

PALGRAVE
HANDBOOKS



THE PALGRAVE HANDBOOK OF BIOLOGY AND SOCIETY

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ISBN 978-1-137-52878-0 ISBN 978-1-137-52879-7 (eBook)

<https://doi.org/10.1057/978-1-137-52879-7>

Library of Congress Control Number: 2017953061

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Cover Illustration: Ralf Hiemisch/gettyimages.

Printed on acid-free paper

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The registered company is Macmillan Publishers Ltd.

The registered company address is: The Campus, 4 Crinan Street, London, N1 9XW, United Kingdom

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Species of Biocapital, 2008, and Speciating Biocapital, 2017

Stefan Helmreich and Nicole Labruto

Introduction

The store of science studies work theorizing the conjuncture of economic action and biotechnology is well stocked. Scholars in anthropology, sociology, history, and literary theory have generated a variety of concepts: biovalue, genetic capital, the biotech mode of (re)production, the organic phase of capitalism, genomic capital, life as surplus, the bioeconomy, and, perhaps most prominently, *biocapital*, which is becoming the prevailing coin in academic exchanges about contemporary unions of biological science with profit-oriented enterprise. A taxonomy of *species of biocapital* is in order.

The word *species* refers not just to durable, though mutable, life forms but also to ‘a particular kind or sort of coin or money’ (OED), so that a classification of kinds of biocapital may take the form of an intellectual phylogeny or of an accounting or both. Following Pierre Bourdieu (1991 [1982]), who first defined four ‘species of capital’ (economic, cultural, social, and symbolic) and showed how they might be convertible into one another, such a classification

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S. Helmreich. 2008. Species of Biocapital, *Science as Culture* 17, 463–478—<http://www.tandfonline.com/doi/full/10.1080/09505430802519256?scroll=top&needAccess=true>.

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could also manifest as a table of exchanges between different coinages. I consider all these possibilities here.

What is biocapital? Scholarship in the social study of biology has suggested that in the age of biotechnology, when the substances and promises of biological materials, particularly stem cells and genomes, are increasingly inserted into projects of product-making and -seeking, we witness the rise of a novel kind of capital: biocapital. The term, paging back to Marx, fixes attention on the dynamics of labor and commoditization that characterize the making and marketing of such entities as industrial and pharmaceutical bioproducts. It gives a fresh name to a phenomenon that Edward Yoxen, writing at the dawn of the biotech revolution in ‘Life as a productive force: capitalizing upon research in molecular biology’, described as ‘not simply a way of using living things that can be traced back to the Neolithic origins of fermentation and agriculture’ but ‘a technology controlled by capital, ... a specific mode of the appropriation of living nature—literally capitalizing life’ (1981, p. 112). Biocapital also extends Foucault’s *biopolitics*, that practice of governance that brought ‘life and its mechanisms into the realm of explicit calculations’ (Foucault 1978, p. 143). Theorists of biocapital posit that such calculations no longer organize only state, national, or colonial governance but also increasingly format economic enterprises that take as their object the creation, from biotic material and information to value, markets, wealth, and profit. The biological entities that inhabit this landscape are also no longer only individuals and populations—the twin poles of Foucault’s biopower—but also cells, molecules, genomes, and genes.

Stem cells have been potent objects on this landscape because of their, well, ... potency—or better, their potential potency, their capacity, under finely tuned circumstances, to grow into diverse sorts of cells, cells that might be employed as resources for regenerative medicine. One might argue that stem cells are animated by a double fetishism—infused with vitality because of the erasure of the labor and regulation that allows them to appear ‘in themselves’ in such places as laboratories and simultaneously imbued with life because of their origin in living things. Whether such fetishism dovetails with commodity fetishism is a complicated question—certainly stem cells’ relation to market, gift, and national economics and imaginaries is multiple—but one of the more general claims of the present chapter will be that biological potency as such, in biocommerce, is often (mis)taken to be a primordial ontology upon which biocapitalism merely elaborates.

This chapter began as a review of two books. Kaushik Sunder Rajan’s 2006 *Biocapital: The Constitution of Postgenomic Life* (Duke) and Nikolas Rose’s 2007 *The Politics of Life Itself: Biomedicine, Power, and Subjectivity in the*

Twenty-First Century (Princeton) each propose a diagnosis of scientific, ethical, and cultural transformations in the way we think of life—biological and social—in the era of capitalized molecular biology, biotechnology, and stem cell and genomic medicine.

Sunder Rajan's *Biocapital* argues that life science commodities—for example, therapeutic molecules, genome sequences, and pharmaceuticals that promise future health—require analysis of capitalist practices as well as of the correlated citizen, corporate, and scientific subjectivities materializing alongside such activities. University and corporate biosciences have become porous to one another, with the circulation of biomaterials between labs governed by novel regimes of buying and selling—regimes set in place by regulatory transformations permitting the holding of intellectual property in biological matter and knowledge. Contouring this landscape, too, are infusions into genomics of money from venture capital. Speculative finance mirrors the speculations of biotechnology. The subjectivities in the making—for scientists, doctors, and patient advocacy groups—also tune to future-looking financescapes. The biocapitalist ethos takes nationally particular forms, too. US rhetoric organizes around sentiments of *salvation*, seeing the promise of genetic medicine in millennial terms, powered by languages of hope and hype; Weber's *The Protestant Ethic and the Spirit of Capitalism* (2001 [1905]) is the key intertext here. In India, a narrative that highlights the importance to the nation of biotechnology prevails; bioproducts promise to make India a 'global player'. Biocapital also depends on older, colonial structures of subordination as well as on new logics, requiring examination of 'where value resides as biology becomes an information science' (p. 41). Sunder Rajan thus tracks permutations in the 'explicit calculations' about 'life and its mechanisms' that Foucault saw as key to biopower.

In *The Politics of Life Itself*, Rose explores how novel forms of personhood, citizenship, race, brain/mind, and crime are under construction as people position themselves in relation to technologies of genetic mapping, genetic diagnosis, genetic counseling, genetic therapy, and genetic profiling. Contemporary biopolitics operates at the level of the *molecular* and from that seat organizes landscapes of risk and ethical subjectification. Family, personhood, race, and crime are refigured as the stuff of biology is made malleable. Rose concludes *The Politics of Life Itself* with a meditation on 'The Spirit of Biocapitalism', detecting an 'elective affinity' between the new molecular bioeconomics of 'life itself' and the modes through which, for example, doctors and patients work on human corporeal being, a corporeal being increasingly fungible and multiple.

Sunder Rajan and Rose have not been alone in their analyses. Below, to make sense of the genesis of discussions of biocapital is a timeline of publications, starting with Marx:

1867

Karl Marx in *Capital* defines *use value* and *exchange value* as, respectively, the value of things in use and the value that things acquire when set against one another as commodities. For Marx (who inherited these terms from Aristotle, Luther, and Smith), use value could be natural or conventional, though Marx sometimes described ‘nature’—materialized in such substances as cultivated soil or the human body—as containing ‘means of production already produced’ (quoted in Franklin 2007, p. 106). This framing posits generativity (or reproductivity) as an elemental property of the natural.¹

1884

Frederick Engels in *The Origin of the Family, Private Property, and the State* theorizes a distinction between means of production and means of reproduction, suggesting that women’s subjection in marriage is aided by their domination as a class of unpaid workers responsible for the material reproduction of persons in households.

1905

Max Weber in *The Protestant Ethic and the Spirit of Capitalism* suggests that in post-Reformation Europe, Calvinist ethics of hard work and rationality underwrote the assignation of moral meaning to capital accumulation, which could be read by believers as a secular sign of salvation for which they were already predestined.

1976

Michel Foucault in *The History of Sexuality, Vol. 1*, theorizes *biopower* as that which made it possible for nation-states to bring ‘life and its mechanisms into the realm of explicit calculations’, that is, to summon forth the bodies of individuals and populations as elements to be governed and managed in the service of such social imperatives as nation-building and colonial expansion.

