An unfolding genetic story
Gary Marcus

Are human beings genomically challenged?

In less than half a decade, scientists' best estimates of the numbers of genes in the human genome have dropped dramatically - from about 100,000 just a few years ago to 25,000, according to a report published last week. Since 25,000 genes is about the same number one might find in mustard seed, should DNA's significance be downplayed?

Prominent biologists, such as Stanford's Paul Ehrlich, have recently suggested there is a "gene shortage." And there's a natural inclination to equate the complexity of a creature with its number of genes. But by itself, the number of genes tells us little. Just as we wouldn't try to guess whether a human is more complex than a chimpanzee merely by counting the number of bones each species had, we shouldn't expect that the number of genes should necessarily be more informative.

Still, it's hard not to notice the gap between the comparatively small number of genes we have and the giant number of neurons (billions) in our brain. Do the new results suggest that genes have little to do with our brains?

Absolutely not. The enormous complexity of the human brain stems not from the sheer number of genes, but from the nature of those genes. If genes were like pixels in a digital photograph - an idea suggested by the common metaphor of genomes as "blueprints" - 25,000 genes really wouldn't suffice. But genes don't really work that way. They aren't pixels - they're instructions, each one something like an IF-THEN in a line of a computer program. As every computer programmer realizes, even a small number of IF-THENs interacting with one another can lead to enormous complexity. (That's why debugging is hard and only gets harder as the size of computer programs increases.)
Genetic IF-THENs specify two things: how to build a particular protein (that's the THEN) and when and where to build that protein (that's the IF). The insulin gene, for instance, tells the body not just how to create insulin, but under what circumstances it should do so.

Other recent studies, less heralded, have shown that what makes us different from other species is not so much the ingredients of which we are made (as specified by the THENs), but the ways in which those ingredients are put together (the IFs). What makes us different from a mustard plant is not that we are made of something special, but that we are put together in a special way. Just as the complexity of a play comes not from the number of lines in a script but the ways in which those lines work together, so, too, the complexity of humanity comes not from the sheer numbers of its genes, but from the unique way in which those genes are put together.

What the ever-shrinking estimates of human genome size are telling us is not that humans are declining in complexity (no matter how much reality TV they might watch), but that the genetic machinery is even more efficient than any scientist ever would have dared dream. Microsoft's finest programmers need hundreds of thousands of lines of code to build something as simple as a word-processor. Through hundreds of millions of years of evolution, nature has given us highly compact genomes capable of overseeing the construction of the most complex organ in the known universe: the human brain.

As we come to know not just the length of our genome but also the meaning of the tens of thousands of individual IF-THEN instructions contained within, we will come to understand ourselves in an entirely new way.

*Gary Marcus is author of "The Birth of The Mind: How a Tiny Number of Genes Creates the Complexity of Human Thought."*