

reader concerned with current issues.

The Environment ends with the emergent concept of the Anthropocene Era, in which the impact of human behavior is on the scale of a geological force wreaking permanent change on Earth's systems. While drawing parallels between the formation of "the environment" and "the Anthropocene," the authors note that in the case of the former, nearly quarter of a century (1948-1972) elapsed from the earliest academic stirrings of "the environment" to widespread popular acceptance of the concept.

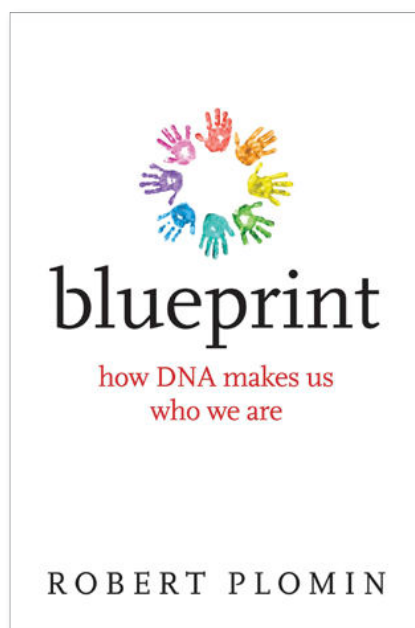
We don't have the luxury of that time now, the authors write in their closing entreaty. We must use all means at our disposal to accelerate the process of learning and understanding. One hopes that we hear their plea.

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Hardwired

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Adding to a prolific career of scientific writing, the psychologist and geneticist Robert Plomin has produced an extremely readable and interesting book about the role of genetics in our lives. *Blueprint: How DNA Makes Us Who We Are* is part scientific memoir, part summary of the current state of the art of behavior genetics, and part introduction of the field to the layperson. In it, Plomin uses highly accessible terminology to explain complicated concepts of inheritance and genetic influences on various human behaviors, as well as the ostensible role of environmental influences. "The main message of *Blueprint*," Plomin writes, "is that genes are the major systematic force in children's development." In other words, the part of behavior that is predictable is primarily a function of DNA rather than environmental influences that are shared by members of a family.



Blueprint: How DNA Makes Us Who We Are
by Robert Plomin. Cambridge, MA: MIT Press, 2018, 280 pp..

Plomin introduces this important idea in the book's prologue, which delivers an overview of the topic of inheritance and DNA. The rest of the book provides his evidence to support this strong—and controversial—statement of the primary importance of genotype for explaining most of human behavior. Plomin uses data from his own famous twin studies as well as from the newest big data sources of genome-wide association studies (GWAS), which examine the whole genome across many people to discover small genetic variations that are associated with particular behaviors or diseases, to demonstrate the predictability of behavior from compilations of genes.

There are two primary lessons to be learned from *Blueprint*. The first is that, according to Plomin, "genetic research has told us as much about the environment as it has about genetics." Initially, psychologists believed that most of the environmental measures they assessed, such as the home situation, parenting behaviors, and cultural differences, were causally related to behaviors. However, exploring relations between environment and behaviors in

genetically informative ways, such as using twin and adoption studies, has led scientists to realize that most of these "predictions" are in fact correlations. That is, although parenting may be related to children's problem behaviors, this relationship is primarily a function of parents' and children's shared genes, not shared environment. This is a critical point that Plomin makes throughout the book.

As Plomin notes, because of our genetic differences, we each have different life experiences. Thus, parenting styles can have different effects on siblings because they may have genetically different temperaments. This is called gene-environment interaction, and it is an essential aspect of how both genes and environment lead to individual differences in behaviors.

Relatedly, correlations between our genes and our environment occur for several different reasons. One of these is that we evoke reactions from those around us based in part on our genetic makeup (this is called evocative gene-environment correlation). Another is "niche-picking," which refers to choosing to put ourselves in environments that fit us, in part as a function of our own genetic makeup (this is called active gene-environment correlation). For these reasons, we actually express our genetic potential more and more as we age, an important point that, Plomin says, makes us appear to become more like our parents as we grow older. Becoming more like our parents is primarily a function of shared genes, although it also reflects being more in environments that reflect or amplify our genetic potential over time.