1981

Feminist scholars Olivia Harris and Kate Young, commenting on Engels in ‘Engendered structures: some problems in the analysis of reproduction’, argue against naturalizing—that is, locating in the ground of the biological—a distinction between reproduction and production.

1981

Marxist scholar Edward Yoxen publishes ‘Life as a productive force: capitalizing upon research in molecular biology’, in which he argues that a shift in the ‘appropriation of living nature’ takes place when capital begins to operate on biotic stuff at the molecular level.

1987

Literary critic Hortense Spillers (1987) in ‘Mama’s baby, papa’s maybe’ examines how the reproductive capacity of slaves under chattel slavery in the antebellum American South was conscripted by slaveholders into producing more slaves as property and as potential capital.

1988

Rural sociologist Jack Kloppenburg (1988), in *First the Seed: The Political Economy of Plant Biotechnology, 1492–2000*, offers a history of the capitalization of plant matter.

1992

Anthropologist Paul Rabinow in ‘Artificiality and enlightenment’ coins the term *biosociality*, arguing that genetics, immunology, and environmentalism are ‘leading vehicles for the infiltration of technoscience, capitalism, and culture into what the moderns called “nature”’ (1992, p. 245).

1992

Anthropologist Marilyn Strathern in *After Nature* (1992a) and *Reproducing the Future* (1992b) describes biological substance modified and capitalized as ‘nature, enterprised-up’.

1993

Ecologist Walter V. Reid (1993) publishes ‘Bioprospecting: a force for sustainable development’ in *Environmental Science and Technology*. The term, a compression of ‘biodiversity prospecting’, refers to scouting in ‘natural’ settings (e.g. rainforests) for biological material (e.g. from plants) or information (e.g. traditional or indigenous knowledge) that may provide leads for natural products that can be industrialized or commercialized.

1995

Historian Harriet Ritvo (1995) in ‘Possessing Mother Nature’ offers a history of the remaking of livestock breeding in eighteenth-century Britain, when curated pedigrees emerged as tools to establish markets in what she terms *genetic capital* (see also Derry 2003 on the profit motive in breeding cattle, dogs, and horses beginning in 1800).

1997

In *Modest_Witness@Second_Millennium*, the historian of biology Donna Haraway (1997) discusses a shift ‘from kind to brand’ in the taxonomy of living things in the days of biotechnology. OncoMouse™ is an exemplar of the new branded biology.

1997

Physicist and critic of development Vandana Shiva (1997) publishes *Biopiracy: The Plunder of Nature and Knowledge*, building on then recent activist analyses of bioprospecting that construe the activity as a neocolonial practice of resource extraction, in which wealthy nations or companies dispossess

poorer nations or people of their territorial, organic, or ethnobotanical inheritances, often at profit.

2000

Historian Hannah Landecker (2000), in 'Immortality, *in vitro*', examines the case of the immortalized cancer cells of Henrietta Lacks, showing how they were serially imagined as valuable as the gift to science of an unknown woman, as the property of science, and, when they were discovered to originate in the body of a black woman, as two things: by some scientists, in line with racist visions of black sexuality, as hyperfecund, and by Lacks's family and advocates as a sign of an historical and continuing dispossession in the United States of black women from their bodies as property. Landecker made early versions of this argument in 'Between beneficence and chattel: the human biological in law and science' (1999).

2000

Medical sociologist Catherine Waldby coins the term *biovalue*, 'generated wherever the generative and transformative productivity of living entities can be instrumentalized along lines which make them useful for human projects' (2000, p. 33).

2001

Anthropologist Chaia Heller (2001) in 'McDonalds, MTV, and Monsanto: resisting biotechnology in the age of informational capital' theorizes 'biotechnology as a mode of production', argues that scholars might name a new moment in capitalism, *the organic phase of capitalism*, in which 'capital targets the reproductive dimensions of cultural and biological life as loci for intensified production and commodification'.

2001

Science studies scholar Mike Fortun (2001) in 'Mediated speculations in the genomics futures markets' suggests that understanding the business of genomics requires attention to its speculative logic, which he examines by demonstrating the role of 'forward-looking statements' in generating investment and profit. This work elaborates his earlier interest in the rhetoric of speed in genomics (1999) and sets the stage for his 2002 argument that genomics operates in the 'future anterior', the *what-will-have-been*—the promise—an argument he will elaborate in *Promising Genomics: Iceland and deCODE Genetics in a World of Speculation* (2008).

2001

Anthropologist Margaret Lock's 'The alienation of body tissue and the biopolitics of immortalized cell lines' (2001) fuses political economic analysis with Foucauldian attention to body politics.

2001

Sociologist Nikolas Rose argues that new markets in health create a circumstance in which ‘biopolitics becomes bioeconomics’ (2001, p. 15).

2003

Anthropologists Sarah Franklin and Margaret Lock define *biocapital* as a kind of wealth that depends upon a ‘form of extraction that involves isolating and mobilizing the primary reproductive agency of specific body parts, particularly cells, in a manner not dissimilar to that by which, as Marx described it, soil plays the “principal” role in agriculture’ (2003, p. 8). Franklin and Lock understand this biocapital to be underwritten not only by production but also by reproduction. Their thinking emerges from a May 2000 conference at the School of American Research, which they recall thus: ‘Imagining ourselves (re)writing volume 1 of (bio)Capital, we attempted to specify as precisely as possible the range of forces at work in the transformation of life and death into means to (re)production and, in turn, into component parts that together compose an emergent global biological economy’ (p. 13). Franklin’s contribution to *Remaking Life and Death: Toward an Anthropology of the Biosciences*, the volume that emerged from this workshop, was entitled ‘Ethical biocapital’.

2003

Sociologist Charis Thompson argues that the *biotech mode of (re)production* operates with ‘promissory capital’, ‘capital raised for speculative ventures on the strength of promised future returns’ (quoted in Franklin and Lock 2003, pp. 6–7). In her *Making Parents: The Ontological Choreography of Reproductive Technologies*, Thompson turns her attention to what she calls the ‘biomedical mode of reproduction’ (2005).

2003

Science studies scholar Kaushik Sunder Rajan in ‘Genomic capital: public cultures and market logics of corporate biotechnology’ defines ‘biocapitalism’ as that which asks, ‘how “life” gets redefined through the contradictory processes of commodification’ (2003, p. 87). His biocapitalism has five features: a rhetoric of speed, corporate/university connections, porosity between commodity and gift economies in labs, excessive production, and biosocialities tuned to market logics.

2003

Anthropologist Cori Hayden in *When Nature Goes Public: The Making and Unmaking of Bioprospecting in Mexico* shows how bioprospectors often seek to create capital through channeling biodiversity through ‘slightly choppy’ (2003, p. 10) networks that mix economies of purchase, benefit-sharing, dispossession, profit, and promise, many of which turn out to be situated in larger frames of North-South political economic inequality.

2005

Literary theorist Eugene Thacker in *The Global Genome* (2005) fixes on how the fluidity of genetic information as data permits it to be used as a currency in globalization. Thacker draws on the Marx of the *Grundrisse* as well as on Foucault to develop a theory of 'biological exchange' that aligns information management with moments in the movement of capital: encoding/production, recoding/circulation, and decoding/consumption. Thacker thinks through the excess of bio-information using the work of Georges Bataille (1967) in *The Accursed Share*, which argues that the accumulation of surplus is not always fed back into production, but is often spectacularly spent on lavish wastage.

2006

Kaushik Sunder Rajan in *Biocapital: The Constitution of Postgenomic Life* follows Marx in parsing *biocapital* into industrial, commodity capital (such as therapeutic molecules) and speculative, commercial capital (such as stocks), which later are often underwritten by quasi-religious sentiment, in the way Weber argued that the rise of merchant capital was motored by the Protestant ethic. Sunder Rajan uses Bataille to think about how speculation underwrites and permits practices of excess, particularly in the over-the-top expenditures of biotechnology start-ups in the United States.

