1 DNA Is Not Our Deep Inner Core

Meaning and Mendel

Who does not know the most basic fact from the science of genetics, that peas and people reproduce in a similar fashion?

It is taught in high schools. Gregor Mendel discovered the fundamental scientific way that organisms breed, and it works the same way in people as it does in peas. Everyone knows that. They may not remember the specifics, with dominant uppercase *A* and recessive lowercase *a* – but they know that humans and peas reproduce basically the same way, because they were taught it, and it's true.

Now I am certainly not going to try and convince you otherwise. But have you ever actually seen peas reproduce? Thanks to the internet, you can readily see videos of plant breeding. The videos of humans breeding, of course, are posted on more restricted internet sites.

There is indeed a legal distinction between watching videos of peas reproducing and watching videos of humans reproducing. Somehow lawmakers and geneticists see the two processes rather differently. Maybe peas and people are less similar than geneticists think; or rather, perhaps the perspective of genetics is not the only meaningful or valid viewpoint.

Actually, human and pea reproduction are only similar from a very specific perspective, that of cells.

Gregor Mendel never thought or said that he had discovered anything about how humans reproduce. The perspective of cells was just beginning to be

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developed when he published his famous work in the mid-1860s. The idea that there might be a common property in the regeneration of starfish limbs, the degeneration of mutant inbred stocks, and the generation of new organisms had emerged gradually over the latter part of the eighteenth century.

Moreover, the idea that there might be a common property in the inheritance of a particular nose form, the inheritance of a debilitating disease, and the inheritance of the human condition itself emerged over the course of the nineteenth century. All were linked by the cell theory, that life became more deeply and meaningfully unified from the perspective of the cell. The cell theory formed the basis of Samuel Butler's 1878 witticism that "a hen is only an egg's way of making another egg." And the cell theory gave generalized meaning to Gregor Mendel's work on pea hybrids, which is why Mendel's work suddenly became important in 1900, 34 years after he originally published it.

Really thinking about science as a culture, that is to say, approaching it as an ethnographic enterprise, involves unthinking your basic assumptions. In this case, suppose that the perspective of cells, by which human and pea breeding are similar, is a perspective that we reject temporarily; and we rather adopt the perspective of bodies, by which penises, vaginas, erogeny (sensual stimulation), and viviparity (live-birth) are significant characteristics of reproduction in one species but not in the other. That was pretty much the perspective of everyone who ever lived, until mid-nineteenth-century European scientists became the official custodians of such knowledge.

After all, it is certainly not obvious that human reproduction and pea reproduction have anything to do with one another. To put it another way, imagine yourself stranded with a group of people who are passingly familiar with plant husbandry, and know where babies come from – but see no reason to connect them. In fact, they kind of think that anyone who sees similarities between breeding peas and making sweet sweet love must be either stupid or crazy. How would you convince them otherwise?

That is a classic ethnographic issue noted by the anthropologist Bronislaw Malinowski a century ago, as he lived among remote, exotic people who would not acknowledge any relationship between having sex and having babies. A modern scientific explanation that purports to identify an underlying

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similarity between pea and human reproduction must require a technological infrastructure (at very least microscopes, in this case) to be minimally convincing to an audience of intelligent open-minded skeptics. Even with a microscope, could you convince someone that the pea pollen on one slide and the human sperm sample on the other slide are somehow the same?

The fact that both slides contain male gametes that can unite randomly with female gametes to produce an array of zygotes, which in turn can develop into organisms, is exceedingly counterintuitive, which is why it was never discovered, and presumably would never have been discovered, but for the work of diverse specialists in nineteenth-century Europe.

Inheriting

While we can see the coalescence of otherwise diverse phenomena as crucial to the development of a science of genetics, other entangled ideas conversely needed to be teased apart – notably, inheritances. After all, you "inherit" from your parents the normal and nearly invariant condition of having two arms and two legs, each terminating in five digits. You also "inherit" your complexion, which varies a bit in our species genetically, and is also partly a product of your own exposure to sunlight. Further, you also "inherit" your religion. But you learn your religion, and even though you might well grow to reject it, chances are that you won't, and that this inheritance from your parents will shape your own adult thoughts in subtle yet pervasive ways. And finally, you "inherit" your parents' dining-room set, a material creation subject to legal constraints, like taxation and rival claims.

