Genes "R" Us

In what sense do genes determine identity?

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DNA fingerprints are not prints of fingers. So why the name? The "fingerprint" label, of course, conveys far more than some pattern of swirls, whorls, and arches on the skin. As celebrated in detective lore, fingerprints are emblems of uniqueness. DNA can thus form a "fingerprint" by establishing personal identity. This seems to echo the notion of genes as information. The DNA "codes for" an organism's unique traits. In terms of uniqueness and developmental causality, then, genes seem to underlie human identity. Yet with deeper reflection, one might find this commonplace association spurious and misleading.

Ironically, perhaps, DNA fingerprinting reveals very little about an individual's DNA, or genome. The technique does not exhaustively profile every allele of every gene, as many imagine. Nor does it even *sequence* the DNA. Rather, it focuses on a rather incidental feature of chromosome structure: differences in non-coding sections of DNA. There, short "nonsense" segments are repeated. The number of repeats, however, varies widely among individuals. Thus, they are convenient markers, or *indicators,* for identifying a particular organism. Or potential criminal suspect. Each person's DNA may well be unique, but only a small and physiologically insignificant fragment of it is needed to *identify* the individual.

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Other biological features function as identifiers, as well. Forensic scientists have long relied on fingerprints and "mug shots," both introduced into criminology by Charles Darwin's cousin, Francis Galton. They also use hair, skin tone, blood and tissue type, and voice sonograms. Some high-tech security systems—including ones recently adopted for airport security and U.S. immigration—use eye scans. These record the unique pattern of the eye's iris. (Blood vessel patterns on the retina work as well.) In all these cases, the aim is unambiguous identification. What matters is diagnostically unique properties. So these particular features are effective *indicators*. At the same time, they are functionally trivial or biologically peripheral. They hardly profile someone's sense of self. Nor do they fully characterize who they are (personally, culturally, or even biologically!). *Identification* and *identity* are distinct. A unique feature is not necessarily important.

Even genetic uniqueness falls short of defining identity. For example: identical twins. Identical twins share a genome. They fail the test of genetic uniqueness. Yet regarding them as distinct individuals is not problematic. (Often the challenge, instead, is discerning which twin is which!) Each twin has his or her own identity. They have separate names, independent lives, recognizable personalities – all quite apart from their fascinating (and sometimes playful) similarity in appearance. Genes, in these cases, hardly establish identity.

(And not just identical twins. Conjoined twins, too. The Hensel twins, Abigail and Brittany, share not just genes, but the same body. How does one characterize *their* separate identities as unique genetically or biologically?)

Genetic uniqueness nevertheless seems central when considering the growing prospect of human cloning. In popular images, cloning—whether horrific or humorous—recreates the original individual. Some imagine armies of anonymous clones. Individuality would be lost in an ocean of biological xeroxes.™ Others envision a clone duplicating memories as well. Could one distinguish copy from original? Cloning thus seems to threaten unique identity. Some have responded by declaring copyright on their genes. The law, they imply, will acknowledge that one "owns" one's own genes. Yet all such fretting seems blind to the lessons of identical twins. Twins are clones. Can one violate the copyright of the other? Are their memories identical? Are they empty, mindless drones? Of course not. Twins are individuals, as any clone would be. Clones are like twins displaced in time. That might challenge our conventions. But not our notions of identity. Confusing genes with identity may lead one wildly astray.

The tendency to locate unique identity in genetics extends to the species level, as well. Each species has its own genome. The differences between genomes are clearly linked to the differences between species. Variations in homologous genes, for example, are effective tools for showing relatedness. From them, one may construct phylogenies. Diverging gene sequences reflect diverging lineages. Genes thereby map common ancestry. They help reveal our species' genealogical identity: our kin and history.

Even more, the degree of genetic difference seems to indicate the degree of relatedness. Closely-related species share more genes. But note that the focus is just on *differences*. One may wonder here, as in the case of fingerprints, just what such differences represent. For example, the variations used to map evolutionary relationships typically do not document functional differences. Cytochrome *c* or hemoglobin fills the same physiological roles in different organisms, even when the sequences vary.

Not all genetic differences are significant, even if valuable, in species level identification. Consider a prospective "human" gene for how hair is distributed over the body surface. It certainly would be biologically unique among primates. Does it matter? Perhaps we should rethink patchy hair as important to our identity? Or perhaps not. Similar reasoning might apply to genes that lead to subtle differences in immunology or nutrition. It is not the genetic differences alone that matter to human identity. Rather, it is how we regard the organismal trait associated with the gene(s). Someday we may well find a gene responsible for differential growth of the cranium and thus brain size. But such a genetic difference will seem significant only given some vague notion of intelligence. Our conceptions of identity, independently of the genes, tell us *which* genetic differences seem to matter. Natural selection, too, acts on the phenotype, not genes. Traits, not genes, establish meaningful identity.

