Genetic Determinism

Abstract

Genetic determinism is the idea that, although environmental factors play a role as well, we basically are our genes, so that the personal genome (i.e., the genetic material of an individual) not only provides us with self-understanding but may also enable us to become the managers of our own life. This idea fuelled the Human Genome Project, meant to grant human beings access to their own "blueprint," as HGP director Francis Collins phrased it. Paradoxically, however, the HGP undermined its own conceptual starting point by demonstrating, once and for all (so it seems), that genetic determinism is untenable, indeed: that genetic determinism is "dead." At the same time, it is "undead" because, notwithstanding the emphasis on complexity that dominates the various forms of post-genomics research, the language and logic of genetic determinism keeps recurring in contemporary discourse, both in the public and in the scholarly domain.
Keywords Genetic determinism - Genomics - Post-genomics - Complexity - Human Genome Project - DNA - Nature-nurture debate - Complexomics

Introduction

Definitions of "genetic determinism" tend to come in two "flavors." The stronger version, which notably thrives in popular culture, proclaims that genes alone determine the traits and behavior of living organisms, including humans. In the scientific literature, however, a somewhat "softer," more nuanced version is in vogue, stressing that, although genes ultimately determine human life, they do so in close interaction with environmental factors. Nonetheless, genes are granted a privileged causal status (De Melo-Martin 2005). The protein-coding genes on the genome are regarded as a genetic program, a building plan (Nusslein-Volhard 2006). In the 1990s, during the heydays of the Human Genome Project (HGP), genetic determinism was fairly widespread, but in recent years the pendulum has swung backwards again toward non-deterministic approaches that emphasize the overwhelming complexity and emergent properties of living systems, notably humans. Genetic determinism has not only been propagated by geneticists and molecular biologists, however. Bioethicists, stressing the exceptional qualities of genetic knowledge (for instance, by endorsing "genetic exceptionalism"), have likewise (intentionally or unintentionally) strengthened genetic deterministic views on human life. In this entry, the focus will not be on the biological details of the debate as such, but rather on the view on human existence (the image of human nature) that is conveyed by it. Has genetic determinism affected the way we see ourselves? And if so, what have been the consequences for bioethics (for instance, in terms of human identity and responsibility)?
In the first section of this entry, I will briefly describe the rise and decline of genetic determinism during the previous century (historical background). Subsequently, I will focus on deterministic and post-deterministic tendencies of contemporary scientific debate and their bioethical implications. But I will also briefly present two examples of cultural genres (a novel and a movie to be exact) in which genetic determinism is initially endorsed but eventually discarded.

Historical Background of the Issue: The Rise and Decline of Genetic Determinism During the "Century of the Gene"

The twentieth century has been referred to as the "century of the gene" (Fox-Keller 2000). It began with the rediscovery of the work of Gregor Mendel in the spring of 1900 and culminated in the formal announcement of the (imminent) completion of the human genome sequencing effort at a famous Press Conference in June 2000. The ultimate outcome of the HGP, a "composite" sequence known as the Human Reference Genome (HRG) which is periodically updated, was published in 2003. But a number of midterm events deserve to be highlighted as well. In 1943, to begin with, quantum physicist and Nobel Prize laureate Erwin Schrödinger (1944/1967) appealed to biologists and physicist to join forces in trying to understand the molecular structure of genes, the "elementary particles of life," and to decipher the "genom" (without the e) as the "Morse code" of living systems. Ten years later, James Watson and Francis Crick, a biologists and a physicist (and avid readers of Schrödinger's book), building on crystallographic data produced by biophysicist Rosalind Franklin, discovered the structure of DNA. This event significantly boosted the idea that the human genome, written in an alphabet

of nucleotides, might be the key to unlock the mysteries of human existence. As soon as we are able to "read" our genome sequence (the molecular language in which the program of our life is written), we will not only be able to know ourselves but also be provided with a window into our future. By taking into account our strengths and weaknesses, as suggested by our genomic code, we may become the managers of our biographies and our health status.