The first inheritance is genetically "hard-wired" – having four pentadactyl limbs is species-wide and nearly invariant, the result of descent from an ancient fish half a billion years ago with those features. The second "inheritance" is partly genetic, but also significantly a product of the conditions of life, namely exposure to ultraviolet light. A day spent surfing and a day spent studying mammal teeth in a museum basement will have different effects upon the body; so will an ancestry from Nigeria versus one from Siberia. Consequently, complexion develops as far more of a biocultural feature than tetrapod pentadactyly, more variable across our species and less constant over the course of a lifetime. The third "inheritance" is the result of your cultural

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upbringing, a product of your learning or enculturation. You have even more wiggle room here, because these features are not so much physical or biological as mental and behavioral; and highly diverse over our species. These features are entirely acquired from the external world, yet are generally inherited very faithfully in our species. The microcosm here is language, without which a human is incomplete, but which is learned in childhood in a specific form produced within the history of a specific human population. And the fourth "inheritance" is the physical expression of a legal code that permits the products of human labor, industry, and creativity to be transmitted intergenerationally. In essence the four forms of "inheritance" mark out decreasing correlations between parent and child, due to increasing input from external or "environmental" influences.

With the word "inherit" and the idea of intergenerational transmission embracing such radically diverse properties and processes simultaneously, it is no wonder that human heredity has been the source of so much confusion. It embraces different kinds of processes of intergenerational transmission as well, because we inherit all kinds of things from our parents, in addition to their DNA. The first "inheritance" is in the genes and is the domain of human genetic study; its objects are the parts of the body that are the most strongly canalized (i.e., buffered against genetic and environmental variation, in the terminology of geneticist C. H. Waddington). The second "inheritance" also incorporates genetics, but is studied within a broader field of human adaptability, largely descended from the first studies of immigrants in the early twentieth century. With the gene pool held constant and the environment different, the children of immigrants invariably differ physically in subtle but significant ways from their parents and relatives back in the homeland, for example in stature and head shape. This shows that the particular features of the human body are co-produced by the genetic program and by the conditions of life. These features are more developmentally plastic (having a longish or a roundish head) and less genetically robust (having a head; not having a head is not really an option). Here, what we inherit is a range of physical possibilities, rather than a single uniform feature, whose eventual expression is a result of a negotiation between the genome and the external conditions of life. The third "inheritance" was the major discovery of the earliest professional anthropology in the nineteenth century, namely the "knowledge, belief,

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art, morals, law, custom, and any other capabilities and habits acquired by [people] as a member of society" – in a word, culture – the stuff that makes us human but isn't in our DNA. And finally, we inherit the things themselves, material culture. Things of value, things of use, things of beauty; evocative things, precious things, old things, made things, bought things, things by which to remember the dead, things through which the dead take care of us – all of these are distinctly human. This is a specifically human form of inheritance. No chimpanzee, after all, ever gave her daughter a twig and said, "Use this well for collecting termites. It belonged to your grandmother."

In other words, the relationship between ancestors and descendants is only minimally revealed by Mendelism. People pass on far more interesting things than merely genes across the generations.

The Human Genome Project

Of the many things we inherit, then, only some are biological, and even those are often strongly influenced by non-genetic factors. Our DNA, our genome, is involved in a complex way in constructing part of what we are.

DNA is a famous molecule, crammed into the nuclei of your cells, with a tiny bit more outside the nucleus, located in your mitochondria (the organelles that generate energy for the cell). DNA is a fairly inert molecule, from which functional molecules are ultimately made. We have learned over the last few decades that DNA is used by the cell to make RNA, which may itself be biologically active, or may in turn be used to make other biologically active molecules, the proteins. RNA is biochemically modified by the cell in various ways to gain its biological activity; likewise, the proteins are biochemically modified before becoming biologically active.

Because of its position at the beginning of the cellular operations, a change in the DNA may be expressed as a change in the RNA or ultimately, as a change in a protein. This change may have large effects, small effects, or no effect at all upon the cell or the body. Like much in science, however, it is often easier to describe what a phenomenon is like than what it actually is or does. In the case of DNA, the set of metaphors that has proven to be of greatest value is from language and information theory. Initially formulated in the 1940s by physicist

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Erwin Schrödinger, DNA is regarded as a kind of code, communicating genetic information between the nucleus, where it is stored, and the cytoplasm, where it is decrypted. This genetic information, the DNA, is in turn transcribed, edited, and translated, ultimately being manifested in the physical structures of the body.

