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Health Fetishism among the Nacirema:

A fugue on Jenny Reardon's *The Postgenomic Condition: Ethics, Justice, and Knowledge after the Genome* (Chicago University Press, 2017) and Isabelle Stengers' *Another Science is Possible: A Manifesto for Slow Science* (Polity Press, 2018)

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Abstract

Personalized medicine has become a goal of genomics and of health policy makers. This article reviews two recent books that are highly critical of this approach, finding their arguments very thoughtful and important. According to Stengers, biology's rush to become a science of genome sequences has made it part of the "speculative economy of promise." Reardon claims that the postgenomic condition is the attempt to find meaning in all the troves of data that have been generated. The current paper attempts to extend these arguments by showing that scientific alternatives such as ecological developmental biology and the tissue organization field theory of cancer provide evidence demonstrating that genomic data alone is not sufficient to explain the origins of common disease. What does need to be explained is the intransience of medical scientists to recognize other explanatory models beside the "-omics" approaches based on computational algorithms. To this end, various notions of commodity and religious fetishism are used. This is not to say that there is no place for Big Data and genomics. Rather, these methodologies should have a definite place among others. These books suggest that Big Data genomics is like the cancer it is supposed to conquer. It has expanded unregulated and threatens to kill the body in which it arose.

Keywords: big data; genomics; book review; TOFT; ecological developmental biology; reductionism

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1. Introduction

We scientists have always liked Plato's allegory of the cave. We are the draggers, after all, who bring the unwilling citizens of the world out of the cave and dispel their illusions. But what if, in some Matrix-like manner, this world of enlightenment were, itself, only a better-constructed cave? How would we react to someone who was trying to drag us out of it, saying that there was a richer, "truer," reality? Would we, too, go kicking and screaming? Two thought-provoking and intelligently argued books, Jenny Reardon's *The Postgenomic Condition: Ethics, Justice, and Knowledge after the Genome* and Isabelle Stengers' *Another Science is Possible: A Manifesto for Slow Science*, attempt to expose the nature-deprived, commercially driven, ethos of our biotechnological world, demand that we see its inconvenient truths, and that some of us then return to try freeing the others.

In *The Postgenomic Condition*, biologist-turned-sociologist Jenny Reardon sees genomic medicine as a salvage-attempt to wrest meaning from the various human genome projects undertaken throughout the world. She takes us through the history of DNA sequencing projects as well as through the narratives spun by these genomics communities. Their narratives portray genomics as producing a more just world, a more open

society, and a community free from disease[1]. However, Reardon insists that the "-omics" narratives end up in one and the same basin, econ-omics. Genome collections become potential treasure-troves of data for the information economy, and a nation's or a region's genomic repository could become a natural resource at a time when other natural resources are dwindling. The trouble for the genome projects, she insists, is that there is no obvious meaning in any of these collections. The hope that genome-wide association studies (GWAS) would quickly identify common allelic variants that produced or made one susceptible to common non-infectious diseases (e.g., diabetes, cancers, cardiovascular disease) or various behavioral conditions has not been fulfilled (and is unlikely to be so; Weiss and Terwilliger, 2000; Gilbert and Epel, 2015; Weiss 2017; Torkamani et al 2018).

The Postgenomic Condition looks at the failure to find meaning in the genome, a failure so profound that Craig Ventor, one of the major actors in sequencing of human genomes, claimed that from all the genomes sequenced, we still can't even tell what color our eyes would be, let alone whether or not we would have cancer (Ventor, cited in Reardon, 2017). Reardon also looks at the moral failure of the funding agencies to recognize that in funding the sequencing projects, one is not funding other projects that may address more immediate health needs. Using Hannah Arendt's notions of active thinking and the ethics of attention, Reardon, the director of The Science and Justice Research Center at the University of California, Santa Cruz, calls for a re-evaluation of who benefits from genomics. When a University of California medical school is building a genomics center while closing a clinic for families with low incomes, she finds that something is definitely wrong. Similarly, she feels the health needs of Amerindian tribes better served by providing clinics, physicians, and counseling than by genome projects. Indeed, many tribal leaders felt that the scientists of the HGDP were insensitive to the Indian notions of body sacredness and to tribal health needs (Dukepoo 1998a,b; IPCB 2000).

Just as Reardon's book follows Arendt's call to "think what we are doing", Isabelle Stengers' (2018) *Another Science is Possible*, calls for a mindful science, a science where thought is given to cultural matters. Using the model of "slow food," where care is taken in the acquisition and preparation of what we eat, Stengers calls for a "slow science" where "matters of concern" matter as much as "matters of fact". Modern scientists, she believes, are caught-up in showing that they have "the right stuff," the abilities to thrive in hard times, and to speed headlong into their endeavors without thinking of peripheral issues such as who benefits from their findings or what these findings might do to change or abrogate social relationships. Her experience in the European debate concerning genetically modified vegetables showed her the difference between laboratory scientists and field scientists. The former criticized the latter as being sentimental women, i.e., not having the "right stuff."

