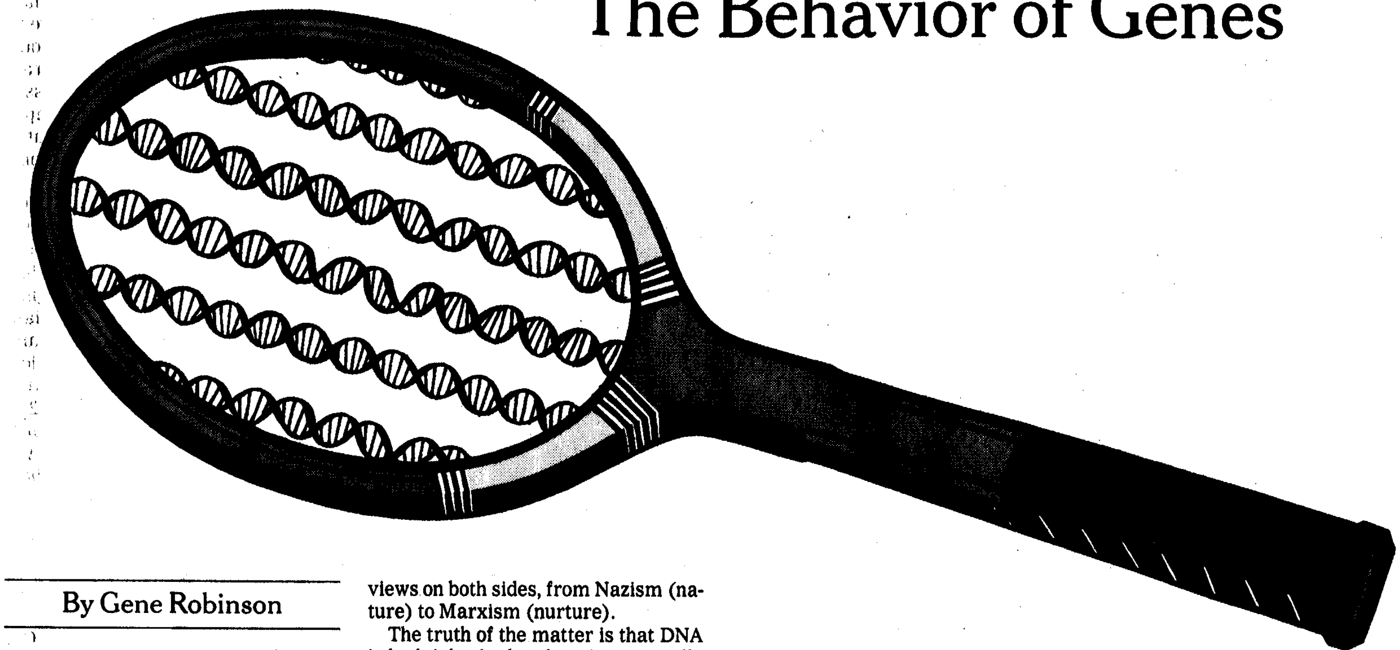
The Behavior of Genes



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By Gene Robinson

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"THE right genes make all the difference." Or so declares an advertisement, as a boy portraying the son of Andre Agassi and Steffi Graf holds his own in a match against Taylor Dent. While neither science, nor this television commercial, can explain much about how the genes of the tennis stars' son might affect his tennis game, people are comfortable linking genes to athletic prowess.

Many people, however, are leery of attributing other components of behavior to genes — personality or intelligence, or social traits like fidelity, for example. They're troubled by the ethical implications of genetic determination; it is as if giving a nod toward the genes automatically diminishes the role of the environment and free will. It is nature versus nurture: a debate that has spawned extremist views on both sides, from Nazism (nature) to Marxism (nurture).

The truth of the matter is that DNA is both inherited and environmentally responsive, and recent findings from animal studies go a long way toward resolving nature versus nurture by upsetting the assumption that the two work differently. The discoveries emphasize what genes do (producing proteins that are the building blocks of life), rather than simply who they are (their fixed DNA sequence).

Traits like loyalty and aggression change over time.

The results hold the promise of breakthroughs in our understanding of human behavior and what factors might influence it. They also pose challenges for policy makers: new types of genetic profiling to try to predict behavior could produce more debates about balancing personal privacy with the need to protect the public.

The studies show that some genes cause the brain to respond differently depending on inheritance or environmental factors. For example, fruit flies inherit different versions of a gene that helps make them slow- or fast-paced foragers for life. But this very same gene that is fixed forever in these different types of flies can change in the honeybee depending on the needs of the hive, allowing a bee to shift from working inside the hive to collecting food from flowers.

Monogamy is another behavioral trait that is influenced by inherited factors, at least in voles. Some species of voles are more faithful to their mates than others. The genes show inherited differences in activity in the brain, but the activity is dynamic and dependent on the voles' experiences.

Some genes that are affected by environmental conditions even have lifelong consequences. Rat pups that are poorly cared for by their mothers show profound changes in brain gene activity and also prove to be bad moms themselves.

These animal behaviors may be simpler than human behaviors, but they are complex and are performed over days, or weeks, or lifetimes, with learned components. And they all involve molecules known to operate in human brains.

What these studies show is that the genome is responsive over different scales of time. Like the voles and fruit flies, individuals may differ in gene activity because of DNA variations they inherited. These differences evolve over very long periods of time, from generation to generation. This is nature.

Individuals may also differ in gene activity because of variations in their environment, like the rats and honeybees. These differences occur over shorter times, within individual lifetimes. This is nurture. In the past, biological conceptions of behavior that are influenced by genetics tended to be rigid and deterministic, spurring misguided concepts like "a gene for aggression." In contrast, social and behavioral scientists have long emphasized the flexible nature of behavior, and as a result have tended to ignore genes entirely. But as much as people like to divide themselves into nature or nurture camps, what genes actually do in the brain reflects the interaction between hereditary and environmental information.

Both sides could find crucial common ground by appreciating the responsiveness of the genome over different time scales.

Such a rapprochement could help us deal with the questions that arise from these discoveries.

For example, what if genetic profiling — determining the sequence of some or all of an individual's genes — were used to help predict behavior? How would genetic profiling be used, say, in education, insurance, medicine and employment, when it appears that what's especially important for behavior is what genes do, rather than who they are?

And since gene activity varies because of both hereditary and environmental factors, can predictive measures of gene activity ever be developed? This question is further complicated because behaviors are influenced by the activities of many genes in the brain.

Last year we celebrated the 50th anniversary of the discovery of the structure of DNA, which opened the door to understanding how traits can be inherited. The concept of "DNA as destiny" has been enormously helpful in diagnosing diseases like Tay-Sachs and in using DNA fingerprinting technology to identify criminals. But it is in appreciating the dual nature of DNA — that it is not just inherited but is also environmentally responsive — that we will understand better how genes influence behavior.

As we all know, the odds are long that young Jaden Agassi, the son of Andre and Ms. Graf, will grow up to be a tennis star, because few children follow so closely in their parents' footsteps in our society, for many reasons. But maybe he will. If so, my bet is that this will be a result, in part, of both his Grand Slam heritage and his parents' (no doubt) dedicated schlepping to tennis lessons with the likes of Taylor Dent, both influences acting on his brain to create connections between gene activity and tennis activity. □

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