2006

Anthropologists Adriana Petryna, Andrew Lakoff, and Arthur Kleinman in *Global Pharmaceuticals: Ethics, Markets, Practices* (2006) examine the inequalities that organize world distribution and markets in pharmaceuticals, a global economy in which access and excess are often inversely related. They draw on Bourdieu's notion of capital to locate pharmaceutical economies—of patents, products, and promises—in regimes of economic, cultural, material, and symbolic capital. They do not put the package together as *biocapital*—though Lakoff argues that in pharmacogenomics, 'Biopolitics and the market were to be brought together through the application of genomic knowledge' (2005, p. 171).

2007

Nikolas Rose extends earlier arguments of his that a 'mutation' from *biopolitics* to *bioeconomics* characterizes the dominant social order in at least the United States and Europe, writing that 'vitality has been decomposed into a series of distinct and discrete objects, that can be stabilized, frozen, banked, stored, accumulated, exchanged, traded across time, across space, across organs and species, across diverse contexts and enterprises, in the service of bioeconomic objectives' (2007, 67). Rose notes that biocapital is already a phrase circulating in the world of pharmaceuticals, frequently as a company name or service.

2007

Sarah Franklin in *Dolly Mixtures* looks at the history of ‘stock’ in livestock to think about the braided logic of breeding and wealth creation, from pre-capitalist to capitalist modes of accumulation, writing that ‘capital in the older sense of stock derives out of a combination of genealogy, property and instrumentality’ (2007, p. 57).

2007

Science studies scholar Joseph Dumit theorizes *surplus health* as that which pharmaceutical companies conjure in order to ‘add medications to our life through lowering the level of risk required to be “at risk”’ (quoted in Sunder Rajan 2007, p. 81). Dumit’s Biomarks (or, sometimes, BioMarx) experiment operates by substituting ‘health’ for ‘labor’ in *Capital* (consult Dumit 2012).

2007

Political theorist Melinda Cooper (2007) in ‘Life, autopoiesis, debt: inventing the bioeconomy’ argues that capitalist culture operates through ‘delirium’, in which the drive of capital to overcome its own material limitations not only finds new resources but also constantly redefines the ‘nature’ of resources (e.g. through turning debt or other crisis moments into value) in order to create surplus. Her later book *Life as Surplus* (2008) elaborates this argument.

This chronology does not take in as many vectors of origin for biocapital as it might. Missing are chronicles of molecular biology (e.g. Kay 1993; Wright 1994; Keller 1995; de Chadarevian 2002), histories of modernist agricultural technique (e.g. Fitzgerald 1990; Boyd 2003), studies of colonial and postcolonial enterprise (e.g. Sidney Mintz’s 1985 analysis of the plantation as a fusion of farm and factory in *Sweetness and Power*), anthropologies of organ donation and trafficking (e.g. Hogle 1999; Scheper-Hughes 2001), and social analyses tracking the rise of markets in racialized genomics (e.g. Fullwiley 2007; Montoya 2007; TallBear 2008). Also absent are works theorizing transformations in capitalism and governance more generally (e.g. Harvey 1989; Comaroff and Comaroff 2000; Maurer 2000; Jasanoff 2005).

The timeline, though organized stratigraphically, also does not indicate which writers relied upon which to develop their arguments—which could trace how the concept of biocapital has developed. Co-citation or co-word analysis might make common links clear (see Cambrosio, et al. 1993), though a search for ‘biocapital’ in Thomson Scientific’s Web of Science database in 2008 yielded only five journal articles. Plugging ‘biocapital’ into Google Scholar in 2008 picked out Franklin and Sunder Rajan as key exponents of

the concept, showing 24 citations to Sarah Franklin's 2003 articulation and 28 to Sunder Rajan's 2006 book and, strikingly, since both publish in anthropological venues, no cross-citations between the two, suggesting that there may be two scholarly conversations in motion here. A simple scientometric approach, of course, would be difficult to cash out as a full tracing of influence. Different scholars cast more and less finely meshed citation nets.

These caveats in mind, just below is a tentative genealogy, full, as all genealogies are of repetitions, omissions, mistakes, surprises. Its nodes are the names of authors of peer-reviewed, published works that contribute to discussions of biocapital. Names are keyed to years and each scholar appears only once (in connection with either their first articulation of a concept important to biocapital or their most significant statement on the matter). The lines represent direct, more-than-in-passing citation. Turning away from the automatic information gathering of citation analysis, I sought to locate authors' developments of concepts central to biocapital by using an antique method: reading (Fig. 35.1).

Gillian Beer has suggested that Darwin's forking figure in the final pages of *Origin* 'could as well be interpreted by the eye as a shrub, branching coral, or

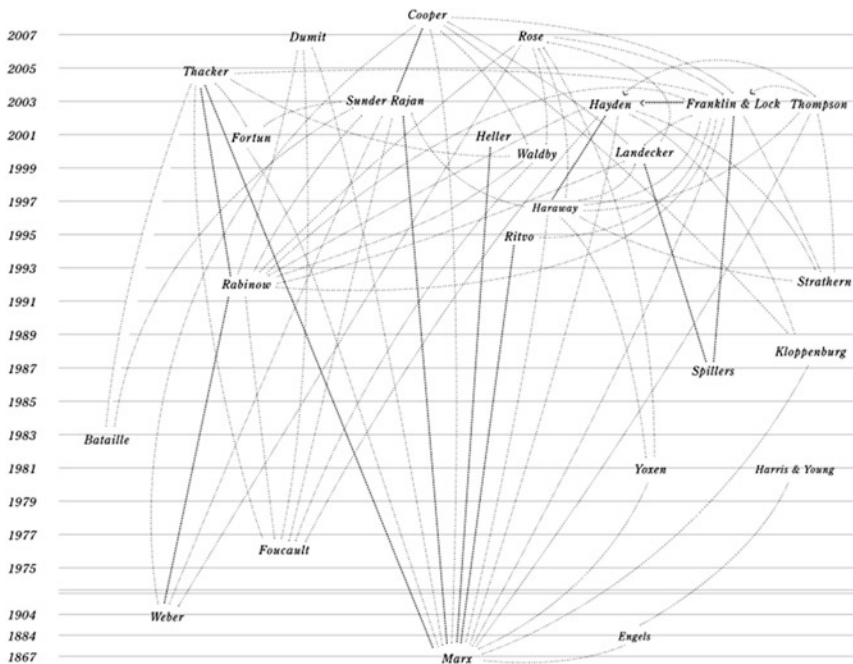


Fig. 35.1 With apologies to Charles Darwin, a diagram of the divergence and convergence of taxa of biocapital. Rendered by Michael Rossi

seaweed' (2000, p. 86). The figure above is even weedier than Darwin's, but even within this thicket, two clusters of writing on biocapital can be discerned.

One cluster—around Sarah Franklin, Margaret Lock, and Charis Thompson, and drawing on Marilyn Strathern, Donna Haraway, and Paul Rabinow—might be called Marxist feminist. Here the binary of *production* versus *reproduction* is key, as are questions to do with sex/gender and race (particularly in work about reproductive technology). The remaking of boundaries between *nature* and *culture* is a central concern—one reason attention to the changing substances and generativities of biology, emblemized by Hannah Landecker's work on the history of tissue culture, is also a signature feature of this scholarship.

A second cluster—around Kaushik Sunder Rajan, Eugene Thacker, and Michael Fortun, and drawing on Haraway and Rabinow—pays attention to questions of meaning, though less to biomatter. Focusing on questions of information management and speculation, this scholarship has a Weberian flavor. Call it Weberian Marxist; relations of production are described alongside accountings of ethical subjectivity.