Like Reardon, Stengers finds the genome projects to be exercises in capitalism more than in science or medicine. Stengers tells us that what constitutes a valid research program has become an opinion backed by financial resources. (P. 31). Science, she says, has been captured by industry, and as such, has been redefined as part of the "knowledge economy." Worse, she continues (p. 54), biological science, now rebranded as biotechnology, has become part of a "speculative economy of promise." Like derivative stocks, one isn't buying a product, but the perception that the promise of a product will be fulfilled.

Stengers confirms and extends Reardon's invocation of Arendt by citing Virginia Wolff's "Let us never stop thinking 'what is this ''civilization'' in which we find ourselves?'". And chief among her thoughts is the redefinition of excellence in science. When "excellence" is defined by internal professional parameters, and not by the consensual standards of the community, then science, as well as the rest of the academic world, will be destroyed by that pursuit of excellence. It would be a difficult, and probably a self-defeating, process to make science obey any community standard (especially when hyper-capitalism has become that standard). It would be better (see Section 2) to imbue scientists with critical and social sensibilities.

Both Reardon's and Stengers' books see genomics as the end of biology. Reardon sees genomics as a field where algorithms replace hypotheses, and practitioners claim that their lack of biological knowledge gives them more objectivity. But objectivity, she notes, is lost in the notion of "curatorship," where DNA connoisseurs determine which sequences are more informative (literally) than others. Rather than preserve organisms, the wardens preserve sequences. Speed, automation, and computers are now the engine of biology, because genomes, rather than organisms, are seen to have agency. It is Richard Dawkin's view of the world writ large in Jacques Ellul's "Technique".

[1] They still do. Reardon's book gives us an interesting context into which to place the rhetoric of biotech ameliorism, such as Bill Gate's (2018) article in Foreign Affairs.

Reardon's major question (p. 27) thus becomes, "How can we know and act ethically in a world where life becomes information, information becomes capital, and capital is equated with freedom?". Lest one think that this is a fantasy, check out the website of the United States' newest genome initiative, "All of Us" (NIH 2018):

> Starting this spring, Americans across the country will be invited to contribute to a massive new pool of genomic information being assembled by the government, a project that represents the most ambitious effort yet to capitalize on the promising new frontier of gene-based medicine.

Their use of the word "capitalize" is telling and rings true[2], for the promise of the information economy is that data is wealth. If the goal of science is public information (i.e., "publications"), and the goal of technology is private information (i.e. "patents"), then which form wins in the fused entity called "technoscience"? The answer, Reardon claims, is: Patents and the private ownership of information. Reardon takes us on the journey from the "opening" of DNA sequences to the public and the participatory democracy that was supposed to end the feudal patriarchy of big science, through the business models of ABA and Illumina sequencers, to the era where corporations use identity politics to recruit paying customers to enlarge their databases. As has also been documented by Stevens (2013), this is a mode of science that is not that of biology, but one that (p. 200) "might suit computers and the computer scientists who program them."

Stengers claims that scientists need to reclaim their science from industry. Actually, she claims more than that. Scientists will have to reclaim the art of dealing with and learning from that which is messy. Like Haraway's "staying with the trouble," scientists will have to understand that the scientific environment has become toxic, not only making the world sick, but making the scientists, themselves, despondent and depressed, divorced from that which they have loved. If science is an army fighting ignorance and disease (as in the "war on cancer"), then it has to acknowledge the damage inflicted not only on its enemy, but also on its soldiers and on the surrounding countryside. Perhaps seeing the military metaphor from a Belgian perspective, Stengers would have scientists on a journey (where the countryside is appreciated as part of the goal) rather than a march. Armies, she says, are mechanized, not civilized, and Stengers would want the soldiers of science to demobilize and civilize themselves once more, learning from others. Civilization, she notes, involves reciprocity, even learning that there are some instances where opinions matter, and that often, a scientific research program (no matter how much excellence there be in its papers) can be merely a well-funded opinion.

And what will happen to other research programs, if organisms are seen as mere epiphenomena of their genomic sequences and its products? Indeed, Reardon asks (p. 200), "what will become of the vast stores of biological knowledge and practices for knowing life crafted over the centuries—taxonomy, descriptive developmental biology, for example—that do not fit easily into this big data approach?"