Genes nonetheless seem foundational biologically. Thus, many persons tend to regard a change in the genome as an *essential* change in the species. New species evolve when the *genes* change. Each species' suite of genes seems a naturally defined and inviolable identity. For example, hybrids are typically cast as "monsters," rather than playful inventions or fruits of nature's creative powers. Concerns about genetically modified organisms, or GMOs, likewise rarely focus on the modification itself. What seems to matter is disturbing the species' genetic identity. Even one gene alone can apparently disrupt a species' integrity. Transplanted genes are not viewed like transplanted organs. Genes seem to signal that the nature of the species is at stake. Ironically, humans have been

altering organisms genetically throughout history. Domesticated plants and animals are all "genetically engineered" from wild species. Common durum wheat (*Triticum dicoccoides*) is even a hybrid of *three* species. Bread, an iconic staple, has long been made from a genetically-modified organism. Yet juggling of genes may be easily overlooked when one focuses on cross-breeding at the organismal level. One may fail to see the "genetic modification" across species. Common concerns about GMOs underscore the depth of beliefs about genes as fundamental to identity.

Belief in genetic uniqueness as group identity underlies most racist thinking, as well. A claim about racial difference is not just about biological variation. It is about essential differences—differences that are "essential" because they are genetic. "Genetic" implies natural, or fixed in the world's organization. Race thereby can seem independent of human culture or human interpretation. In contrast, racial categories are much harder to rationalize as given by nature when one views identity as equally shaped by a complex context of an organism's social and ethnic environment. Highlighting genetic differences at the group level also eclipses thinking about differences within groups. Unwarranted stereotypes easily substitute for individual features and variation—further masking the creative role of culture. Conceiving racial identity as genetic may be all too convenient to some, but is nonetheless biologically unjustified.

Genes ultimately seem closely related to identity because of their generative, or developmental, role. Genes seem singularly important causally—in guiding individual, species-specific development and determining all cell physiology mediated by proteins. Genes seem the root cause of every biologically important detail. Why should they not be viewed as central to identity?

Genes are indeed part of the causal story. But focusing on their differences (again) misrepresents their relative importance. In a widely-used metaphor, genes encode information, like recording tapes or CDs or Braille. The metaphor can help show how genes are causally limited. Tapes need tape players. CDs, CD players. Likewise, DNA needs ribosomes. (One might note, too, all the transcriptional and pre-translational enzymes and nuclear membrane porters.) An instruction in Braille is meaningless without the ability to read Braille. Just so with genes. Tape players are also idle without energy. Likewise, protein synthesis requires ATP and GTP. In a cell without energy or ribosomes, genes are idle. They do not "express" themselves. A heap of DNA, by itself, is causally inert. Organisms reproduce through whole cells (eggs), not genes alone. The cellular context, with all its material "machinery," is equally inherited. Genetic "information" may be significant in guiding alternatives, but the genes themselves do not fuel the process. Focusing on genes simply because they differ from one organism to another distorts the whole causal picture.

Just as the genes rely on the cell's internal environment, so too does the developing organism rely on many extragenetic factors. These may include temperature, pH, available nutrients or metabolites, cell-cell contact, hormones, or other chemical triggers. Perhaps light or gravity as well. The environmental elements provide the developing organism "information" of a different type. Cells that share genetic information (like identical twins) thus do not all develop alike. Change the environment and a different cell develops—or none at all. A parent that provides the appropriate environment to an egg ensures these critical causal factors. The environment can be inherited, too. To the degree that the environment seems predictable from one generation to the next, its causal role may seem transparent. But it is no less important in guiding an organism's development. Genes and environment together shape identity developmentally.

From cloning to GMOs to racism to DNA fingerprint identification, genetic reductionism (reducing identity to genes) is problematic. More than genes are involved. For example, a sense of our species' identity might well include a potential for humor, morality, or appreciation of music. Yet we cannot trace these directly to discrete genes or genetic differences from our closest relatives. No doubt there is a "genetic basis" for their neurological opportunity. But this hardly informs how the behavior develops. Genes might well contribute to a concept of identity. But they cannot substitute for a phenomenon that is ultimately more complex and established in a cultural context.

Addressing how genes and identity relate may seem a recreational subtlety of interest only academically. But the notion has strong political overtones. If one believes that humans are determined primarily by their genes, then biology, not society, is responsible for any differences in the human condition. Variations in social status, for example, seem to arise from "natural" causes. Social inequities can easily be attributed to biological stratification, not human politics. Such a framework, of course, tends to justify the status quo. It favors individuals who already have social power or wealth. Worse, a political position or value might seem derived from fact. Genetic reductionism seems scientific, but like other forms of biological determinism it is political ideology. For this reason alone, one might be concerned about what is taught about genes, whether inadvertently or with a sense of purpose.