So DNA is communicative. DNA is like language. It is also like a blueprint, since it contains the instructions needed to build the cell's proteins. It is also like an atlas, a set of maps directing a fertilized egg through a path of embryogenesis, birth, adolescence, maturity, and senescence. In the world of the literary, DNA is like a lot of things, all derived from Schrödinger's metaphor. In the world of the literal, rather than the literary, all the DNA in a sperm or egg is a genome, and most cells in the body have two genomes. When the Human Genome Project was conceived in the 1980s, its goal was to establish the fine-scale structure of the DNA of a normal genome of a normal human (some observed at the time that this was a Platonic goal, ignoring the reality of individual variation in favor of an imaginary abstraction; it eventually came to be regarded as a reference sequence against which others would be compared). To accomplish this, the Human Genome Project asked for three billion dollars in taxpayer money, which they eventually received. In short measure, the popular science section of bookstores came to be populated by genome-for-the-masses titles invoking codes, blueprints, languages, and maps – alone and in mixed-metaphorical combinations.

The Human Genome Project came to near-completion with considerable fanfare in 2000, with President Bill Clinton declaring, "Today we are learning the language in which God created life." Schrödinger's metaphor is so powerful that there is hardly any other way to think of DNA scientifically, aside from being like human communication in various ways. But that is what DNA is like, which is only related symbolically to what DNA is.

When Is DNA Not DNA?

What, then, does it mean if two decades later Land Rover says, "Adventure. It's in our DNA"? Surely it must be a metaphor of some sort, because automobiles don't actually have DNA. The advertisement is intended to convey something

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along the lines of, "It's who we really and truly are. No kidding. Deep down inside, our cars are imbued with adventure."

And yet, that isn't really what DNA is or does within your body.

There are indeed some ways in which your status, or identity, or fate could be bound up in your DNA – notably, for diseases and biochemical variants. In most cases, however, DNA diversity is correlated weakly or strongly with physical features, and a phenotypic (i.e., bodily) outcome can at best be probabilistically predicted from the DNA. Why? Because the intervening physiology is complex and only sketchily understood.

Aerdata (a Dutch subsidiary of Boeing) advertises, "Aviation. It's in our DNA." That claim is of particular interest to an anthropologist, since if there is one thing that we can pretty safely say is *not* in our DNA, it is flying. Our bodies are built for walking and running, and maybe a bit of climbing, hanging, and swinging; but flight is not in our DNA. Yet obviously the company is not attempting to make a literal, scientific statement, but rather a metaphorical, neoliberal one.

Or Sony, telling potential customers that high-definition television is in its DNA. The only way that a multinational electronics corporation could have DNA (aside, obviously, from the cells of its employees) is if they are using the term very differently than molecular geneticists do when they envision that famous double-helical sequence of A, G, C, and T nucleotides. DNA here means more than biochemistry, or science. It is a metaphor, and an obviously powerful and evocative one, as different companies are using it so freely. In fact it has become a broader part of contemporary jargon: "It's in my DNA" means "It is a feature deeply embedded within me." But not a feature deeply embedded like having two arms instead of three; rather, a feature deeply embedded like stinginess instead of generosity, which isn't really in anyone's DNA.

"I am cheap. It's in my DNA." And there is no appropriate response to the statement, since it is absurd both scientifically and literally. The DNA is working metaphorically here, identifying stinginess not only as a core property, but as a property so fundamental that it requires no further elaboration.

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I am that way, just because – timeless, preformed, changeless – it's in my DNA.

My point is just that nobody was using this metaphor before the Human Genome Project.

In a classic 1995 book, sociologist Dorothy Nelkin and historian Susan Lindee showed how the Human Genome Project was imparting a "mystique" to DNA and transforming it into a "cultural icon," with meanings far beyond the mere biology.

Indeed, although they are rarely part of the formal training of scientists, metaphors constitute an important part of science (See *Understanding Metaphors in the Life Sciences*, in this series, by Andrew Reynolds). Making sense of a phenomenon starts with understanding what it is like. To Copernicus, the earth was like a ball embedded in a sphere revolving around the sun. To William Harvey, the blood circulated around the body like planets circulating through the solar system. To Charles Darwin, nature selects who will survive and reproduce like an animal breeder does, but more subtly. To Thomas Hunt Morgan, the genes are arrayed on chromosomes like beads on a string. To Erwin Schrödinger, the genes are coded instructions, like Morse telegraphy. To Richard Dawkins, genes are selfish, looking out only for themselves, like a paranoid despot in constant peril from all directions.