The answer to this question is as easy as it is tragic. The sciences will be redefined to fit the methodology. This happened when genetics redefined evolution as changes in allele frequency and redefined development in terms of gene expression. It happened when taxonomy was redefined by cladistics. The redefinition of biology to make it more mathematical has been an ongoing project of those who believe that a discipline is scientific only to the extent that mathematics presides (Gilbert, 2018), and genomics is the newest approach to set aside as secondary anything that is physical. Biology would become a science of algorithmic abstractions, not of cells, organs, or organisms. Ask any biologist who works on organisms about the pressing need to "go genomic" when writing grant applications. If one wishes to survive, one redefines one's work. Medicine, moreover, would become a means of applying those algorithms in a healthcare system optimistically called "personalized medicine."

2. Alternatives

Those of us with a few miles on the odometer may recall anthropologist Horace Miner's remarkable 1956 study of "body ritual among the Nacirema."Indeed, this paper is still given to students in many cultural anthropology courses in order to illustrate the extremes of "magical beliefs and practices." Members of this North American tribe divided their time between laboring in its highly developed market economy and performing the ritual activities needed for the maintenance of their bodies, which they believed to be ugly and disease-prone. Each of the native's houses contained

[2] This paragraph containing "capitalize" was removed from the first page of the website once the program was started. However, it can still be found in other areas of the site (https://allofus.nih.gov/about/scientific-opportunities) as of April 4, 2018. The original wording of the press release can be found in the Washington Post (Cunningham 2018).

at least one shrine for the ritual activities of cleansing and beautifying the body, and the worth of a home was often described in the number of such shrines. Without the magical potions used in these rooms, the Nacirema believed they would be deformed and severely debilitated.

Of course, this tribe was the dominant white culture of the USA ("Nacirema" spelled backwards). But however ritualistic its hygienic practices might be, its medical system prided itself in being based on empirical and experimental science. Since the Flexner Report of 1910, Western (and especially, American) medicine has claimed to distinguish itself from the ideologically or theologically based medical practices of other cultures by our regard for scientific evidence.

Until recently. It now appears that Western medicine is turning its back on science and is putting its faith and its funding in a cultural ideology based in genomics and the genetic conception of human individuality. The books by Stengers and Reardon provide provocative and thoughtful evidence for genomics as a faith-based medical belief and a basis for a biology lacking physicality or carnality. But the argument must also be made that there are social and scientific alternatives to the genomic reorganization of biology and medicine.

First of all, there is a very successful alternative to science as a commercialized march to "progress." This is the approach taken by the liberal arts college, a model that takes pride in seeing science in context and in integrating science with the humanities and social sciences. These schools have been remarkably successful in generating important scientists. Seven of the ten schools whose graduates earn the most PhDs are liberal arts schools. One such college, Swarthmore College (whose logo is a scroll, a telescope, a chemical retort, and a microscope atop a book), is fourth in the number of Nobel Prize winners and members of the U. S. National Academy of Sciences per undergraduate student (Hsu and Wai 2015; Clynes 2016). In a very important way, the American liberal arts college is attempting to teach and perform the mindful science that Stengers so forcefully recommends, and other institutions, especially the honors colleges and interdisciplinary programs at many universities, are using this model. Root-Bernstein (1989) sees this approach as being critical for American science, and he documents that most of the scientists who make major discoveries have been those who were trained (or-self-trained) in the arts and humanities. The liberal arts approach allows opinions, doubt, and social context to be spoken aloud in science.

One scientific alternative to the high-tech genomics freeway is the recently formulated science of ecological developmental biology (Gilbert and Epel, 2015; Sultan, 2015). This is a science where organisms and environments possess agency, and the genome is both passive and active. It integrates the work of C. H. Waddington (environmental agency), Richard Lewontin (developmental plasticity), and Lynn Margulis (intra-organismal symbiosis). This is not an approach against genetics or big data. Rather, it demands a broadening of the scientific portfolio, so that other perspectives are also included in biological funding and as appropriate biological explanations. It argues that scientific data —especially those of phenotypic plasticity and developmental symbiosis--reveal that the physical organism is critically important, and that environmental context plays a large role in gene expression. This would make "personalized medicine" a very improbable goal.

Developmental plasticity is the normal ability of a single genome to produce different phenotypes depending on the environment. This has been documented throughout the animal and plant kingdoms (see Gilbert and Epel, 2015; Sultan, 2015). The presence of different temperatures can alter the sex of turtles and fish and the pigments of butterflies; the presence of predators in the environment can change the phenotypes of many vertebrates and invertebrates to give them protective structures (often at the expense of reproductive organs), and different diets in utero can yield different phenotypes in mice and rats. Indeed, the ratios of enzymes that metabolize glucose and fats in mature mice are altered by the diet that the mouse experienced in utero (Lillycrop *et al*, 2005; Lillycrop and Burde, 2015). Genetically identical rats can have different behaviors, since maternal grooming can initiate a hormonal cascade that demethylates certain genes whose products (such as the glucocorticoid receptors) promote and constrain certain behaviors (Weaver *et al*, 2004).