Indeed, as Nelkin and Lindee (1995/2004) have demonstrated, the HGP has had a major impact on the Nature-Nurture debate, one of the most important scholarly disputes of the twentieth century (Düwell et al. 2008). This debate followed a series of pendulum swings from "nature" (which in the twentieth century came to be equated with our genetic predisposition) toward "nurture" (i.e., the social environment) and back again. From 1900 until 1935, due to ideas and insights coming from genetics, combined with evolution theory, the nature paradigm held sway. Indeed, the first decades of the twentieth century were the heydays of the eugenics movement, notably in the United States. After 1935, however, a decline set in, partly due to scientific developments (the growing criticism of the supposedly hereditary nature of complex traits such as alcoholism, poverty, or delinquency), but predominantly due to social and political developments such as the rise of Nazism in Germany. Thus, after World War II, the "nature" paradigm seemed convincingly discredited, and "nurture" became the dominant factor in explanations of deviant, antisocial, delinquent, or otherwise exceptional behavior. The focus of attention clearly shifted to environmental and social factors.

During the late 1980s, however, that is, during the preparatory years of the HGP, the pendulum began to swing back again. As Nelkin and Lindee put it, "By 1992, the consensus that had dominated public policy since the 1950s - that 'nurture' was more important than 'nature' - was changing" (p. 106). Society began to accept biological differences. The focus was now once again on inherited predispositions (Zwart 2013). Social success, intelligence, poverty, or aptitude to criminality seemed predominantly determined by our genes.

During the first decade of the twenty-first century, however, genetic determinism quickly began to lose ground and credibility again. The completion of the human genome sequence, proudly announced at the June 2000 Press Conference, was actually a disappointment, resulting in a scientific hangover. First of all, the human sequence contained no more than ~23,000 genes, a remarkably small number in comparison to previous estimates (which had ranged from 100,000 up to 350,000 or more). Apparently, our genome is remarkably similar to the genomes of other species. Although the human genome sequence will no doubt remain an interesting research topic from a purely biological point of view, it does not tell us much about uniquely human achievements, experiences, and health issues and hardly produced new treatment options. Moreover, it quickly became clear that genes only account for a relatively small section of the astonishingly complicated set of processes known as "life." In order to understand life in general, and human life in particular, "proteomes," "metabolomes," "transcriptomes," and various other dimensions of living systems have to be taken into account as well. In other words, although the HGP was inspired by a genetic deterministic view on life, in the end this very project, more than anything else, has proven that genetic determinism is untenable (Zwart 2007a): its "truth" (its conceptual end result) was antithetical to its starting point.

In 2010, 10 years after the Press Conference, Nature published a special issue, a retrospect as it were, addressing the question what the (lavishly expensive) HGP had actually delivered. Francis Collins, former director of the HGP, and now Director of NIH, contributed a paper entitled Has the revolution arrived? (Collins 2010). His answer essentially was not yet. The most important outcome of the HGP was the acknowledgment that life is much more "complicated" (Hayden 2010) than was envisioned back in 1989, when Collins wrote his very first e-mail, the Berlin Wall collapsed, and the HGP was about to be launched.

In that same year, Collins published a book entitled The Language of Life (2010b). In this monograph, he still presents the HGP as "one of the boldest scientific efforts that humankind has ever mounted" (p. 299). Yet, the enthusiasm that had peaked during the days of the Press Conference had more or less evaporated: "Nearly a decade has passed since that moment of celebration… But the effect on the public of all the hoopla in 2000 has been mixed. Most people know that the genome has been spelled out, but they have lost track of what has happened since then. They remember the ascent of the mountain, but they are unaware of the rewards that are starting to appear in the valley" (p. 3). In his book, Collins continues to argue in favor of the idea that genes hold the key to human life, but the focus of attention now shifts from the general to the personal genome. Once individuals are granted access to their individual sequence, they will be provided with a window into their own personal future, allowing them to assess their congenital strengths and weaknesses and act accordingly (in terms of diet, lifestyle, professional career, or treatment options). Yet, although some of the gene-speak language used in the book is still fairly deterministic, the examples that are actually given of how personal genomes are supposed to revolutionize our lives are actually quite unassuming (Zwart 2011).

