Review of Susan Hockfield (2019). *The Age of Living Machines: How Biology Will Build the Next Technology Revolution*

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Birgül Ulutaş

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Introduction

Published before the Covid-19 pandemic, *The Age of Living Machines: How Biology Will Build the Next Technology Revolution* (Hockfield 2019) activates thinking and imagination about the possibilities of biology and biotechnology in the context of the dignity and worth of human beings. Book’s author is Susan Hockfield, the sixteenth president of Massachusetts Institute of Technology (MIT) and its first female biologist president.

The book begins with the 1798 predictions by a British clergyman, economist, and demographer Robert Malthus that population growth would outpace food production and cause famine, wars, and epidemics (Hockfield 2019). This prediction was overcome by technology-oriented agricultural revolutions of the nineteenth century. Hockfield claims that humanity now faces a similar crisis, which can be overcome with technologies shaped by the convergence of biology and engineering. She offers some suggestions for ‘cheating’ Malthus in the context of the USA: large investments in basic research (ambitious federal research and development investment strategies, world-class research universities), creation of new industries (forward-looking industrial models), long-term flows of capital to encourage and develop immigration policies that attract the best scientists from around the world, and others.

Crises caused by famine, wars, and epidemics are directly linked to allocation of resources and ownership of the means of production. In the past, the main means
of production had been land and industrial machinery; today, they are joined by the means of defining, producing, collecting, analysing, and disseminating information. In our postdigital age, concepts such as cognitive capitalism [which describes emerging forms of post-industrial capitalism (Boutang 2011)] and knowledge capitalism [which describes mechanics of capitalism in knowledge development and dissemination (Peters 2004; Peters et al. 2015, 2020)] are the key ingredients for understanding and responding to today’s crises.

From Convergence 1.0 to Convergence 2.0

Technics, as a universe of instrumentalities, may increase the weakness as well as the power of man. At the present stage, he is perhaps more powerless over his own apparatus than he ever was before. (Marcuse 1964: 240)

Hockfield claims that that multidisciplinary research, which started from the Second World War to become apparent during the Cold War years, has pioneered important discoveries based on the convergence of physics and engineering, which she dubs Convergence 1.0. These include light bulbs, radio, television, telephone, airplanes, radar, nuclear energy, computers, the Internet, lasers, satellites, GPS devices, MRI and CT scanners, home electrical systems, and others. Hockfield introduces new possibilities that will emerge from the convergence of biology and engineering, or Convergence 2.0, which has started in the twenty-first century. The new possibilities include virus-based batteries, protein-based water filters, cancer-fighting nanoparticles, intracortical brain-computer interface (IBCI), image-based plant phenotyping technologies, and others.

Hockfield historicizes Convergence 2.0 using the example of the physicist Karl Taylor Compton. In the early 1930s, Compton was appointed head of MIT as an atomic physicist. Although the potential of atomic physics was new and uncertain, a series of discoveries in the field opened the gates to vacuum tubes, transistors, silicon-based circuits, and computer technology. In 1933, Compton was appointed head of the National Defense Research Committee (NDRC) and played an important role in the development of technologies (such as radar) which significantly changed the course of the Second World War. Compton was perhaps not personally motivated by war or competition, yet the development of Convergence 1.0 technologies was largely determined by war and power relations. The world has significantly changed since Compton’s times, and Hockfield questions motivation for today’s Convergence 2.0.

Thanks to the privileged view of the scientific and technological future granted to me as the president of MIT, I have seen the promise of Convergence 2.0, which has the potential to transform the twenty-first century every bit as dramatically as Convergence 1.0 transformed the twentieth. … But what I wonder today is whether the United States can mobilize itself to lead the way for Convergence 2.0 in the manner it did for Convergence 1.0 and, moreover, whether it can do this without the unfortunate accelerant of war. This strikes me as one of the great political questions of our time – and it is a question that we must try to answer. (Hockfield 2019)
Hockfield outlines fascinating possibilities of Convergence 2.0-based technologies and reminds that scientific discovery implies standing firmly in the face of uncertainty: ‘That’s the nature of scientific revolutions: they unfold in powerful and unpredictable ways and unleash vast possibilities.’ (Hockfield 2019) However, Hockfield also realizes the importance of political economy. She acknowledges that research funding is increasingly directed towards research that promises predictable results, and insists that science cannot be reduced to applied research. The links between basic research and technological change are often ‘subtle and indirect’ and can occur over extended periods of time (Bok 1982: 138). Analysing a series of studies conducted from the 1940s to the mid-1970s, Bok (1982: 138–149) suggests that more than 60% of new technological advances is based on basic research. Another major drawback of reducing science to applied research — and thereby marketplace — is related to scientific culture. Ben-David (1971: 179–182) writes: ‘If science is perceived as partial to some social interests, and scientists are seen in an invidious light, then people may start doubting the moral value of seeking scientific truth for its own sake and applying it for the purpose of changing the world. This may spell the end of scientific culture.’ Similar arguments can be also found in postdigital literature (Jandrić et al. 2018), and they seem particularly apposite in the context of Covid-19 research (Jandrić 2020).

Hockfield claims that applied sciences are only possible through basic research and that basic research is only possible with the support of public funds. Looking at history, she argues that the USA has taken the technological lead in the twentieth century thanks to a continuous federal commitment to research and development funding. In the USA, public research and development investment have fallen from 2% of GDP in the 1960s to below 1% today (Hockfield 2019). Due to neoliberal transformation, scientific progress is motivated by market mechanisms that enable, and thus direct, scientific research, causing a decline in scientific autonomy (Bok 1982: 143).