Developmental plasticity also enables an organism to metabolize drugs differently. When wood frog tadpoles are exposed to certain herbicides, the herbicides seem to be harmless to the animals. However, when the tadpoles are exposed to the same concentration of herbicides, but in the presence of predators or competitors, they die (Relyea and Mills, 2001; Jones *et al*, 2011). The metabolism of the herbicide depends on the environmental stresses given to the tadpoles. Similarly, humans are thought to metabolize drugs differently under different stress conditions (Konstandi *et al*, 2014; Rabasa and Dickson, 2016). Stress-induced glucocorticoids activate the adrenergic receptors and play a major role in

regulating the enzymes that metabolize drugs. So in addition to genes, long-term plasticity and short- term stressors also play roles in drug metabolism. These and other epigenetic effects (such as those induced by aging or lifestyle) mean that even though one has particular genetic alleles, whether they are functional or not depends upon chance and environmental contexts. Indeed, cancer cells are often found to have unbalanced epigenomes (Feinberg, 2018). This does not bode well for personized medicine based on one's genome.

Symbioses are also universal, and they also play major roles in drug metabolism. In addition to the 22,000 genes we receive from our human parents, we receive about 8,000,000 different genes from the bacteria that reside in and on our body. We have as many bacteria as we have diploid cells, and it is thought that the microbiome is as active as our liver. As much a thirty percent of the metabolites in our blood are direct or indirect products of our symbiotic bacteria (McFall-Ngai, 2013). Differences in bacteria have been shown to effect the ways individual patients metabolize drugs for cardiac arrhythmias, cancers, psychotic conditions, diabetes, and other medical conditions (Patterson et al 2014; Gopalakrishnan *et al*, 2018). Identical twins discordant for kwashiorkor were found to harbor different bacteria, and the sick twin underwent remission when his bacteria were altered by dietary means (Smith *et al*, 2013). Differences in fish bacteria are reflected in diabetic conditions, as certain bacteria are necessary for the expansion of pancreatic beta cells (Hill *et al*, 2016).

This, too, bodes poorly for personalized medicine. Differences in the drug metabolism can be due to several genomes, not merely the one we inherit from our parents' gametes (Spanogiannopoulos *et al*, 2016; Turnbaugh, 2018). Indeed, the environment can alter the symbionts, since each time we eat, we change the populations of bacteria in our gut. If environments are so important, the very notion of genome-based predictability is fundamentally undermined. Personalized medicine would have to know a patient's bacterial genomes, stress responses, and how these were integrated at the time the drug is given.

Ecological developmental biology takes biology out of the laboratory and into the real world, melding biological data with political and social concerns. This is especially seen in research in cancer and endocrine disruptors. In cancer research, the genome projects have so far failed to find the common alleles for common tumors. Indeed, there is much evidence suggesting that tumors originate through a variety of mechanisms that disrupt communication between the tissues of the body. This has given rise to the Tissue Organization Field Theory, an important alternative to the genomic somatic mutation theory (Sonnenschein and Soto 1999; 2017). TOFT claims that the evidence supports a tissue-level, rather than cellular level, model for the origins of tumors, that most cancer-causing agents do not cause mutations, and that change and motion, rather than stasis, is the default case of cells. Thus, knowledge of the genome won't help prevent cancers as much as removing oncogenic chemicals (such as the endocrine disruptor bisphenol-A, which, like most cancer-forming agents, is not a mutagen) from the environment.

In TOFT and in related endocrine disruptor research, the biochemical pathways involved in hormone synthesis and the repression of cell division are linked with the ecological pathways concerning their use and the political pathways concerning their manufacture and licensing. For example, when Tyrone Hayes (2005) represents the pathway of endocrine disruption from the herbicide atrazine, his illustration includes the biochemical, genetic, political, and environmental causes. The biochemical reaction converting testosterone into estrogen is in the center of the figure. The geopolitical and economic concerns are upstream in the figure, leading to the production of atrazine, which stimulates the activity of the aromatase enzyme that converts testosterone into estrogen. Below the chemical reaction are the endocrinological results of "demasculinization" and "femininization", both of which lead to the physiological and behavioral phenotype: "decreased reproductive success". From here, Hayes puts arrows to the two evolutionary consequences: "Extinction" and "Adaptation".