DNA, Human Nature, and Artichokes

The metaphor of most direct relevance here is the one that imagines our consciousness to be layered, as a bestial inner nature enclosed and suppressed by a civilized outer layer. Like an artichoke, whose tender and tasty heart must be exposed by peeling away the fibrous outer leaves, the human core is imagined to be fundamentally different from its surface. This idea long predates Darwin, although Darwinism gave it renewed vigor as a pseudo-evolutionary narrative. "Darwinian man, though well-behaved," wrote W. S. Gilbert in *Princess Ida* (1884), "at best is only a monkey shav'd."

You may learn airs, this image tells us, but beneath it all you are a beast, an ape, a brute. Without the acquisition of a veneer of civilization, we would all

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descend into the brutal chaos of the British schoolchildren in William Golding's *Lord of the Flies* (1954). In fact, one of the most well-known expositions of this idea was written centuries earlier by Thomas Hobbes in *Leviathan* (1651), who saw the lives of people without civilization to be "solitary, poore, nasty, brutish, and short."

Acquiring civilized ways can thus tame the animal within, but the animal is always there, ready to be unleashed. By the nineteenth century this had crystallized into an antithesis between nature (inherited, innate) and nurture or culture (acquired, environmental). DNA fits rather neatly into the former slot.

The DNA, the genes, are easily transformed from the cellular biochemicals of science into one pole of a metaphysical antagonism between inherent nature and external culture, at eternal war with each other within the human spirit. That is, of course, scientific rubbish, and the recruitment of DNA into such a model is problematic. Nevertheless, there is a widespread equivalence between "DNA" and "human nature" (in all its complexity), with some scholars even using that as a Darwinian litmus test. The deep core of our being, cultureless humanhood, must be there in the DNA, and must be there as the product of evolution.

That neglects, unfortunately, the major features of human evolution, which undermine the idea that nature and culture are indeed separable, and their effects additive and oppositional. They are not actually like the leaves and heart of an artichoke, but rather more like the eggs and flour in a cake. Some cakes may be too rich or too doughy, but the precise contributions of eggs and flour can't be established because their respective contributions are not additive, and both are necessary.

Consider the two most fundamental evolutionary adaptations of our species: walking and talking. Our genetically based adaptations to nature are unimpeachable: our weight-bearing, rather than grasping, feet; our bowl-shaped pelvis, beneath our center of gravity, rather than behind it; and our spinal column entering the skull from below, rather than from behind. Likewise, the position of our larynx, our small canine teeth, and our oral musculature are genetically based features facilitating speech. Yet we learn to walk, and we learn to talk.

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Thus, "genetic" and "learned" are not antonyms. Our most fundamental hard-wired evolved biological adaptations are actively learned by every normal person. As far as can be told from old studies of abandoned children, without a model to imitate, one just doesn't spontaneously walk or talk properly. It is not so much that we have an inner genetic core overlain by a superficial learned patina, but that we are genetically programmed to survive by learning, and to do so in unique, local ways.

And ours is an extraordinarily slow process. It takes a couple of years for us to learn to locomote properly (compared to less than an hour for most other mammals), and far longer to learn to communicate properly – even though if we are genetically programmed to do anything, it is to walk and talk. Once again, it is not that our DNA opposes our cultural existence; it's that our DNA compels us to have a cultural existence.

There is consequently no cultureless state of human existence. It is a contradiction in terms. The idea that there is a deep DNA-based human nature, independent of culture, is false. DNA and culture aren't like that.

Chimpanzees make and use tools, as Jane Goodall famously documented in the 1960s. By a million years ago, our ancestors were using tools successfully in two ways that apes don't: to cut things, and to burn things. Our own more remote ancestors had been cutting things for nearly two million years already, which proved to be such a useful adaptation that the structure of their hands had evolved in concert with their tools. So had the structure of their brains. In other words, culture has been an ultimate cause of our biology for well over a million years. Culture has very deep roots in our evolutionary history; our brains, bodies, and gene pools have been genetically adapting to culture for a long time.