The Bewildering Complexity of (Human) Life: Implications for Bioethics

Before presenting a preliminary assessment of the current situation, I would like to say a few words on method. How are philosophers in general, and bioethicists in particular, to read contemporary scientific discourse in booming research fields such as genetics, genomics, and post-genomics?

First of all, as Hegel already noted in his Philosophy of Nature (1830/1970), there is more philosophy in science than scientists are usually aware of, or willing to acknowledge. In order to bring this latent philosophical content to the fore, scientific discourse must be read from a particular perspective, looking for the basic philosophical conceptions, referred to by Hegel as the "philosophemes." During periods of scientific turmoil, moreover, such as we are witnessing today, these basic philosophical convictions (these "philosophemes") are likely to be in a state of transition, of conceptual flux. Due to changes in the "spirit of the time," the basic categories (the basic "philosophemes") of scientific thinking are now amenable to shift and change.

Genetic determinism, claiming that we are our genes (up to a certain point), is an interesting example of what Hegel would refer to as a "philosopheme." In this case, the collection of protein-coding genes is seen as the "idea" that realizes itself in us, or more generally in the life of an organism. Yet, the philosopheme of determinism (seeing genes as ultimate causal determinants of organic processes) is currently being challenged by approaches that tend to emphasize the bewildering complexity and emergent characteristics of life.

Yet, complexity is not only encountered in life as such (as the "object" of research) but also in the scientific research practices that are studying it. We have entered an epoch of transdisciplinary, large-scale, highly ambitious global research programs ("big" life science). Already in 1972 Michel Serres argued that we live in an era of disruptive change, exemplified in science by the emergence of large-scale, high-tech, transdisciplinary research fields such as molecular biology (Serres 1972). Philosophy runs the risk of losing track, of becoming outdated and irrelevant. Yet, philosophers can still play a pivotal role, provided they acquaint themselves with contemporary life science research practices from a position of close proximity, entering the capillaries and tissues of techno-science as embedded scholars, addressing philosophical issues raised by these developments in close interaction with the scientists involved, analyzing how techniques, vocabularies, research practices, forms of information, and metaphors spread through research fields worldwide.

This means that the scientific literature must be read with "evenly poised attention," to use a Freudian term. As bioethicists, we are usually not focused on the biological issues and details as such. Rather, we are "reading for the philosophemes," opting for what can be referred to as an "oblique perspective," persistently on the alert for interesting metaphors (such as: "The Morse Code of Life"), latent controversies, and intriguing terms (such as particular neologisms, or words that seem completely out of place).

If we read contemporary science from such a perspective, we will quickly notice that life science discourse is remarkably creative, not only in view of the metaphors that are produced and used to explain the meaning and function of the genome (such as "The Morse Code of Life," "The Book of Life," "The Recipe of Life," "The Musical Score of Life," "The Map of Life," etc.) but also as a producer of novel terms, especially now that we have entered the so-called post-genomics era. The list of -omes (dimensions of living systems) that are studied by various -omics fields seems interminable, as attention is shifting from genomics (studying the genome, i.e., the genetic information in an organism) to subsequent research fields such as proteomics (studying the proteome, i.e., proteins, protein-coding genes, and their metabolic pathways), metabolomics (studying the metabolome, i.e., the collection of metabolites: the end products of cellular processes in cells or organisms), transcriptomics (studying the transcriptome, i.e., mRNA transcripts and other RNA molecules in cells), physiomics (studying the physiome, i.e., providing quantitative description of the physiological dynamics or functions of the whole organism), environomics (studying the environome, i.e., environmental factors that influence human health and complex social behavior), and so on.

This plethora of neologisms indeed seems to indicate that the basic philosopheme is shifting in the sense that genetic determinism gives way to the awareness that life is bewilderingly complex. In view of the countless interactions between the various dimensions of life captured by these neologisms, a deterministic view (explaining life predominantly on the basis of genes) seems out of the question.

This is underscored by a number of recently coined and even more extravagant -omics terms that explicitly seem to criticize a genetic deterministic approach, such as unknomics (studying the unknome, i.e., everything that cannot be

studied by other -omics approaches), complexomics (studying the complexome, i.e., the complex interactions in organisms on cellular and molecular levels), and (finally) promisomics (analyzing and assessing the promises and expectations raised by all these genomics and post-genomics research activities (Chadwick and Zwart 2013)).