Alternative sciences, such as ecological developmental biology and the TOFT approach to cancer research may become critically important, especially if the personalized medicine promised by genomics fails to occur. While GWAS studies have found only a few rare diseases associated with rare markers, it has not fulfilled its promise to find common genetic variants that cause common diseases and conditions such as cardiovascular disease (CVD), obesity, Parkinson's disease, and intelligence. Indeed, recent studies suggest that the genetic variants found by GWAS are swamped by environmental factors. For instance, Pazoki and colleagues (2018) have shown that despite the genetic risk for high blood pressure and CVD predicted by 314 GWAS variants, lifestyle quality was associated with CDV at $p<10^{-320}$. The genetic variation was seen to cause less than 3% of the variation in blood pressure. To prevent CDV, the authors recommend changes in lifestyle, and they

are concerned with the possible negative consequences of disclosing genetic risks about blood pressure. Similarly, while the headline (Zimmer, 2017) stated "In 'enormous success,' scientists tied 52 genes to human intelligence," further reading showed that these 52 allelic differences collectively accounted for less than 5% of the variance among the people[3](Snieckers *et al*, 2017).

The GWAS program is also failing in cancer research. Common cancers were not seen to be produced by or associated with common genetic variations. Indeed, rather than finding common variants for common cancers, the Cancer Genome Atlas project found nearly 3000 mutations appear to be associated with tumors (Baily *et al,* 2018; Feinberg 2018). Jamshidi *et al* (2017) found no difference in the mutational burden of "cancer-associated genes" when comparing malignant prostate cancers to adjacent regions that were normal or merely suspicious. Harold Varmus, Director of the National Cancer Institute, remarked nearly a decade ago (Wade, 2010), "Genomics is a way to do science, not medicine," and Robert Weinberg (2014), who brought the somatic mutation theory of cancer to such prominence, now admits that most cancers are not caused by mutation.

So, there is evidence that the claim that knowing one's genome will enable one to get the best set of drugs or the best preventative care may be a fantasy. Moreover there is biological evidence that the environment has agency in normal and pathological conditions, sometimes interacting with and sometimes trumping the genome. Yet, our news broadcasts are replete with assumptions that genes, alone, are responsible for our health or sickness[4]. And the US government is willing to shunt billions of dollars from normal biology and health care programs into the very unlikely program that genomics will solve our health problems and give us a more just society.

What could explain this?

3. Fetishism

Possibly, fetishism. Let's approach personalized medicine as the fetishism of the genome, empowered by industry. Fetishism can be defined as the worship of some object or idea for its alleged magical powers or as the excessive attachment or attention given to some object or idea. In this case, the object of such veneration is the genome. The three-way intermeshing of science, religion, and economics has yielded a strange outcome, where the hereditary material has been honed to be a financial tool, and traditional antagonisms, such as that between biology and religion, are transcended.

The fetishization of genes goes way back to its origins in Morgan's laboratory (see Gilbert, 1998). The early geneticists used so much religious rhetoric in promoting their new science that historian R. E. Kohler (1994) noted that, "the Morgan crowd did sometimes sound like prophets of a new religion". Morgan, especially, liked to say that genetics had superseded experimental embryology, which "ran for a while after false gods that landed it in a maze of metaphysical subtleties" (Morgan, 1932). At the dawn of the molecular age, Jack Cohen (1979) railed against the 'DNA-is-God-and-RNA-is-his-prophet molecular biologists." But as the human genome project took over the field of genetics, all manner of rhetoric sought to give the life-giving power of the Deity to the "master molecule" of life (Keller, 1992). Dorothy Nelkin and Susan Lindee's (1995) T*he DNA Mystique* shows that DNA has become the secular analogue of "soul." It has become our "essence," the basis of our physical and behavioral phenotypes. When an advertisement says that "the sauna is in the DNA of every Finn," or that the mid-sized Hummer has the "same DNA" as the regular model, we know that "DNA" has replaced the word "soul." Similarly, when the advertisement for Ancestry.com tells you that their analysis of your DNA will be "revealing what it is that makes you, you," they are selling an ideology that your essence is your genome[5].

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[3] It must be recalled that all GWAS can give us are correlations, the weakest type of inference, without evidence of causation. Thus, Big Data will give spurious correlations, such as the divorce rate in Maine correlating (99.26%) with the per capita consumption of margarine (Vigen 2015). Indeed, the number of nesting storks observed in Germany from 1965 to 1980 correlates quite well with the number of live births there during those same years (Sies 1988), an association which, if causal, would undermine the foundations of both genetics and embryology. The microchimerism now seen to pervade our body (Lodato et al 2018) makes such spurious associations very probable. Other problems with GWAS include what to do with the data. One possible GWAS association, that between an allele of the NFKB1 gene and asthma in black children, provides a stark ethical quandary. If asthma is caused by the combination of a particular allele and bad air quality, does one develop a drug to alleviate the disease (albuterol does not appear to work well on people with this allele of NFKB1) that will be at the expense of the families, or does one try to alleviate the bad air quality? Extending this model beyond poor urban blacks, will each of us be expected to take personalized medicines to allow us to survive in an otherwise toxic environment, i.e., Roundup for humans?

