant by both first-order and second-order social and biological developments. We don't think of ourselves in terms of these legacy categories, and those who study us increasingly realize that they shouldn't as well. Taken together, we have outgrown the conceptual horizons of not only classical sociology, which largely identified 'society' with the nation-state (hence the meaning of 'anti-social'), but also what might be called 'classical biology', which has somehow managed to retain Aristotle's essentialism, even though evolutionary theory – both Lamarck and Darwin – had irreversibly delegitimized it. Both classical expressions of these disciplines are 'folk intellectual' in that academics who should know better nevertheless treat them as default discursive positions when dealing with the public. In this sense, the Canadian psychologist Jordan Peterson counts as a 'folk intellectual' in today's world, since his pronouncements can only begin to withstand scrutiny if they are treated as the academic equivalent of 'white lies'.

I mention Peterson because he not only embodies but also, through his massive audience, amplifies the confusion surrounding our bioinformatic condition. After all, he first gained notoriety for publicly refusing to abide by a Canadian law that would require people to be recognized in terms of gender self-identification. He defended his refusal with a mix of appeals, some of which were about his personal freedom to deal with people as he sees fit and some about what he regards as the facts of biology. Moreover, this conflation of the libertarian and the deterministic was wrapped around a crypto-paternalist rhetoric that declares it immature not to own up to who one 'really' is. Although Peterson's rather exotic intellectual roots lie in Jung, Piaget, and Joseph Campbell's mythology, laced with some watered-down cognitive-behavioral therapy, he ends up in the same normative place as those who take a more direct route from the Bible to the sort of hierarchical mentality that undergirds Conservatism. His first book, published nearly a quarter-century ago, is revealing in this regard (Peterson 1999).

Ever since the US feminist biologist Anne Fausto-Sterling (1993) proposed a sexual continuum thirty years ago, and the Silicon Valley firm 23andMe[1] started to market genome scans to consumers for tracing genealogy fifteen years ago, whatever 'essentialism' remained in the categories of gender and race began to be exploded on what might be called 'data-driven' grounds. (The category of class had been destroyed in the 1980s with the decline of Marxism and the rise of Neoliberalism.) These developments don't require genuflection to 'performativity' or the other idols of postmodernism. They are as 'science-driven' as anything else that interacts with the uncertainties of the policy arena.

The bottom line is that we have entered a bioinformatic world where people will possess sufficient information *both* to self-identify *and* to watch others similarly engaged. But one shouldn't think about this potentially perilous situation as necessarily favoring the 'surveillance state', though the specter of China's social credit system always looms large. However, even the Chinese example reveals that the state needs to be synchronized with the commercial sector, by whatever means that is achieved. (Western states do not currently enjoy this advantage – though they're trying!) In short, as long as there remains a 'market' aspect to the bioinformatic world's heightened social reflexivity, people will be flexible and adaptive because

[1] See https://www.23andme.com/en-int/. Accessed 21 November 2021.

they will see themselves as possessing *choice*. That will provide new meaning to 'Liberty means responsibility', a slogan popularized by George Bernard Shaw in *Man and Superman*, based on John Stuart Mill's coinage of 'responsibility' to mean being held accountable for one's free actions (McKeon 1956). Shaw couldn't resist adding a punchline: 'That's why men dread it.'

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Index

M. A. Peters et al. (eds.), *Bioinformational Philosophy and Postdigital Knowledge Ecologies*, Postdigital Science and Education,
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