This leads up to the inevitable conclusion that genetic determinism (the basic philosopheme of the HGP) seems "dead" (Gould 2001). Life is "simply" much too complicated to be analyzable in terms of gene-speak alone.

At the same time, as Susan Oyama aptly phrased it, all these efforts to criticize genetic determinism seem like fighting the "undead" (1985, pp. 26-7; Cf. Griffiths 2006). Like a conceptual vampire, a phantom idea, genetic determinism still seems to fuel many of the -omics approaches listed above. Once we have found new ways and tools to combine all this information coming from the proteome, the metabolome, the transcriptome, etc., determinism may once again become a viable "regulative" ideal.

Genetic Determinism in Genres of the Imagination

Genetic determinism proves a rich source of inspiration for popular culture, notably in the case of movies and novels. A fairly long list of examples can be given. Whereas the novel [1976]/movie [1978] Boys from Brazil, for instance, is devoted to a project aimed at revivifying Adolf Hitler through cloning, Robert Harris's (somewhat more subtle) novel Archangel (1998) plays on a similar idea, now featuring Joseph Stalin's unknown son. And while the movie Gattaca [1997] envisions a world where genetic predestination reigns, and in which the future prospects of individuals are completely determined by their DNA, at birth, the movie Alien [1992] depicts a prison planet populated by men genetically predisposed to violence (possessing an extra Y chromosome: XYY males). Another movie, Naturally Born Killers [1994], builds on a similar idea, conveying the gloomy message that some individuals are congenital killing machines and psychopaths by birth. And this is only a very small sample from a rather extended list. Interestingly, many of these titles, stories, and images are subsequently taken up by scholarly literature in return. An article on the genetic origins of extreme violence by Ferguson and Beaver (2009), for instance, has "Naturally Born Killers" for a title. In short, rather than constituting two separate cultures, there is a significant amount of border traffic from scientific discourse to popular culture and back.

Genres of the imagination often prove an interesting read for bioethicists because they explore (in a lively, albeit often somewhat amplified/exaggerated manner) some of the ideas at work in scientific discourse. These novels and movies may function as laboratories, where "thought experiments" and future scenarios can be elaborated and explored. For this entry, I have selected two items, a novel and a movie, to show how the "philosopheme" of genetic determinism is taken up and fleshed out in popular culture.

As my first example I would like to use Michael Crichton's novel Next (2006). As is indicated by the title, this novel belongs to the era of "next generation sequencing": dramatically improved automated sequencing machines and supercomputers are now expected to enable us to make the leap from the general human reference genome (produced by the HGP, as described above) to the individualized genome, also known as the "$ 1,000 genome" (Davies 2010). What will happen if individual genomes become easily available to all citizens?

Crichton's novel is a kind of bioethical laboratory in which a series of imaginary experiments are being conducted to address this type of questions: What will happen if personalized genomics information begins to spread through society, affecting the ways in which individuals think and speak about themselves? In other words, Crichton's novel explores the possible impact of personalized gene-based bio-information on individual self-understanding. The book introduces a considerable number of intersecting storylines concerning individuals who are actively engaged in redefining themselves on the basis of their genetic profile. Thus, Next can be read as a literary scenario study devoted to outlining the meaning of genomics for identity formation. Most of the novel's storylines develop around a number of "genes for" - genes that supposedly (co-)determine behavioral characteristics, such as the maturity gene, the novelty-seeking (or thrill-seeking) gene, the sociability gene, the infidelity gene, and so on. Genomics terms and technologies are used for a broad variety of practices of the Self, ranging from paternity testing and partner selection up to jurisdiction. Lawyers for instance may consider the presence of the novelty-seeking gene on a client's genome as a potentially mitigating circumstance for suspects who engage in risky lifestyles, while the presence or absence of the infidelity gene may play a role in cases of divorce. The novel also describes the treatment of a drug addict with a spray containing an experimental virus that carries the "maturity gene," which will solve the drug problem but also causes premature aging.