[4] As I write this, my newsfeed shows an article from *Business Insider* (Brueck 2018), declaring matter-of-factly that "All cancer is a result of DNA damage or genetic mutations in our DNA." Meanwhile, another article (Craig 2018) calls for turning more biologists in "bioinformaticians".

[5] This genomic fetishism also puts a premium on having a

But the leaders of such rhetoric that instilled God-like agency to the genome are the two archrivals of the contemporary science-religion conflict, Francis S. Collins and Richard Dawkins. Richard Dawkins has been the great popularizer of genetic determinism for the general public. His book *The Selfish Gene* has been voted the most inspiring British science book of all time by the Royal Society of London (2017). This is the book wherein Dawkins claims, "We are survival machines-robot vehicles blindly programmed to preserve the selfish molecules known as genes". He can be remarkably poetic. In *The Blind Watchmaker* (1986), he writes:

> It is raining DNA outside. On the banks of the Oxford canal at the bottom of my garden is a large willow tree and it is pumping downy seeds into the air.... not just any DNA but DNA whose coded characteristics spell out specific instructions for building willow trees that will shed a new generation of downy seeds. These fluffy specks are literally spreading instructions for making themselves. They are there because their ancestors succeeded in doing the same. It's raining instructions out there. It's raining programmes; it's raining tree-growing, fluff-spreading algorithms. This is not a metaphor, it is the plain truth. It couldn't be plainer if it were raining floppy discs.

The genetic program is, of course, a metaphor. And it is about as up-to-date as floppy discs. But just as importantly, as alluded to by its title, *The Blind Watchmaker*, Dawkins has become the public atheist of the English-speaking world. He is the scientist against religion, the one who is certain that God does not exist. Evolution has taken over from God the ability to generate life, and at the center of evolution are the algorithms of the genome.

For Francis S. Collins, the head of the Human Genome Project and the current Director of the National Institutes of Health, the human genome is the signature of God, "God's Instruction Book". Indeed, he writes that his decision to become director of the Human Genome Project was that of a response to a calling (Collins 2006, p. 119).

> As a believer in God, was this one of those moments where I was somehow being called to take a larger role in a project that would have profound consequences for our understanding of ourselves? Here was a chance to read the language of God, to determine the intimate details of how humans had come to be.

Collins spends a chapter of his *The Language of God* defending his theistic evolution against the atheism of Dawkins, with whom he's publically debated.

Collins' theistic evolution is the striving of the natural world towards its telos—humans, the animals that can understand God and God's creation. No other genomes are mentioned. Collins' evolutionary tale is an exclusionary and exclusivist one. Humans are the pinnacle of evolved creation. No other animal or plant needs to be considered. Collins' God wrote his signature into the human genome, and his biology concerns no other animal. Collins (and for that matter, his financial backers, such as Bill and Melinda Gates), are interested in farms, not ecosystems (see Gates 2018). The only genomes that matter are those involved directly with human welfare. Several anthropologists have recently warned (Haraway *et al,* 2015) we are entering a Plantationocene Epoch, where the world is merely a farm for human exploitation. At a time when the planet's ecosystem needs our help the most, the most important person in prioritizing the funds of life sciences in the United States is a God-fearing human exclusivist. Another inconvenient truth.

The concept of fetishism does some heavy work. First, as mentioned above, it unites religious and anti-religious rivals. The pious Christian NIH director Francis Collins and his atheist opponent, Richard Dawkins, are now fighting on the same side—for the genome. They both can be seen as idolaters worshipping the same totem. Both worship the genome as the Demiurge of creation. If one wishes icons, look to the cover of *The Language of God*, to see the double helix done in stained glass.