Strains of each line are present in the other. And Marx's political economy and Foucault's biopolitics operate as crucial conditions of possibility for each. Melinda Cooper's work marks a fusion of the lines.²

Another feature of the discussion that leaps out is the acceleration of the discussion in the late twentieth century. For scholars interested in new kinds of financial speculation of genomics, biocapital tracks biotechnological innovation (recombinant DNA, PCR) as well as the history of legal agreements between universities and companies about the commercialization of university property, which begins in 1980 with the passage in the US Congress of the Bayh-Dole Act, which permitted universities and their employees to retain rights in patented inventions developed with federal monies and, if desired, to license or sell those inventions to private business. Academic-industrial biotech hybrids became common in the United States after the Supreme Court in 1980 permitted the patenting of modified organisms in *Diamond v. Chakrabarty*. For theorists of biocapital interested in the intercalation of reproductive technologies (IVF, cloning, pre-implantation genetic diagnosis) with new kinds of relations of commoditization (of women's reproductive labor, most notably), biocapital is entangled with changing relations of reproduction and kinship.

The two schools of thinking on biocapital also have distinct orientations: they represent two sides of what, once upon a time, was called the *substantivist* position in economic anthropology. Against *formalist* economic anthropolo-

gists who believed that a common rational logic animated all exchange, *substantivists* sought to examine logics of exchange with respect to the cultural values that motivated them—values to do, for example, with kinship or prestige (see Isaac 1993).

The cluster of which Franklin, Landecker, Lock, Thompson, and Hayden are a part, I suggest, represents a substantivism interested in the changing substances of biology. Associates of this cluster attend to matters of generativity and reproduction. But they are careful not to take generativity and reproduction as ‘natural laws’ (as Marx did). In earlier work, Franklin, writing with Helena Ragoné (1998, p. 2), cautioned against ‘the relegation of “reproduction” to a domain of “natural” or biological facts ... considered prior to, and separate from, sociality’—an argument that echoes an earlier position in Marxist feminist anthropology, in a piece by Olivia Harris and Kate Young (1981), entitled ‘Engendered structures: some problems in the analysis of reproduction’, in which the authors argue against positing, as did Engels in *The Origin of the Family, Private Property, and the State*, a fundamental difference between reproduction and production.

A scholar like Sunder Rajan, meanwhile, may be read as a substantivist who looks at moral economies, joining Marxist political economy with a Weberian attention to meaning. Though he offers clear analyses of molecular biology lab practices, he is less interested in the substances of the biological, calling attention instead to the constructedness of biological facts upon which speculative exchange value is predicated.³ In *Biocapital*, he takes care not to impute any particular ontology to biological material—though by not engaging the arguments of writers like Franklin and Lock about the new substances of ‘life itself’ which (via such materials as stem cells) contain and morph histories of sex/gender, race, colony, and nation, he misses a chance to dig into the politics of generation and reproduction that are in the remaking in biotechnology. Together, however, Sunder Rajan’s and Franklin and Lock’s attention to the making of facts and the remaking of generativity can complicate such analyses as Eugene Thacker’s, which argues that bioengineering relies on a “molecular species being,” a species being in which labor power is cellular, enzymatic, and genetic’ (2005, p. 40). That formulation is a molecular rewrite of Engels’s famous 1876 reflection on ‘The part played by labor in the transition from ape to man’, in which Engels naturalized labor, via evolutionary theory, as that process at the heart of anthropoid organisms’ self-making (see Engels 1884).

But let me cut across these substantivisms and offer a less nit-picky classification. Taking a cue from evolutionary biology, I’ll pick an analogous structure that operates in the bodies of all the work I’ve discussed: the very concept

of *biocapital* (and its similarities). Comparing how the concept fares in different bodies of work may permit us to set up a series of exchanges among them.

What is biocapital? My sense is this:

In *Capital*, Marx describes the circulation of money as capital—in which ‘More money is finally withdrawn from circulation than was thrown into it at the beginning’ (1867, p. 251)—using the formula M-C-M’, where M stands for money, C for commodity, ‘ for the surplus value gained in a profitable exchange of a commodity for money, and M’ for the total capital produced by that exchange. For the biotech imagination, I suggest an analogous formula to describe the making of biology into capital: B-C-B’, where B stands for bio-material, C for its fashioning into a commodity through laboratory and legal instruments, and B’ for the biocapital produced at the end of this process, with’ the value added through the instrumentalization of the initial biomaterial.

What does B-C-B’ look like for the theorists discussed above? How do different species of biocapital organize the metabolic pathway that makes B into B’? What ‘primes’ biology?

I have suggested that the sentiment of many biotech boosters has them imagining B’ already to be latent in B—to believe that biological process itself already constitutes a form of surplus value and profit production (Helmreich 2007). This logic naturalizes biotech. Biological generativity is configured as accumulated labor power, the products of which can be harnessed to create productive futures. This belief is based, it bears emphasizing, on a metaphor: that organisms are laborers (an equivalence declared even by Marx, who saw the natural consumption of eating entailing production of the body [1857–58, p. 228]). The negative image of biocapital then becomes *necrocapital*, dead matter, like fossil fuel, put to unregenerative, zombie-like work. But we must be careful not to imagine reproduction as a transparently ‘natural’ process, as though organisms’ coming-into-being straightforwardly designates them as what Marx would have called ‘means of production already produced’, as though their productivity is the essence of their *species being*. To see matters this way is to see organisms as natural factories or assembly lines, when in fact they only become so in certain relations. As Landecker argues, contemporary biology has become expert at stopping, starting, suspending, and accelerating cellular processes, wedging these dynamics into processes that look like a molecular version of industrial agribusiness. But biotech geese cannot lay golden eggs without daily tending.

What does thinking in terms of B-C-B’ permit us to do? To begin, this accounting points back to Bourdieu—a figure mostly absent from theories of biocapital—and allows us to name how B’ corresponds to economic, cultural,

social, and symbolic species of capital (also, in the bargain, making explicit the Darwinian, Marxist, Weberian, and Foucauldian ancestries in play in different theorists' formulations). It could allow us to draw up a table of exchanges between different B primes, species of biocapital.

But—to draw upon the evolutionary biology idiom once again—such a classification assumes the neatness of the species concept, which is these days in crisis; recent research has seen the creation of transspecific hybrids and contemporary molecular biology has discerned thick lateral gene transfer tangling up taxonomic boundaries almost everywhere. But more, sorting biocapital into species has the effect of holding stable the item against which different species of biocapital exist at all—namely, *capital* itself. What if we asked not what happens to biology when it is capitalized, but asked whether capital must be the sign under which all of today's encounters of the economic with the biological must travel? It is certainly the case, as medical anthropologists such as Margaret Lock (2002), Lawrence Cohen (2005), and Leslie Sharp (2006) have shown, that the circulation of organs is not in every instance overdetermined by capitalism (the fraught language of donation and trafficking is a giveaway). Cathy Waldby's *biovalue*, Sarah Franklin's *breedwealth* (1997; see also Franklin 2006 on *biowealth*), and Donna Haraway's 2008 *encounter value* are germs of theory that undo the capitalocentrism of so much writing on biocapitalism—and also, perhaps, the emphasis in such writing on the commodity form. Emerging social histories of 'bioeconomy'—looking back to early population sciences to think through political economy—might be another place to look for analyses that include but reach beyond capitalism (see Larsen 2005). What if we imagined biovalue and bioeconomy through J. K. Gibson-Graham's *The End of Capitalism (As We Knew It): A Feminist Critique of Political Economy* (1996), which seeks to break away from the delirious reinscription of capital that happens even in its Marxist critique? What if, refusing to make capital into the coin of exchange across these concepts—and, more, refusing to trust that exchange as such can permit the adequation of different values—we found that capital itself, like the species concept, was unstable, was not so easily reproduced, or so generative, or omnipresent, after all?