Sustainability of market-based scientific production is also controversial. Biomedical technologies develop unevenly, and issues such as the ownership of products with high public benefit such as the Covid-19 vaccine are now paramount (Peters et al. 2021a; Teräs et al. 2020). How is it possible to determine the principles of sustainability aimed at the survival of humanity as a whole? What should be the share of large multinational companies? A meta-convergence approach (it may be postdigital theory), including social, cultural, economic, and philosophical analysis, is also required on the ethical problems like ownership of plant and animal species (genomic rights) or ownership of the algorithmic data (Peters et al. 2021a, 2021b: 6). Hockfield (2019) indicates these questions, but leaves them largely unanswered.

Hockfield (2019) insists that scientific development is cumulative. According to Barnett, the cumulative nature of knowledge production is closely linked to openness of knowledge:
In knowledge production, there can be no Robinson Crusoes, no one-man bands, no single entrepreneurs and no self-made men or women. What counts as knowledge is an outcome of particular kinds of conversation conducted both contemporaneously (perhaps even across the world) and over the generations. Conversations are even held with the dead (the writings of the Greeks and so forth continue to be mined and critiqued). Furthermore, what counts as knowledge has to be in principle universally open. In practice, the principle goes characteristically unheeded but the point is that knowledge cannot be the outpourings of a closed sect. (Barnett 2020: 221)

The principle of scientific openness1 was significantly thwarted by the Bayh-Dole Act, which went into effect in 1980 in America and which gave the right of patent to non-profit organizations, small businesses, and academics. It was updated by the US president Ronald Reagan in 1987, making it possible for all companies in the market to obtain patents from research carried out with public funds. The Bayh-Dole Act reinforced knowledge as private property and played a preventive role in the transmission of scientific developments to next generations, thus paving the way for intellectual monopolies.

The Bayh-Dole Act turned America’s higher education institutions into ‘a cog in the wheel of the medical-industrial complex’ (Ismail 2011: 218). According to Bok (2003: 59), the Act caused significant criticism even immediately after it was enacted.

In 1945, Vannevar Bush, in his famous report to President Roosevelt on the future of American science, had pointed out how much the flow of new products and medical treatments depended on a vigorous program of basic research that only universities could provide. Responding to this vision, the federal government came to invest billions of dollars every year in university labs, creating the strongest basic science capability in the world. Suddenly, forty years after the Bush report, critics such as Martin Kenney warned that commercialization was about to destroy the foundations of scientific progress by diverting professors from basic research to more lucrative applied work with high market potential. (Bok 2003: 59)

Hockfield (2019) shows that US academic institutions were granted fewer than 500 patents in 1980, over 2000 patents in 1996, and about 7000 patents in 2016. Thanks to the Bayh-Dole Act, the country had significant benefitted from large research investments. However, Hockfield argues that the USA will lose its technology leadership if the fall of public research and development investments continues. Therefore, she suggests development of policies that would encourage investment in long-term, capital-intensive industries for Convergence 2.0 technologies and bring tax advantages that increase in proportion to the duration of the investment.

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1 For a detailed explanation of how copyrights and patents increase privacy, see Boldrin and Levine (2008: 166–170).
Postdigital Meta-convergence

The Age of Living Machines: How Biology Will Build the Next Technology Revolution (Hockfield 2019) sketches a valuable vision of opportunities offered by the convergence of biology and engineering. The book offers important insights into the necessary conditions for scientific progress: potentials of scientific research may not always be obvious; ideas derived from pure curiosity can bring ground-breaking results; financial conditions that allow scientists to stand firmly in the face of uncertainty are important; interdisciplinarity and cooperation can trigger important innovations; scientific progress cannot be achieved without the public funds, etc.

Scientific and technological advances have always had positive and negative consequences, yet technology never does exactly what its producers had intended (Jandrić and Hayes 2019). ‘Technological unemployment’ is not desirable, but technological advances have caused it in various sectors (Peters et al. 2020). A ‘control society’ is also not desirable, yet today’s usage of data and algorithms significantly contribute to increasing social control (Peters and Jandrić 2018). Technological developments need to be managed for the common good of all people, and biodigital convergences open up myriad new questions in that regard. New knowledge ecologies place responsibility on each of us in determining the future of human ontologies (Peters et al. 2021b; Savin-Baden 2021).

During the Cold War, Marcuse (1964: 142) declared: ‘history is still the history of domination, and the logic of thought remains the logic of domination’. This is still the case in the twenty-first century. The ownership of the means of producing and disseminating knowledge cannot be separated from the ownership of other means of production. Unequal distribution of knowledge obscures the ideal of a sustainable life for everyone. The ownership of the means of defining, producing, manipulating, and spreading knowledge is an important site of political struggle, and current power relations in producing and disseminating knowledge, described as knowledge capitalism, are now challenged by various movements towards reclaiming knowledge as a global public good, described as knowledge socialism (Peters 2004, 2019; Peters et al. 2020).

Convergence 2.0 technologies in the shadow of the Covid-19 pandemic can be as transformational as Convergence 1.0 technologies in the shadow of the Cold War. In order to reach their full potentials, however, Convergence 2.0 technologies need to develop beyond war and competition. Our postdigital age requires a holistic meta-convergence approach that will enable technological development conscious of power relations and their social, political, ontological, and epistemological implications. Postdigital theory is ‘both a rupture in our existing theories and their continuation’ (Jandrić et al. 2018: 895); as such, it develops a wide framework that includes a high-degree convergence between yesterday’s incommensurable research approaches and methods (Peters et al. 2021a, b). Building important links between yesterday’s Convergence 1.0 and today’s Convergence 2.0, The Age of Living Machines: How Biology Will Build the Next Technology Revolution (Hockfield 2019) is a valuable contribution to the latest shift in postdigital theory (Jandrić 2021) towards the intersections of biology, information, and society.
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