Second, there is epistemic ambivalence that allows one to believe in the fetish while knowing full well that it is not the truth. This ambivalence—the fetish-worshipper knows the fetish is man-made, even as he gives it supernatural power-- is characteristic of fetishism (Latour, 2010). Geneticists know that the genome is a surrogate (or at best, a simplification) of multiple networks of social and scientific enterprises (Haraway, 1997). We know that most cancers are not genetic (Sonnenschein and Soto 2017b) and that environmental changes can be effective means to preventing cancers

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biologically related baby. "Who are you?" becomes less a matter of how you were raised and what opportunities or crises you had, than what your human genome is. Moreover, identity politics become reified, as one finds out that you are, for instance 25% German and 25% Sardinian. Can someone be 100% German? What does this mean? "Sardinian" is an actual category for some of the commercial companies, despite the fact that Sardinia is at the border between Europe and Africa, and has been ruled by Phoenician, Roman, Visigoth, Byzantine, and Islamic cultures. To be 25% Sardinian must be similar to being 25% New Yorker.

and many non-infectious diseases. We know that developmental plasticity and symbionts change the way we metabolize our drugs. But the genome projects continuously add epicycles to their genomic theories. The genomes are given unique agency, denying and disavowing both the interactions of phenotype production and the cultural interactions that brought the genome into material-semiotic existence (Haraway 1997, p. 143). As Richard Lewontin (1992, p. 33) said, "First, DNA is not self-reproducing, second, it makes nothing, and third, organisms are not determined by it."

Third, according to H. K. Bhabha (1994), the fetish "gives access to an 'identity' which is predicated as much on mastery and pleasure as it is on anxiety and defense, for it is a form of multiple and contradictory belief in its recognition of difference and disavowal of it." This observation is paramount; for the genome is seen by its worshippers as both (1) the handiwork of God, stunning evidence of His creative power, and at the same time, (2) the source of humanity's misery and disease. Both holy similarity and debilitating allelic differences are critical for the argument for personalized medicine. The fetish encourages and is sustained by this ambiguity.

Fourth, there is commodity fetishism, which demands the abstraction of the entity coupled with its later interpretation of worth. The abstractive flattening involves the compression of many rich dimensions of living organisms into algorithmic computations. The science of life has become the science of genes, and the science of genes has become bioinformatics, which takes its place in the executive suite of capitalism's "economics of information." Biology is no longer the study of living organisms, but a set of wagers concerning the outcomes of sequence recombinations. Stengers calls it a "capture" of biology. This process of making the fetish (according to Marx, cited in Keenan 1993, p.130) de-animates entities and then re-animates them without presuming they had any life prior to the abstraction. "Value," writes Marx (167/88), "does not have its description branded on its forehead; rather it transforms every product of labor into a social hieroglyphic. Later on, men try to decipher the hieroglyphic." The labor of many people and expensive machines have turned humans into data, and the value of this data will be determined by the social interactions among potential consumers. Donna Haraway wrote (1997, p. 135), "Ask any biodiversity lawyer whether genes are sources of 'value' these days, and the structure of commodity fetishism will come clear." Twenty years later, a recent reviewer of Reardon's book (Isasi, 2017) maintains, "The human genome has an ineffable value." Q.E.D.

Those who possess and control the data demand that it be considered a most valuable possession. And this worth can be evidenced by the amount of labor put into extracting it and the perception that it is something that generates wealth. (Indeed, the dominant metaphor has been that data is a precious stone that is "mined." There is no intrinsic worth to a ruby or sapphire except that which our interactions have placed on it. And it "means" little until it is properly cut. Similarly, the DNA sequence is just a series of nucleotides until it gets placed in a setting that gives it worth.) This means that there has to be concerted effort by those possessing the data to have society agree that this information is, indeed, worth having. Health is a value worth having, and Collins knows the power of his budget to make health equal genomics. At the recent annual meeting of the American Society of Human Genetics, Collins (2017) is reported to have told the assembled researchers,

> "Researchers may not always like to share their data, and getting them to behave in certain ways can seem like herding cats", Collins said, "but I have a big bag of cat food, which is the NIH budget".

Herding cats is easy when you hold the power of life or death over their projects. Richard Goldschmidt (1949) predicted this in his prophetic paper 70 years ago, and it is worth reading in the footnote[6].

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[6] From Goldschmidt (1949): But now a man does not work on some subject or problem. He has a "project." A plan has been laid out, even worked out in all detail, a staff has been brought together and each one has been assigned his duty. An organization has approved the plan and furnished the funds; in return it expects progress reports, visible and quick results, and no deviation from the plan agreed upon. Everybody is happy to have a "project," and only Minerva covers her face and sends the owl away to catch mice. I realize certainly that there are types of work which should be handled as organized "projects." If you want to prepare 200 stereoisomers of some organic compound and test their action as insecticides, a project is in order. If you want to eradicate a certain mosquito in a certain place, go and organize it. But how a major discovery or idea can come from a project I am unable to understand. This, however, is not what I want to discuss. I want, rather, to point to the danger to the freedom of science which lurks behind this way of making science. The danger will come from the men who are attracted to such a type of scientific big business. The thinker, the blaster of new paths, the keen observer, the man of intuition whose thinking is ahead of his time, will not flock to the big Government-financed and -sponsored projects. Sooner or later leadership will fall to the university politician, the promoter, the men who make the headlines--headlines not in the history of discovery but in the press. Second-raters will attain the power that goes with the big funds, and then the moment of danger arrives. They will favor what they like and understand, suppress what is beyond their vision. Being not too intelligent, they will fall prey to the flatterer, and will always go along with the latest scientific