Culture is not just an ultimate cause of the human condition, however. Every human being develops in an environment that determines the expression of their genome. That environment includes naturalistic variables, like the altitude, latitude, and temperature; but it also is strongly cultural. There are more obvious cultural features of the environment, such as diet, language, and religion, but also more subtle features, like labor, stress, and social networks. Thus, culture is both an ultimate, evolutionary component of the human condition, and also a proximate, developmental component of the human condition.

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Human nature is cultural in yet a third way. This discussion began a few paragraphs ago with a description of the broad metaphor at play: that the DNA represents a deeper animalistic nature within us, which is cloaked or suppressed by culture (or environment, or nurture), but which is analytically separable. The idea of the cultureless human, the blank slate, has been around for centuries, and is very much itself a cultural idea. That is to say, we conceptualize human nature, our DNA, our inner beast, our *tabula rasa*, and whatever equivalences they may have, in cultural terms. How we regard our own nature is an inherently cultural activity.

There is consequently no separating our DNA from our environment, our nature from our nurture, our biology from our culture. The structure of our hemoglobin may be extractable from our DNA; but the structure of our lives and thoughts is not.

So Is Human DNA Cultureless Nature?

No, of course not.

How about when we read about coalitional male aggression – that is to say, war – "inscribed in the molecular chemistry of our DNA" as some enthusiastic sociobiologists put it? Only in a trivial sense. It is among the many things our DNA permits us to do. Our DNA permits us to gang up and commit violent acts; it doesn't permit us to photosynthesize or to turn invisible.

The fact that humans are able to do certain things, however, doesn't describe human nature, any more than the fact that there are people who can use a manual transmission effectively means that driving a stick shift is inscribed in the molecular chemistry of our DNA. What is inscribed, so to speak, in our DNA is far more generalized: learning to follow abstract rules. It forms the basis of human communication and social interaction. And unlike the rules that govern the behavior of most species, our rules are acquired externally. They are learned; moreover, they are not species-specific, but local and historically produced. And further, as the earliest anthropologists discovered, the rules are commonly nothing short of ridiculous to outsiders.

The important question for any act of human violence, then, is whether it involves following the rules, or not following the rules. Thus, the injunction

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"Thou shalt not kill" is understood *not* to apply to a wartime enemy. Killing people is sinful; but if they are enemy combatants, it is heroic. Killing is acceptable in self-defense, but not to effect a change of doctoral thesis supervisor. It may be excusable if the killer is mad (insane), but not if the killer is mad (angry). Or perhaps crimes of passion and crimes of lunacy are equally excusable?

So what does it mean to say that killing is in our DNA, if *not* killing is also there, in our DNA? The crucial variable is the context in which the killing takes place, not the act itself. Is the killing appropriate? And that assessment is very much a cultural variable, a product of history, and instilled by learning. Sure, there are psychopaths who ignore the rules, but they are by definition abnormal.

What we do, what our DNA programs us to do, is to *not* be guided by programming, but by rules of culture that are abstract, invented, learned, interpreted, bent, circumvented, and otherwise constructed and leveraged. It is what we evolved to do, and why our brains are so big that our mothers are imperiled by simply the act of giving birth to us. Human DNA is rendered biologically meaningful culturally. We have evolved genetically to think and to communicate in a zoologically unique way, which involves acquiring a local historically produced variant of human language by listening to it for a few years and learning the arbitrary meanings of specific sounds, words, tones, expressions, and movements, alone and in combinations.

There is obviously a human nature, as distinct from a chimpanzee nature or a dog nature. It consists most fundamentally of walking and talking. But those are not the kind of features that actually enter into arguments about human nature. Arguments about human nature are about behaviors with moral valence, things like sex and greed and violence.

But we were talking about DNA. What has DNA to do with morality?

DNA as a Moral Failing

Consider this statement, from a popular science book of the late twentieth century: "Take first the fact that adult men are slightly bigger than similar-aged women … A zoologist from Outer Space … would instantly guess that we belonged to a mildly polygynous species."