For most of these genes, there actually is some connection with serious academic research so that, although many of the events described in the book seem to take the logic of genetic determinism to the point of absurdity, there are traceable connections with ongoing research efforts (Zwart 2007b). In 1996, for example, a research group confirmed that variation

in the length of the gene for the dopamine D4 receptor correlated with "novelty seeking," i.e., extravert and thrill-seeking behavior (Benjamin et al. 1996; Cf. Hamer and Copeland 1998). Yet, the small print in Hamer and Copeland's Nature Genetics study can be easily overlooked: "this was far from the gene for bungee jumping, as some newspapers reported" (Cf. Davies 2010, p. 233). Likewise, various research papers have been published on the "sociability gene," but this type of research studies solitary versus group feeding in C. elegans, and it is far from evident how the findings in question can be extrapolated to the intricacies of human behavior. The most prominent "gene hunter" in Crichton's book is Dr. Robert Bellarmino, head of the National Institutes of Health (NIH), top scientist but also devout Christian, politically skilled, and media savvy. He seems to be (at least partly) modeled on Francis Collins, who also began his career as a "gene hunter."

Via literary strategies such as exaggeration, absurdism, and satire, the basic conviction (the "philosopheme") of genetic determinism is systematically ridiculed. Thus, the novel points to the enormous tension between the kinds of insights genomics research is actually producing and the way they are sometimes represented in the public realm (also by scientists themselves). Yet, the novel also contains some serious debate and criticism of gene hunting, arguing that "no single gene controls any behavioral trait" (p. 158).

One of the fictitious critics of genetic determinism in Next is Professor William Garfield of the University of Minnesota who claims that "despite what you hear, nobody has ever proven a single gene causes a single human behavioural trait… The interaction of genes and environment is just too complex" (p. 211). There is, for instance, no single gene that accounts for alcoholism. Although the public readily seems to believe that genes cause behavior, the actual relationship between genes and environment is very complicated. Scientists do not yet really understand how genes work. In fact, "there is no general agreement on what a gene is… [Among scientists] there is no single agreed-upon definition of what a gene is" (p. 212; Cf. Dupré 2004 for an philosophical version of this debate). Garfield also mentions how startled scientists initially were to find such a small number of protein-coding genes on the human genome. "After all, a lowly earthworm has 20,000 genes. How, then, could you explain the huge difference in complexity between the two? That problem vanished as scientists began to study the interactions among genes [and began to move into] 'epigenic studies', which look at exactly how genes interact with the environment to produce the individual that we see" (p. 213). But as a rule, Crichton preferably relies on literary techniques, such satire and absurdism, to make his point.

A second example I would like to mention is the movie Blueprint, based on a novel by Charlotte Kerner (1999) and released in 2003, the year in which the Human Reference Genome was completed (while 50 years had passed since the discovery of the structure of DNA by Watson and Crick). The title echoes a metaphor often used by spokespersons of the HGP themselves, notably Francis Collins, whose quote "Mankind is about to see its own blueprint" (1999, p. 28) was already cited.

In the movie, the German star actress Franka Potente plays Iris Sellin, a world-famous pianist and composer, but also her daughter Siri. Upon being informed that she is suffering from a degenerative disease that will eventually ruin her career, but unwilling to accept the prospect of premature decline and death, Iris decides to pay a visit to Dr. Fischer, a biomedical expert in Vancouver, indicating her willingness to volunteer as a research subject in an experiment in reproductive cloning. Iris wants to give birth to a daughter who will be an exact genetic copy of herself (and whose first name therefore mirrors her own). Scientifically speaking, the experiment is a real success. Mother and daughter are not only look-alikes in terms of outward appearance, but Siri also shares her mother's singular musical talents. And yet, at a certain point, she suddenly turns her back on the prospect of a musical career, thereby shattering her mother's dreams. Instead, she seeks shelter on an island just off the coast of British Columbia, where she takes up photography and develops a personality and a biography quite her own.

