

## Editorial

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### Manipulating the Genome, Enhancing Humans, and Creating Robots to Keep Us Company: Thoughts on What's "Human"

I've been fantasizing lately about a dinner party at which a collection of our best genomic scientists, MIT's robot designers, DARPA's\* most creative thinkers, and Charles Darwin find themselves at the same table. After a few hours in company like this, what would Darwin think about the role of natural selection in shaping the 21st-century human? I'd love to watch his response to the concept of the genome and then see him react to the news that we had decoded it, are learning how it works in concert with the myriad things that regulate genetic expression (including biological sex), and, most mind-blowing of all, are aggressively tinkering with its very structure in living things. Craig Venter (who would certainly immediately claim a seat as close to Darwin as possible at my imaginary dinner) would regale Charles D with his latest feat: taking the whole genome out of 1 bacterium and inserting into another—and finding that he had created a duplicate of the donor bacterium!<sup>1</sup> (Exactly how the new genome seized control of the recipient bacterium, Venter admits, still eludes him.) Doubtless, Venter would quickly offer to decode Darwin's entire genome and then present it to him as a gift...and of course, in record time. MIT and Harvard's George Church would explain to Darwin that without question, we were now able to create living beings from simple, inanimate molecules, and that those beings would themselves be capable of reproduction and thus, presumably, would themselves evolve. Richard Dawkins would interrupt everyone else to explain to Darwin (who, you may be surprised, was a theology student in the divinity school at Cambridge) that God simply doesn't exist.<sup>2</sup> This would be particularly interesting, because Darwin is believed to have had some radical thoughts about how man had come to be but stopped short of writing them down. No one who's read *The Origin of Species* or *The Voyage of the Beagle* could conclude that Darwin was a creationist.

As soon as they could get a word in edgewise, DARPA's brain trust would explain to Darwin that we were working on developing warriors who would make infinitely more efficient soldiers: humans whose brains, like those of whales, never entirely slept; who could communicate with one another by thought alone, even over huge distances; and who could control intense pain in 10 seconds by using a "pain vaccine" that would last for 30 days!<sup>3</sup>

Poor Darwin. I wonder if even his superb mind could take in the scope, nature, and possible consequences of what we have accomplished since that astounding announcement, made at the White House 7 years ago by then-President Clinton (with Venter and Francis Collins of the National Institutes of Health by his side), that we had decoded the human genome. It boggles the mind—just leafing through *Science* every week beats any science fiction or comic book fantasy any of us have ever seen or dreamed of. Church might ask Darwin if he believed that all this progress was simply a new and accelerated kind of evolution, a sort of profoundly escalated shortcut in altering the nature of what it means to be human. One of the guests might even ask him what the definition of a human actually was—Darwin might need a little time to ponder that. How would he classify enhanced humans, that is, people with immensely sophisticated body parts controlled by the brain as if they were natural, or people with microchips in their brain that stopped tremors or with implants that allowed the profoundly deaf to hear? And what would he think of the latest wonder of them all,

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\*Defense Advanced Research Projects Agency of the United States, the central research and development organization of the Department of Defense.

robots?<sup>4</sup> We are now able to make completely artificial machines that can carry out commands and, even more remarkable, *learn*, by using their experiences to generate principles that help them expand their power to interact with the environment. Some robots have been deliberately created with human-like attributes, such as large eyes that focus on the face of the person who is speaking to them. Moreover, they will nod in agreement when questioned. Other robots will be able to recognize themselves in a mirror. One might imagine a sequence of improvements in robotic science that may give rise to an entirely agreeable, never-tiring, collaborative, and empathetic companion for a lonely or limited human being. Sound far-fetched? Read Robin Marantz Henig's description of the young woman who said she would gladly trade in her boyfriend for a sophisticated humanoid robot, as long as it could produce what the student called "caring behavior."<sup>4</sup>

We are living in a remarkable era in which what it means to be human may be changing in ways we could never have imagined. It's our custom to hurtle headlong in enthusiastic pursuit of whatever science can develop—and not devote equal time and enthusiasm to ponder the implications of what we are undertaking. It's almost as if we don't think these questions are relevant. Clearly, we are at the beginning of almost unlimited opportunities to alter the nature of living things and, inevitably, the planet on which we live. But, as usual, our reflections on how we should use our new powers and even the very nature of what we are creating lag far behind the science. There are exceptions: Church is making impressive efforts with government agencies to exercise oversight of some of our achievements.<sup>5</sup>

Spelling out the human genome, learning how it works, and developing ways to alter it; creating composites of humans and sophisticated machinery; making computers that, for some, might one day be preferable to actual, fallible, limited human beings—all of this is not unlike the Manhattan Project, in which the discovery of a force that could have been used for either tremendous good or unimaginable destruction was subsequently used to end the Second World War.

On further reflection, I would also include some eminent jurists and ethicists (maybe even some theologians, seated far from Dawkins, naturally) in my imaginary dinner party. And, because I'm reaching across time to compose the final guest list, I think Robert Oppenheimer would be a good candidate for the other seat next to Darwin. By the time dessert was served, Oppenheimer might have made the most important comments of all.

Marianne J. Legato, MD, FACP  
Editor-in-Chief

## REFERENCES

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