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What does that mean? First, what does "polygynous" mean? It refers to a social order in which a single male mates with more than one female. The opposite would be "polyandrous." Neither of them is "monogamous," which technically refers to a single marriage partner, but more generally refers to a social/sexual unit consisting of two organisms, no more. The extraterrestrial scientist – who is of course super-smart, but more importantly is entirely objective, and most significantly agrees with the author – is a literary device first employed effectively by Thomas Huxley, to make a scientific proposition sound more compelling by transforming it into a science-fiction proposition. Of course, in reality there are no zoologists in Outer Space, so any speculation on what they might think has far less value scientifically than it may have rhetorically.

The alien scientist is simply a stand-in for the unbiased, wise observer who obviously agrees with you. And what do the two of you agree on? In this case, the proposition that the human species is, naturally and objectively, "mildly polygynous." First off, is there any reason at all to believe it? It is indeed true that a correlation exists among the primates between the extent to which males are larger than females (sexual dimorphism) and their normative social/sexual system. The polygynous baboons and gorillas are on one end of the spectrum, and the monogamous gibbons are on the other. By that primate metric, then, humans are a bit sexually dimorphic in body size, and so you might consider us to be a bit polygynous by virtue of our primate nature. And yet, the social/sexual systems of those same primates also correlate with the sexual dimorphism in their canine teeth. In the monogamous gibbons, the males and females have canine teeth the same size, but in the polygynous species, the canines of the males are much larger than those of the females. And humans have no sexual dimorphism in their canine teeth, like the monogamous gibbons by this metric. And if those patterns of sexual dimorphism reflect different patterns of sexual selection operating in baboons and gibbons, then the human pattern seems to show cross-currents. Moreover, humans have their own patterns of sexual dimorphism that don't parallel anything in our close primate relatives – things like pubic hair, breasts (when not lactating), beards, and overall body composition – and would presumably suggest powerful and non-comparable patterns of sexual selection in our own ancestry.

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It looks rather like, in the context of primate biology, our "natural" social/sexual system pretty much sums to zero. It only comes out as "mildly polygynous" if you cherry-pick your primate data and ignore the most prominent features of human sexual dimorphism.

But there is more here than just a poorly structured biological argument. There is also a rationalization in nature for some bad behavior. After all, when the professor catches his wife in bed with another man, he can see that as a crime against the natural order, for he knows that we are *not* naturally mildly polyandrous. But when his wife catches him in bed with another woman, he hopes she will excuse him because he was simply obeying his polygynous biological imperatives; and of course, it's not nice to fool Mother Nature.

In other words, it's not my fault; it's just my DNA! It's human nature, and I'm only human!

"Human nature" in the post-genomic age is a conceptual category to embrace moral behaviors for which you bear diminished responsibility, because you lack completely free will. DNA here stands for loaded dice on the crap table of human life.

A traditional Christian theology holds that you can choose freely between good (God) and evil (Satan). If you choose evil, you'll pay for it with an eternity of unpleasantness. But that presupposes a level playing field. Suppose you are tilted toward evil by virtue of circumstances beyond your control? Then you couldn't really be blamed for going over to the dark side, for the choice wasn't really yours. Contrast, for example, Anakin Skywalker, who chooses the Dark Side freely, against the Pharaoh in Exodus, whose heart was hardened by God Himself! It seems hardly fair, then, to regard Pharaoh in precisely the same way that you might regard Darth Vader. Vader had a choice; Pharaoh didn't.

In light of such theological, mythological, and moral considerations, human nature can quickly become disembodied and reconstituted from human cells and tissues, and become transformed instead into the tilt of the playing field of life itself. Rather than a 50:50 shot at good or evil, suppose you are preformed in some way to lean 80:20 toward an evil act. Then there are now forces beyond your control, DNA forces embedded in your brain cells, which compel you toward the devils and away from the angels. That in turn raises

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the question of how you can blame someone for an immoral act when they didn't really have an open choice, or voluntary control, in the first place. That is to say, human nature here becomes a denial of free will, which in turn has moral and theological implications.

Or in a secular universe, legal implications. A 2012 study found that when judges believed a criminal act to have been partly caused by biology, they were inclined to sentence more leniently, knocking about 8% off of the imaginary perpetrator's jail time. Whether or not your eternal soul is at risk, a few extra months behind bars is definitely on the table on account of your DNA, or at least on account of what a judge believes about your DNA. DNA has mutated, it seems, into something quite unlike the templates for cellular transcription that biochemists work with. DNA is now the raw material out of which to construct an argument about free will.

This is a strange place for our friend DNA, the double-helical nucleotide polymer, to be.

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