4. Concluding remarks

The projects that replace creative science in Goldschmidt's dire prophecy are those now detailed by Reardon. The latter, unplanned, science mentioned at the end of Goldschmidt's diatribe is the "other science" that Stengers alludes to. It is not a return to a past that never was. Rather, it is an amalgamation of all that science, philosophy, sociology, and art can bring together. It is a mindful science, where the mind is now able to access areas of philosophy, sociology, and art that were previously "unthinkable". It seeks a science that does not go alongside the humanities and social sciences, and that does not conquer the humanities and social sciences; but a science travels with them, making new chimeras of thought that will promote and constrain various types of scientific research programs. It looks forward to a fully renewed biological science that will take on the questions of promoting thriving ecosystems rather than attending solely to the more immediate questions of human health and longevity.

In addition to the Allegory of the Cave, another famous scientific trope is the Displacement of Humans: Copernicus showed that the earth is not the center of the universe, Darwin showed that man is not the center of life, and Freud showed that the conscious brain is not the center of thought. However, if Stengers and Reardon are correct, we've placed humans and the human genome right back into the center of our universe. Indeed, "the human genome" is becoming a sociotechnical system, something (like coal or guns) that constructs the social and political order not only by its technical properties, but also by the institutions that emerge to organize it, make it useful, or realize its social potential (Lindee, personal communication). This worldview has impoverished the biological sciences and may be severely impairing our medical sciences.

These books are also calls to arms, beseeching biologists to "take back" biology from informational biotechnology, and to study and appreciate organisms, their interactions, and their messy interpenetrations. Others have also argued this point. Ken Weiss (2017) for instance, claims that Big Data projects are locking up far too much of America's funding for biomedical research, and he suggests that we should pursue intensive research in curing such obvious genetic diseases as cystic fibrosis and Huntington's disease before we start looking at autism, schizophrenia, or those health problems where lifestyle changes are already known to work. But the problem, he writes, is "that the reality of improving the yield of publically sponsored science is about the money, not the science."

And this may be a problem that bodes poorly not only for biology and for personalized medicine, but also for the global economy and the roles universities play in the world. Mirowski (2012) has characterized the modern commercialization of biology as a "passel of Ponzi schemes." He notes that intent to defraud is not necessary for an investment strategy to turn into a Ponzi scheme. It can emerge quite naturally from investors desiring to make large profits when a product is being promised, such that dividends are paid to early investors from the money deposited by later investors. Many major research universities have invested wholeheartedly in these schemes, and as Mirowski (p. 288) sadly notes, "there is no governmental equivalent of the Federal Reserve to intervene in order to rescue universities deemed too big to fail, or too significant in the cultural patrimony to abandon". In the conclusion of their article on "saving science," Bizzarri and colleagues (2017) quote Carl Woese's dictum that "a society that permits biology to become an engineering discipline ...is a danger to itself." These are important books for realizing what may be happening our worldview of science, nature, and technology.

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fashion or even the doubtful schemes of fanatics or reactionaries, and certainly always with well-entrenched schools. They will easily find the ear of the politicians who run the funds, for both talk the same language. At this point the setting is ready for a Lysenko type. Though our political system will not give him a chance to act as savagely as is possible in Russia, he could do enormous damage to the progress of science and the freedom of research if not checked in time. This sounds very pessimistic, but human nature is the same everywhere, fanatical activists are available everywhere if not kept in check, and men who believe in "politics as usual" are not only more numerous than men of original ideas but are also more selfish and ruthless. Thus, I believe that the increasing financial support of research, especially by government and political agencies, tending to flow into the channels of organized research, is fraught with the danger of bossism in science, with the danger of subsidizing mediocrity, and in the end with a threat to the freedom of science and its teaching. This is not to say that I am opposed to government funds' being set aside for fundamental research. This is a need of our time, a necessity. But precautions should be taken and a watchful eye should be kept to prevent such funds from working to the detriment of real science. It is the young generation, who will profit from the incoming funds, who should also be alerted against the danger that politicians, both those within and those outside the universities, will take over science. The young researcher must insist upon the right to think for himself, to plan for himself, to make his own mistakes, and to be happy over an unplanned, unforeseen discovery. Real progress in science has always been made and will always be made by the free mind, left to its own working under a system where science is free.

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