Speciating Biocapital

In 2008, Stefan Helmreich identified two genealogies of writing on *biocapital* that examined how biological materials were being leveraged into profit-oriented undertakings: a 'Marxist feminist' lineage that described change and

continuity in economies of reproduction, transformations in the boundaries between nature and culture, and manipulations of biotic substance; and a ‘Weberian Marxist’ cluster that attended to relations of production, ethical subjectivity, and economic sentiment. While some scholars have offered the *bioeconomy* (Birch and Tyfield 2013; Birch 2016; Hauskeller and Beltrame 2016) as a more expansive analytic, biocapital has continued to gain traction. At the same time, in the age of the post-genome, what counts as ‘the biological’ has multiplied, with epigenetics and microbiomics, to take two examples, complicating the genetic determinism organizing early attempts to aim biology at market ends. As Hannah Landecker writes, the ‘economics and politics of life are changing, but so are biologies’ (2016, p. 44). This postscript identifies four primary speciations of biocapital since 2008:

1. Into ever-more international and transnational contexts, as scholars have taken the concept into domains outside the West, often into global South, postcolonial, decolonial, and other settings.
2. Into domains concerned with biological processes beyond the scale of the genetic and cellular, reaching toward accounts of how full organisms and their relations—non-human and multispecies—are being newly capitalized.
3. Into discussions of embodiment that extend feminist concerns with sex/gender, now centering not only on such practices as IVF and stem cell science but also on different exploitative uses of human bodily, affective, reproductive, and procreative labor—in sex work, in surrogacy, in domestic labor, and more.
4. Into discussions of environments, particularly in the age of the Anthropocene and the moment of epigenetics and microbiomes.

Biocapital is therefore no longer so centered on molecular processes isolated and elaborated in US or European laboratories (see Vermeulen et al. 2012 on ‘economies of life’). New trajectories reflect increased concern with non-Western and postcolonial science, multispecies engagements, post-genomic biology, and value beyond the economic sphere.

Non-Western/Global South Elaborations

Scholars have continued tracking biocapital in non-Western/global South contexts. Sunder Rajan (2012) examines the ‘global knowledge formations’ that transnational life sciences create. Aihwa Ong in *Fungible Life* (2016) fol-

lows scientists in Singapore's Biopolis as they make genomic information interchangeable across markets. Biopolis scientists rely on British colonial racial categories to create treatment options for what they claim to be particularly Asian infectious diseases and the health outcomes of Singapore's populations (see Waldby 2009 on Biopolis as brokering a 'utopian vision of a regenerative bioeconomy' and Fischer 2013's attention to the everyday ways biosciences are employed in Singapore not only in market frames but also as tokens in cross-national science diplomacy). Moving explicitly away from genetically animated visions of biocapital, Jean-Paul Gaudilliere (2014) considers how traditional Indian Ayurvedic knowledge is mobilized to build pharmaceutical markets, in marked distinction to the molecular paradigm that has characterized the drug industry.

Biocapital has also received attention in non-English-language literatures as translations of the biocapital conversation become available (Turrini 2011). From a study of pharmaceuticals and risk in Brazil (Rodrigues et al. 2015) to a theorization of transspecies reproductive technologies in Italy (Balzano 2015) to an investigation of the making of biocapital using biosafety scenarios in Spain (Marco et al. 2015), *biocapital*/*biocapitale*/*biocapitalismo* have become concepts with futures of their own, naming changing landscapes of national and transnational science, ethics, and risk.

New Scales and Species

Biocapital has been applied to new biotic scales and a widening range of species. In *When Species Meet* (2008), Donna Haraway imagines a 'Marx-equivalent' writing *Capital* today as *Biocapital*, volume 1, transcending Marx's human exceptionalism and accounting for the multispecies encounters that shape labor and commodities. To Marx's *use value* and *exchange value*, Haraway adds *encounter value*, a genre of interspecies value that, pace Gibson-Graham, does not subsume all value to the market. In *The Mushroom at the End of the World* (2015), Anna Tsing attends to 'unpredictable encounters' between humans and nonhumans in the lifeworlds of matsutake mushrooms as they are grown, gathered, and traded in spaces of 'capitalist ruin.'

Cutting-edge biotechnologies, such as the gene-editing technology CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats), promise to reorganize multispecies relations; mythical hybrids, enhanced transspecies, and programmed extinctions become possible. Eben Kirksey (2015) reports on synthetic biologists creating bioengineered mice that may eradicate Lyme-disease-bearing ticks and mosquitoes crafted to blunt the travel of

malaria through mosquito-human populations. Scientists marry these gene-editing projects to aspirations for new 'transspecific' bioeconomies; researchers claim to want to undo the proprietary secretiveness of biotech companies like Monsanto in order to make what they call 'open source' and even anti-capitalist research platforms (and see Roosth 2013). The future of multispecies markets may transcend conventional economic exchanges of biocommodities, relying instead on minimally regulated private donor-funded projects that alter inter-species interactions—from the scale of ecosystems down to organisms' genomes. Use, exchange, and encounter value may be joined by what we could call *transaction value*, where such transactions are not only about economic exchange or affective encounters but rather and also about as-yet unmarked relations of sharing, transfection, contamination, and displacement.

Embodied Biocapital

The feminist genealogy of thinking about biocapital has extended traditions of examining sex and gender as formations that involve biological and social reproduction, arguing that biocapital is generated from these exploitative forms of embodied labor (Happe 2015). See also Taussig, Hoeyer, and Helmreich 2013 for an introduction to an issue of *Current Anthropology* on the new political economy of biomedical 'potentialities'). Authors in this vein also tend to look to the global South as sites for investigating unequal exchanges of affect and capital. Nurul Ilmi Idrus and Anita Hardon (2015) adapt the concept of biocapital to describe technologically enhanced human bodies and the relations into which they enter. In their research on sex workers in Indonesia, they look at how contemporary technological interventions into the bodies of sex workers and waitresses—in the forms of cosmetics, psychoactive drugs, and antibiotics—produce economic power but also dependency. In another domain in which the well-being of bodies is at stake, David et al. (2015) worry about the biocapitalization of human bodies in the context of medical aid to HIV patients. Their study of the new industry-oriented funding philosophy of the Global Fund, a key distributor of subsidized drugs to infected patients in non-Western countries, raises ethical concerns about the evaluation of bodies that are 'captive' to programs that keep them alive but with uncertain future commitments and treatment policies.

Kalinda Vora (2015) focuses on the unidirectional movement from India to the United States of the 'vital energy' produced by human labor in gestational surrogacies, call centers, domestic labor, and more. As affective and

reproductive labor are commoditized and outsourced, human biocapital from India supports life in the United States, producing new socialities alongside economic value (see Murphy 2017 for an historical analysis of rubrics that quantify the cost and value of populations).

Environments

In the era now marked as the Anthropocene, in which human activities have irrevocably degraded the livable world, Anthropocenic concerns increasingly drive the development of new biologically derived commodities, as biocapitalist forms define interventions, solutions, and ethics related to social-ecological problems. Nicole Shukin (2016) looks to a group of Fukushima residents who defied government orders to evacuate as a way to evaluate ‘resilience’ as an embodied biocapitalist resource, one that is ‘consciously cultivated and valorized by corporate and state institutions’ that benefit economically from populations’ ability to manage life amid disaster conditions. Here are entwined human biocapital, resource extraction, and economic imperatives, oriented toward an activist, anti-capitalist politics in a technologically mediated landscape (see also Acero 2012 on environment, gender, and ‘citizen controlled’ biotechnology).