The second important lesson in *Blueprint* is that scientists now have access to an exciting new methodology that allows much more successful prediction of behaviors from genetic information. This new tool is the creation of polygenic risk scores, which has become possible because of the increasing number of genetic studies being performed around the world. Scientists have amassed huge data sets of DNA, along with measures of specific behaviors. These huge data sets are essential

because each gene that influences behavior accounts for only a fraction (less than 1%) of the variance across individuals. Thus, at the intersection of big data and behavioral genetics lies GWAS, which have become large enough in recent years that researchers are beginning to have the power to detect correlations between specific genes and certain behaviors.

GWAS aggregate a large number of miniscule genetic variations, called single nucleotide polymorphisms (SNPs), each of which is related to a tiny amount of variation in a given behavior. Researchers then match these SNPs to the behavior of interest across thousands of study participants. When aggregated into a single polygenic risk score, they are capable of predicting certain behaviors more accurately than traditional environmental predictors. For example, Plomin provides evidence that children's achieved years of education can be predicted more accurately from polygenic risk scores than from family socioeconomic status—a putative environmental variable (it actually has significant heritability because of gene-environment correlations, as described above) that has fairly good predictive ability. He finds that about 10% of the variance in years of education can be explained through polygenic risk scores; that is higher than for any other single genetic or environmental measure presently available.

Plomin rightfully characterizes polygenic risk scores as “inherently probabilistic, not deterministic.” This is perhaps the most important message in the book. Even though such risk scores may provide excellent predictors at the population level, they do not determine any single person's behavioral outcome. They indicate a probabilistic tendency toward a certain behavior, but many other factors also come into play, many of which are random environmental events that may interact with genetic dispositions to influence eventual outcomes.

It is essential not to lose sight of this, and *Blueprint* would have benefitted from repeating this message at regular intervals.

For example, Plomin suggests that mental illness might someday be treated prior to the onset of any overt symptoms, based solely on DNA predictors. This is exciting and may even become reality at some point in the future, but it also evokes serious ethical concerns regarding the potential treatment of “at risk” people who may not actually ever require treatment. Caution is clearly warranted.

Another example involves gene editing, which currently is being explored to correct errant genes even before birth. Visions of a science fiction world with designer babies abound, with all the ethical and moral concerns that ensue. As Plomin notes, although precision gene editing is approaching reality for certain physical flaws such as heart defects, the likelihood of this process being used for psychological traits is very low because thousands of genes, each having a miniscule effect, are responsible for most behaviors. Although polygenic risk scores may be valuable for predicting general risk, they will not be useful in identifying specific outcomes for individuals at risk with any great specificity. Again, this should have been stated more definitively in the book as a reminder to the reader.

Relatedly, Plomin makes the strong and contentious point that “parents matter, but they don't make a difference.” By this he means that most of the effects of parenting on children come from shared genes, not specific parenting behaviors (except for extreme behaviors such as abuse). This is meant to be liberating to parents, freeing them from worrying about every mistake that they perceive themselves making as they raise their children. His positive and affirming message is to enjoy one's children rather than obsess about one's parenting. He goes on to say the same for schooling, noting that most effects from school experiences are actually a result of gene-environment correlations or interactions and therefore are more a function of children's genes than of the school environment. However, it is essential

not to lose sight of the fact that there are many events that occur at school that may have huge influences on a child's behavior; it's just that these tend to be nonsystematic and therefore not useful for predicting behavior.

In general, *Blueprint* is full of optimism for the future of behavioral genetics. Plomin's enthusiasm for the predictability of behaviors from genetic makeup is palpable. However, this enthusiasm must be tempered by the limitations of the current state of the science. As he notes, “genetic influence does not imply hard-wired programming that you can't change.” But Plomin could have gone further in his considerations of the potentially dangerous outcomes of genetic research. I would have preferred more discussion about the ethical ramifications of this new knowledge that scientists are accumulating at breakneck speed. I was concerned about the oversimplification of the value of DNA as a predictor of human behavior throughout the book. In the wrong hands, or if misunderstood, such oversimplification could lead to dangerous laws and methods of supposed treatment for individuals who might have no use for such treatment.

Overall, Plomin has a very accessible writing style. He provides excellent summaries of the current state of knowledge of the role of genes in human behavior. His inclusion of personal examples is informative and intriguing. If, as Plomin states, “the DNA revolution is unstoppable,” education about genetic research on behavior is important for people from all fields of study, including psychology, medicine, law, and biology, along with the general public. The more information we have, the better armed we will all be to address complicated ethical issues and policies. Books such as *Blueprint* that are accessible to everyone should be required reading to help us prepare for the genetic future.

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