The morale of the story is that we are not our genes, so that parents cannot predetermine the personalities of their offspring by means of the genome as blueprint. The movie mirrors the vicissitudes of the genomics debate triggered by the HGP. Initially, Blueprint seems to endorse a genetic deterministic view on human life, but gradually the movie's basic "philosopheme" is bound to shift. Siri's process of "individuation" shows that she is not a replica at all. As an adolescent, she blatantly refuses to play the role of a substitute her mother has laid out for her (as the next runner in the relay race of life). Whereas Iris enjoys city life, connoisseur audiences, spotlights, and classical music, Siri yearns for wilderness, silence, and solitude. In the end, mother and daughter are opposites rather than copy and original.

In many ways, the story line is reminiscent of the fairy tale of Snow White. Initially, for Iris, looking at Siri is like looking in a mirror, seeing a rejuvenated version of herself. But as mother and daughter both excel in beauty and musicality, they are bound to become competitors sooner or later, so that their relationship shifts from proximity to polarization. Like Snow

White, Siri flees to the (Canadian) forest, into the wild. Although their "nature" is similar, "nurture" pushes Siri in a completely different direction. And although Iris is a powerful and forbidding woman, her daughter's personality and autonomy ultimately escape her.

Dr. Fischer likewise sees Siri initially as instrumental for realizing his own personal ambitions, rather that as an autonomous subject. He is not a physician, but rather a researcher and his aim is not the well-being of his patient, but the publication of a landmark paper that will immortalize his name. He is hardly interested in Siri's well-being at all. Although he is bent on documenting all the details of her life, Siri remains a case, a "file," a research subject, rather than a person. Fischer is caught up in a race over priority. He desperately tries to be the first to publish the results of a successful reproductive cloning experiment, involving a child whose genome is an exact copy of her mother's. The cupido sciendi, the will to know of biomedical research, is not directed toward the benefit of the patient, but primarily to controlling life. On the one hand, Siri is highly exceptional (a highly talented young pianist, as well as the "Louise Brown" of reproductive cloning), on the other hand, in terms of physiological and psychological indicators, Fischer wants her to be as "normal" as possible, without any detrimental side effects: normalcy as a performance indicator for success.

A struggle for power over Siri inevitably emerges between Iris and Fischer as "partners in crime." Iris wants her daughter to be left alone, to grow up as normally as possible, with a life solely devoted to musical training. But at the same time, the situation is far from normal, as the goal of Siri's life is already predefined: she is to help her mother in realizing her endangered ambitions, her lifework. As soon as Fischer realizes he has lost the struggle for power, he decides to disclose the secret. Without the consent of either mother Iris or daughter Siri, he gives a press conference, is arrested, and sent to prison but at the same time heralded as a martyr of science by his supporters worldwide. Siri's revolt (her process of individuation) is directed against genetic determinism as a creed. Although genetically parents and children may be similar, in terms of personality and biography, significant differences are bound to occur - an experience which Iris and Siri share with "normal" parents and their offspring.

In fact, Franka Potente also plays a key role in another intriguing genomics movie, namely, Elementary Particles, based on the novel by Michel Houellebecq (1998), about a scientist who discovers the algorithm that will allow us to drastically enhance and refurbish the human genome, so that we are on the brink of a "metaphysical mutation." Where previous revolutions (notably the political, sexual, narcotic, and hedonistic revolutions of the 1960s) failed, the genomics revolution may finally succeed: a message which must be read with cynicism, I suspect, featuring genetic determinism as the new illusion.

Conclusion

The HGP was fuelled by genetic determinism, with the idea that we basically are our genes as its basic "philosopheme." Once our blueprint is made available by next generation sequencing, we will be able to know ourselves and to become the managers of our life and health. Interestingly, the basic outcome of the HGP rather was that life in general and human life in particular is much too complex to be explained along genetic deterministic lines. Thus, in the end, genetic determinism "sublates" or abolishes itself ("aufheben," in German). The "truth" of genomics (the awareness of the overwhelming complexity of life) is antithetical to its conceptual starting point. Genomics has taken us beyond determinism, has given way to post-deterministic research areas such as complexomics. And yet, although genetic determinism is dead, it is at the same time undead, for gene-speak and other instances of genetic deterministic logic and language are still present, both in the public domain and in scholarly discourse.

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Addiction
Alcoholism
Autonomy
Biology: Philosophy of
Cloning: Human
Designer Babies
Freedom and Free Wil
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