Concomitant with new understandings of the role of humans in making environments come post-genomic research agendas that see extracellular factors playing crucial roles in shaping biologies (Richardson and Stevens 2015). Parallel to CRISPR’s genetic reductionism are postgenomic biologies such as epigenetics (Landecker and Panofsky 2013; Meloni and Testa 2014), genres of life science that modulate assumptions of genetic fixity to account for how organic and social forces combine to render ‘the biological’ plastic and porous to ‘the environment’ and to history (Landecker 2016). Think, for example, of how our very food bears ‘the traces of scientific and economic rationalizations of plant and animal bodies’ (Stassart 2003: 449), a dynamic that brings earlier bioeconomies into the multicellular, metabolic processes of today’s populations (and that in turn has been narrated in ways that suggest that economic theorizations and measures of human biological life chances may be reanimated in light of new biologies; see Almond and Janet 2011; Pentecost 2016 and see Meloni and Testa 2014 on new attempts to capitalize epigenetic understandings of nutrition). ‘Environment’—global, bodily—is coming to matter in new ways as scholars investigate research on the factors that influence biological, social, and economic outcomes (Heckman 2007).

If the concept of ‘species’ is becoming ever more ontologically unstable, so are ‘species’ of biocapital, edited and spliced into more heterogeneous social, political, and economic relations. As scholars have shown, biocapitalist forms and operations increasingly rely on the intracellular/intraecological exchanges, encounters, transactions, and drives that biotechnologies make possible. Most contemporary biocapital emerges from exploitative, neoliberal models of commodification and circulation—trans-infecting biologies, ideologies, and markets from the inside out. And as post-genomics, environmental remediation, climate change amelioration, global disease eradication, and resource scarcity motivate new biological research platforms, biocapital will see new inventions, edits, contaminations, and wirings, yielding new species of biocapital for scholars to probe critically.

Acknowledgments Thanks to Samer Alatout, Kean Birch, Joseph Dumit, Sarah Franklin, Hannah Landecker, Vincent Lépinay, Bill Maurer, Heather Paxson, Ramya Rajagopalan, Sophia Roosth, and Michael Rossi for comments. Nicole Labruto and Stefan Helmreich thank Maurizio Meloni for soliciting this revision of the original ‘Species of Biocapital.’

Notes

1. For Aristotle, *generativity* was such an essential property of nature that he saw the application of its logic to the artifice of exchange as an ethical problem. In *Politics*, he wrote, ‘Currency was intended to be a means of exchange, whereas interest represents an increase in the currency itself. Hence its name [*Tokos* (‘offspring’)] for each animal produces its like, and interest is currency born of currency. And so of all types of business this is the most contrary to nature’ (I x 1258a27) (1981). Martin Luther had a similar view: ‘I do not understand how a hundred guilders can make twenty profit in a single year, or even one guilder make another. Nothing like this takes place by cultivating the soil, or by raising cattle, where the increase does not depend on human wits, but on God’s blessing’ (1961 [1520], p. 482).
2. The tree representation overlooks important mechanisms and vehicles for the travel of concepts. It leaves out the lateral transfections and endosymbiotic fusions consequent on classes taken, conference papers heard, drafts circulated, and readers’ reports rendered (Rabinow started giving a biosociality talk in 1990; Fortun was speaking on ‘Projecting Speed Genomics’ as early as 1994; Thompson’s notion of the promissory circulated at a 2000 conference; and Sunder Rajan’s dissertation, with the same title as his book, was finished in 2002, etc.). It also leaves out the fact that authors’ positions change over

time. Any model of the inheritance of properties would also map out a story of the transmission of what Bourdieu called *academic capital* (with credit and credibility not far behind—see Latour and Woolgar's (1986, p. 201) circle diagram of cycles of conversion between types of capital, in which recognition → grant → money → equipment → data → arguments → articles → recognition → and so on...).

3. Compare social theorists of finance as far back as Gabriel Tarde, who in 1902 looked to organic metaphors to think through capital as a relationship between potentialities of invention and accumulation. Tarde developed the metaphors of *germ capital* and *cotyledon capital* to account for the origin and maintenance of capital not exclusively in accumulated labor but in ratios of difference and repetition realized in reproduction and production imagined as contingent collaborations of human, machine, and nature (Lépinay 2007b). Complicating another biological metaphor in social studies of money, the work of Vincent-Antonin Lépinay (2007a) critiques the notion that financial formula packages such as Capital Guarantee Products are 'parasitic' on the industrial goods to which they putatively refer, arguing that such products circulate in the same sphere of valuation as the 'organisms' to which they are calibrated. Such a critique of how 'parasitism' is employed to describe derivative financial instruments could be extended to direct attention to the parasite metaphor's anti-Semitic resonances in the history of finance in the West (particularly in characterizations of lending money at interest) (see Raffles 2007).

References

- Acero, Liliana. 2012. Biocapital, Biopolitics and Biosocialities, Reframing Health, Livelihoods and Environments with New Genetics and Biotechnology. In *Women Reclaiming Sustainable Livelihoods*, ed. W. Harcourt, 221–237. Basingstoke, UK: Palgrave Macmillan.
- Almond, Douglas, and Currie Janet. 2011. Killing Me Softly: The Fetal Origins Hypothesis. *Journal of Economic Perspectives* 25 (3): 153–172.
- Aristotle. 1981. *The Politics*. Harmondsworth: Penguin.
- Balzano, Angela. 2015. Biocapitale e potenza generativa postumana. Per una critica delle biotecnologie riproduttive transpecie. *La camera blu* 11 (12): 29–46.
- Bataille, Georges. 1967. *The Accursed Share, Volume I: Consumption*. New York: Zone.
- Beer, Gillian. 2000. *Darwin's Plots: Evolutionary Narrative in Darwin, George Eliot and Nineteenth-Century Fiction*. 2nd ed. Cambridge: Cambridge University Press.
- Birch, Kean. 2016. Rethinking Value in the Bio-economy: Finance, Assetization, and the Management of Value. *Science, Technology and Human Values*, August 10. <http://journals.sagepub.com/doi/abs/10.1177/0162243916661633>
- Birch, Kean, and David Tyfield. 2013. Theorizing the Bioeconomy: Biovalue, Biocapital, Bioeconomics or ... What? *Science, Technology, and Human Values* 38 (3): 299–327.

- Bourdieu, Pierre. 1991 [1982]. *Language and Symbolic Power*. Cambridge: Harvard University Press.
- Boyd, William. 2003. Wonderful Potencies? Deep Structure and the Problem of Monopoly in Agricultural Biotechnology. In *Engineering Trouble: Biotechnology and its Discontents*, ed. R.A. Schurman and D.D.T. Kelso, 24–62. Berkeley: University of California Press.
- Cohen, Lawrence. 2005. Operability, Bioavailability, and Exception. In *Global Assemblages: Technology, Politics, and Ethics as Anthropological Problems*, ed. A. Ong and S. Collier, 124–143. Malden, MA: Blackwell.
- Comaroff, Jean, and John L. Comaroff. 2000. Millennial Capitalism: First Thoughts on a Second Coming. *Public Culture* 12 (2): 291–343.
- Cambrosio, Alberto, C. Limoges, J.P. Courtial, and F. Laville. 1993. Historical Scientometrics? Mapping Over 70 Years of Biological Safety Research with Coword Analysis. *Scientometrics* 27 (2): 119–143.
- Cooper, Melinda. 2007. Life, Autopoiesis, Debt: Inventing the Bioeconomy. *Distinktion* 14: 25–43.
- . 2008. *Life as Surplus: Biotechnology and Capitalism in the Neoliberal Era*. Seattle: University of Washington Press.
- David, Pierre-Marie, G. Girard, and V-K. Nguyen. 2015. AIDS & biocapitalisation. *Books & Ideas.net*. <http://www.booksandideas.net/AIDS-Biocapitalisation.html>
- de Chadarevian, Soraya. 2002. *Designs for Life: Molecular Biology after World War II*. Cambridge: Cambridge University Press.
- Derry, Margaret. 2003. *Bred for Perfection: Shorthorn Cattle, Collies, and Arabian Horses since 1800*. Baltimore: The Johns Hopkins University Press.
- Dumit, Joe. 2012. Prescription Maximization and the Accumulation of Surplus Health in the Pharmaceutical Industry: The_Biomarx_Experiment. In *Lively Capital*, ed. K. Sunder Rajan, 45–92. Durham: Duke University Press.
- Engels, Friedrich. 1884. *The Origin of the Family, Private Property, and the State in the Light of the Researches of Lewis Henry Morgan*. New York: International Publishers, 1972.
- Fischer, Michael. 2013. Biopolis: Asian Science in the Global Circuitry. *Science, Technology & Society* 18 (3): 381–406.
- Fitzgerald, Deborah. 1990. *The Business of Breeding: Hybrid Corn in Illinois, 1890-1940*. Ithaca: Cornell University Press.
- Fortun, Michael. 1999. Projecting Speed Genomics. In *The Practices of Human Genetics*. *Sociology of the Sciences Yearbook* 21, ed. M. Fortun and E. Mendelsohn, 25–48. Dordrecht: Kluwer.
- . 2001. Mediated Speculations in the Genomics Futures Markets. *New Genetics and Society* 20 (2): 139–156.
- . 2002. The Human Genome Project: Past, Present, and Future Anterior. In *Science, History, and Social Activism: A Tribute to Everett Mendelsohn*, ed. E.A. Garland and R.M. MacLeod, 339–362. Dordrecht: Kluwer.

