GUEST EDITORIAL

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Genomics—Past, Present, and Future: A Letter to My Daughter

Eric D. Green, M.D., Ph.D. is the Director of the National Human Genome Research Institute (NHGRI) at the U.S. National Institutes of Health (NIH). This editorial is written as a letter to his daughter, Abbey, who will graduate from high school in June 2018.

To Abbey, My Remarkable Daughter:

In a few weeks, you will graduate from high school and begin the next phase of your life journey. Reflecting on this milestone, I am struck by how your life has paralleled spectacular advances in an area of biology that I have worked in for my entire career—genomics, the study of all the DNA of a living organism.

When you were born in 1999, I and thousands of other genomics researchers around the world were working intensely on the Human Genome Project, a 13-year odyssey to "decode" the human genome (that is, to determine the order of the roughly 3 billion "letters" in human DNA). While you were finger-painting and napping in pre-school in 2003, we completed that effort. As you moved through grade school and middle school, we worked diligently to make sense of our genome's code by analyzing all those ordered Gs, As, Ts, and Cs—we identified the approximately 20,000 genes in the human genome; we began to identify the additional sequences that precisely turn those genes on and off in the right cells and at the right time; and we came to appreciate the way that chemical modifications of DNA influence how genomes operate (something known as epigenomics). We also made great progress in cataloging the 3–5 million "spelling differences" present in each of our genomes, and launched major studies to determine which of these differences play a role in human health and disease.

These efforts were greatly aided by one of the most stunning technological advancements seen in either of our lifetimes—no, not the "smart phone" or Instagram or self-driving cars—rather, methods to sequence or read the code within DNA. Sequencing that first human genome by the Human Genome Project cost nearly $1 billion. However, in the time that it has taken for you to move from a pre-K student to a high school senior, scientists have developed totally new and inexpensive ways to sequence DNA. Now, a human genome can be sequenced for about $1000, which is only slightly more expensive than the latest iPhone!

Once limited to research laboratories, DNA sequencing is now affordable for numerous applications—perhaps the most impactful of these will be in medicine. During your past few years of high school, we have witnessed some truly inspirational early successes using a patient's genome sequence to tailor their medical care—an area known as genomic medicine. This has led to novel approaches for helping patients with rare genetic diseases and more common diseases like cancer, for performing prenatal genetic testing, and for selecting medications more precisely based on a patient's unique genomic makeup. Just as graduating high school will mark a pivotal transition in your life, genomics is in the midst of transitioning from the research laboratory to the clinic.

But should you really care about all this genomics stuff? Is this all nothing more than your researcher dad being nerdy about his work again? Or will genomics have a meaningful role in your future and the futures of everyone else? Along with the genes that your mother and I have already given you, let me now give you some loving advice as an early graduation present—***genomics will be relevant to you.***

Obviously, genomics will be directly relevant if you become a scientist, doctor, nurse, pharmacist, or other healthcare professional, or if your career takes you into an area related to genomics (such as law, ethics, engineering, computer science, or education). More importantly, genomics will be relevant to you as patient—and as a relative or a friend of a patient. Your generation will witness genomic medicine becoming widespread and routine. That means your healthcare providers will speak the language of genomics, so you too will need to be literate in the basics of genomics to make informed healthcare decisions. Beyond medicine, DNA sequencing will be used for detecting infectious outbreaks, improving and monitoring our food, increasing the accuracy of forensic investigations (think CSI!), assessing the health of our environment, and advancing our understanding of evolution, among other applications. It will also provide a new lens through which you will be able to view aspects of human origins, your own family history, and even elements of our culture. However, this is a powerful lens—one that must be used carefully and with appropriate consideration of the important ethical and societal issues involved. In short, your generation will truly see genomics become part of everyday life, but with that will come some important challenges for health equity and social justice.

While I realize you learned a few basics about genomics in high school biology, the field is moving rapidly, and many things will change in the coming years; for that, you must commit to becoming a life-long genomics learner. The good news is that the necessary information will be but a mouse click (or two) away, with numerous online resources (for example, genome.gov and unlockinglifescode.org) already available and poised to track upcoming genomic advances and to provide tools for keeping you "genomically literate."

More than a decade before you were born, I chose to be a genomics researcher because I believed that a more complete understanding of our DNA blueprint would improve human health. Today, I am confident that the genomic advances made by my generation will provide a foundation on which your generation will further advance genomics in previously unimaginable ways. Most importantly, I am certain that genomics will benefit your life—and, as a veteran genomics researcher, that makes me immensely proud.

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