- . 2008. *Promising Genomics: Iceland and deCODE Genetics in a World of Speculation*. Berkeley: University of California Press.
- Foucault, Michel. 1978. *The History of Sexuality, Volume 1*. New York: Vintage.
- Franklin, Sarah. 1997. Dolly: A New Form of Genetic Breedwealth. *Environmental Values* 6: 427–437.
- . 2003. Ethical Biocapital. In *Remaking Life and Death: Toward an Anthropology of the Biosciences*, ed. S. Franklin and M. Lock, 97–127. Santa Fe: SAR Press.
- . 2006. Bio-economies: Biowealth from the Inside Out. *Development* 49 (4): 97–101.
- . 2007. *Dolly Mixtures: The Remaking of Genealogy*. Durham: Duke University Press.
- Franklin, Sarah, and Margaret Lock. 2003. Animation and Cessation. In *Remaking Life and Death: Toward an Anthropology of the Biosciences*, ed. S. Franklin and M. Lock, 3–22. Santa Fe: SAR Press.
- Franklin, Sarah, and H. Ragoné. 1998. Introduction. In *Reproducing Reproduction: Kinship, Power, and Technological Innovation*, ed. S. Franklin and H. Ragoné, 1–14. Philadelphia: University of Pennsylvania Press.
- Fullwiley, Duana. 2007. The Molecularization of Race: Institutionalizing Human Difference in Pharmacogenetics Research. *Science as Culture* 16 (1): 1–30.
- Gaudillière, Jean-Paul. 2014. An Indian Path to Biocapital? The Traditional Knowledge Digital Library, Drug Patents, and the Reformulation Regime of Contemporary Ayurveda. *East Asian Science, Technology and Society* 8 (4): 391–415.
- Gibson-Graham, J.K. 1996. *The End of Capitalism (As We Knew It): A Feminist Critique of Political Economy*. Oxford: Blackwell.
- Happe, Kelly. 2015. Capital, Gender, and Politics: Toward a Marxist Feminist Theory of Convergence. *Media Tropes* 5 (1): 25–57.
- Haraway, Donna. 1997. *Modest_Witness@Second_Millennium.FemaleMan©_Meets_OncoMouse™: Feminism and Technoscience*. New York: Routledge.
- . 2008. *When Species Meet*. Minneapolis: University of Minnesota Press.
- Harris, Olivia, and Kate Young. 1981. Engendered Structures: Some Problems in the Analysis of Reproduction. In *The Anthropology of Pre-capitalist Societies*, ed. J.S. Kahn and J.R. Llobera, 109–147. London: Macmillan.
- Harvey, David. 1989. *The Condition of Postmodernity: An Enquiry into the Origins of Cultural Change*. Cambridge, MA: Blackwell.
- Hauskeller, Christine, and Lorenzo Beltrame. 2016. The Hybrid Bioeconomy of Umbilical Cord Blood Banking: Re-examining the Narrative of Opposition between Public and Private Services. *BioSocieties* 11 (4): 415–434.
- Hayden, Cori. 2003. *When Nature Goes Public: The Making and Unmaking of Bioprospecting in Mexico*. Princeton: Princeton University Press.
- Heckman, James J. 2007. The Economics, Technology, and Neuroscience of Human Capability Formation. *PNAS* 104 (33): 13250–13255.

- Heller, C. 2001. McDonalds, MTV, and Monsanto: Resisting Biotechnology in the Age of Informational Capital. In *Redesigning Life? The Worldwide Challenge to Genetic Engineering*, ed. B. Tokar, 405–419. London: Zed Books. <http://www.social-ecology.org/article.php?story=20031028150738895>.
- Helmreich, Stefan. 2007. Blue-green Capital, Biotechnological Circulation and An Oceanic Imaginary: A Critique of Biopolitical Economy. *BioSocieties* 2 (3): 287–302.
- Hogle, Linda. 1999. *Recovering the Nation's Body: Cultural Memory, Medicine, and the Politics of Redemption*. New Brunswick: Rutgers University Press.
- Idrus, N., and A. Hardon. 2015. Chemicals, Biocapital and the Everyday Lives of Sex Workers in South Sulawesi. In *Sex and Sexualities in Contemporary Indonesia: Sexual Politics, Health, Diversity and Representations*, ed. L.R. Bennett and S.G. Davies. New York: Routledge.
- Isaac, B. 1993. Retrospective on the Formalist-substantivist Debate. In *Research in Economic Anthropology*, ed. B. Isaac, 213–233. Greenwich, CT: JAI Press.
- Jasanoff, Sheila. 2005. *Designs on Nature: Science and Democracy in Europe and the United States*. Princeton: Princeton University Press.
- Kay, Lily. 1993. *The Molecular Vision of Life: Caltech, the Rockefeller Foundation, and the Rise of the New Biology*. Oxford: Oxford University Press.
- Keller, Evelyn Fox. 1995. *Refiguring Life: Changing Metaphors of Twentieth-century Biology*. New York: Columbia University Press.
- Kirksey, Eben. 2015. The CRISPR Hack: Better, Faster, Stronger. *Anthropology Now*, April 26. <http://anthronow.com/print/the-crispr-hack-better-faster-stronger>
- Kloppenborg, J.R. 1988. *First the Seed: The Political Economy of Plant Biotechnology, 1492–2000*. Cambridge: Cambridge University Press.
- Lakoff, Andrew. 2005. *Pharmaceutical Reason: Knowledge and Value in Global Psychiatry*. Cambridge: Cambridge University Press.
- Landecker, Hannah. 1999. Between Beneficence and Chattel: The Human Biological in Law and Science. *Science in Context* 12 (1): 203–225.
- . 2016. Antibiotic Resistance and the Biology of History. *Body & Society* 22 (4): 19–52.
- Landecker, Hannah. 2000. Immortality, In Vitro: A History of the HeLa Cell Line. In *Biotechnology and Culture: Bodies, Anxieties, Ethics*, ed. Paul Brodwin, 53–72. Indianapolis: Indiana University Press.
- Landecker, Hannah, and Aron Panofsky. 2013. From Social Structure to Gene Regulation and Back: A Critical Introduction to Environmental Epigenetics for Sociology. *Annual Review of Sociology* 39: 333–357.
- Larsen, L.T. 2005. Speaking Truth to Biopower: On the Genealogy of Bioeconomy. *Distinktion* 14: 9–24.
- Latour, Bruno, and Steve Woolgar. 1986. *Laboratory Life: The Construction of Scientific Facts*, 2nd ed. Princeton: Princeton University Press; 1st ed. Beverly Hills: Sage, 1979.

- Lépinay, Vincent-Antonin. 2007a. Parasitic Formulae: The Case of Capital Guarantee Products. *Sociological Review* 55: 261–283.
- . 2007b. Economy of the Germ: Capital, Accumulation and Vibration. *Economics and Society* 36 (4): 526–548.
- Lock, Margaret. 2001. The Alienation of Body Tissue and the Biopolitics of Immortalized Cell Lines. *Body & Society* 7 (2-3): 63–91.
- . 2002. *Twice Dead: Organ Transplants and the Reinvention of Death*. Berkeley: University of California Press.
- Luther, Martin. 1520. An Appeal to the Ruling Class of German Nationality as to the Amelioration of the State of Christendom. In *Martin Luther: Selections from His Writings*, ed. J. Dillenberger, 403–488. Garden City, NY: Anchor Books, 1961.
- Marco, M., F. Tirado, E. Baleriola, and P. Torrejón. 2015. Biocapitalismo y suspensión de la norma. *Nomadas* 43: 39–55.
- Marx, Karl. 1857–58. *The Grundrisse. Excerpted in The Marx-Engels Reader*, 2nd ed, R.C. Tucker, (ed.), 221–293. New York: W. W. Norton & Company, 1978.
- . 1867. *Capital, Volume 1*. London: Penguin.
- Maurer, Bill. 2000. A Fish Story: Rethinking Globalization on Virgin Gorda, British Virgin Islands. *American Ethnologist* 27 (3): 670–701.
- Meloni, Maurizio, and Giuseppe Testa. 2014. Scrutinizing the Epigenetics Revolution. *BioSocieties* 9 (4): 431–456.
- Mintz, Sidney. 1985. *Sweetness and Power: The Place of Sugar in Modern History*. New York: Penguin Books.
- Montoya, Michael. 2007. Bioethnic Conscription: Genes, Race, and Mexicana/o Ethnicity in Diabetes Research. *Cultural Anthropology* 22 (1): 94–128.
- Murphy, Michelle. 2017. *The Economization of Life*. Durham: Duke University Press.
- Ong, Aihwa. 2016. *Fungible Life: Experiment in the Asian City of Life*. Durham: Duke University Press.
- Pentecost, Michelle. 2016. Introduction: The First Thousand Days of Life. *Somatosphere*. <http://somatosphere.net/2016/04/introduction-the-first-thousand-days-of-life.html>
- Petryna, Adriana, A. Lakoff, and A. Kleinman. 2006. *Global Pharmaceuticals: Ethics, Markets, Practices*. Durham: Duke University Press.
- Rabinow, Paul. 1992. Artificiality and Enlightenment: From Sociobiology to Biosociality. In *Incorporations*, ed. J. Crary and S. Kwinter, 234–252. New York: Zone.
- Raffles, Hugh. 2007. Jews, Lice, and History. *Public Culture* 19 (3): 521–566.
- Reid, W.V. 1993. Bioprospecting: A Force for Sustainable Development. *Environmental Science Technology* 27 (9): 1730–1732.
- Richardson, Sarah, and Hallam Stevens. 2015. *Postgenomics: Perspectives on Biology after the Genome*. Durham: Duke University Press.
- Ritvo, Harriet. 1995. Possessing Mother Nature: Genetic Capital in Eighteenth-century Britain. In *Early Modern Conceptions of Property*, ed. J. Brewer and S. Staves, 413–426. London: Routledge.

- Rodrigues, R., D. Galindo, F. Lemos, M. Nalli, and D. Santos. 2015. Governo das condutas e subjetividades contemporâneas: o biocapital em questão. *Revista de Ciências Humanas* 49 (2): 41–59.
- Roosth, Sophia. 2013. Biobricks and Crocheted Coral: Dispatches from the Life Sciences in the Age of Fabrication. *Science in Context* 26 (1): 153–171.
- Rose, Nikolas. 2001. The Politics of Life Itself. *Theory, Culture & Society* 18 (6): 1–30.
- . 2007. *The Politics of Life Itself: Biomedicine, Power, and Subjectivity in the Twenty-First Century*. Princeton: Princeton University Press.
- Scheper-Hughes, Nancy. 2001. Commodity Fetishism in Organs Trafficking. *Body and Society* 7 (2-3): 31–62.
- Sharp, Lesley. 2006. *Strange Harvest: Organ Transplants, Denatured Bodies, and the Transformed Self*. Berkeley: University of California Press.
- Shiva, Vandana. 1997. *Biopiracy: The Plunder of Nature and Knowledge*. Zed.
- Shukin, Nicole. 2016. The Biocapital of Living—and the Art of Dying—After Fukushima. *Postmodern Culture* 29 (2).
- Spillers, Hortense. 1987. Mama's Baby, Papa's Maybe: An American Grammar Book. *Diacritics* 17 (2): 65–81.
- Stassart, Pierre. 2003. Metabolizing Risk: Food Scares and the Un/re-making of Belgian Beef. *Environment and Planning A* 35: 449–462.
- Strathern, Margaret. 1992a. *After Nature: English Kinship in the Late Twentieth Century*. Cambridge: Cambridge University Press.
- . 1992b. *Reproducing the Future: Anthropology, Kinship, and the New Reproductive Technologies*. New York: Routledge.
- Sunder Rajan, Kaushik. 2003. Genomic Capital: Public Cultures and Market Logics of Corporate Biotechnology. *Science as Culture* 12 (1): 87–121.
- . 2006. *Biocapital: The Constitution of Postgenomic Life*. Durham: Duke University Press.
- . 2012. *Lively Capital: Biotechnologies, Ethics, and Governance in Global Markets*. Durham: Duke University Press.
- . 2007. Experimental values: Indian clinical trials and surplus health. *New Left Review* 45: 67–88.
- TallBear, Kim. 2008. Native-American-DNA.com: In Search of Native American Race and Tribe. In *Revisiting Race in a Genomic Age*, ed. B. Koenig, S.-J. Lee, and S. Richardson. New Brunswick: Rutgers University Press.
- Taussig, Karen-Sue, Klaus Hoeyer, and Stefan Helmreich. 2013. The Anthropology of Potentiality in Biomedicine. *Current Anthropology* 54 (7): 3–14.
- Thacker, Eugene. 2005. *The Global Genome: Biotechnology, Politics, and Culture*. Cambridge: MIT Press.
- Thompson, Charis. 2005. *Making Parents: The Ontological Choreography of Reproductive Technologies*. Cambridge: MIT Press.
- Tsing, Anna. 2015. *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins*. Princeton: Princeton University Press.

- Turrini, Mauro. 2011. *Biocapitale: Vita e corpi nell'era del controllo biologico*. Verona: Ombre Corte.
- Vermeulen, Niki, S. Tamminen, and A. Webster, eds. 2012. *Bio-Objects: Life in the 21st Century*. Surrey, UK: Ashgate Publishing.
- Vora, Kalindi. 2015. *Life Support: Biocapital and the New History of Outsourced Labor*. Minneapolis, MN: University of Minnesota Press.
- Waldby, Catherine. 2000. *The Visible Human Project: Informatic Bodies and Posthuman Medicine*. London: Routledge.
- . 2009. Singapore Biopolis: Bare Life in the City-State. *East Asian Science, Technology and Society* 3 (2-3): 367–383.
- Weber, Max. 2001 [1905]. *The Protestant Ethic and the Spirit of Capitalism*. New York: Routledge.
- Wright, Susan. 1994. *Molecular Politics: Developing American and British Regulatory Policy for Genetic Engineering, 1972–1982*. Chicago: University of Chicago Press.
- Yoxen, Edward. 1981. Life As a Productive Force: Capitalizing Upon Research in Molecular Biology. In *Science, Technology, and the Labour Process*, ed. L. Levidow and R. Young, 66–122. London: Blackrose Press.

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