

Direct-to-Consumer Genetic Testing is Disrupting Our Healthcare System by Empowering Consumers

by Jim Greenwood

Three years ago, at the urging of my daughter, I swabbed the inside of my mouth and sent off my DNA to discover my family's ancestry and learn more about the stuff of which the Greenwood clan is made.

For decades, my father had relentlessly pursued our family lineage in the old-school way: paper research through courthouse and cemetery archives and even a visit to Salt Lake City to study records of the Mormon Church. In his research, he found an immigration manifest showing his Protestant Irish and German relatives arriving here by boat to escape a depression in the 1830s. He also found relatives who fought in the Civil War against one other in the Battle of Trevelyan Station. On my mother's side, I learned that my Catholic Irish heritage comes from a family who emigrated here during the potato famine in the mid-1800s. Census records we obtained suggested my maternal grandfather moved in and out of the family hearth. This has fueled speculation into the antecedents of the strong, independent women who followed on that side of the family.

When my father passed away, my daughter Laura eagerly took the baton and continued to

build out the family tree using more modern methods. That's how I came to swab my gums and join the millions of people who are capitalizing on the latest innovation story for biotechnology: direct-to-consumer (DTC) genetic testing.

Consumers like me are finding that genetic testing can confirm and confound previously held beliefs about one's genealogy. In some instances, it can bring together long-lost relatives. In others, it can expose family secrets harbored for years. When my DNA test results came back, they dispelled one long-held family myth but revealed other new insights. We are not, contrary to Greenwood lore, part Sioux. We are, however, related to Daniel Boone and a great grandfather, several times over, who had 19 children in the 1700s. We're now in touch with many of these long-lost family members spread across Virginia and the Carolinas.

DTC genetic testing has been a powerful tool for family reunification. During the recent

national immigration uncertainty, consumer genetic tests were utilized to identify separated families and reunite children taken from their parents. One promise of this powerful tool in these divided times is that it might help more people understand how much our diverse heritage overlaps, and perhaps this insight can facilitate greater understanding. As more Americans swab their mouths, the line between "us" and "them" could eventually become so blurred that it helps bridge divisions that have sowed conflict throughout human history.

Yet the biggest transformation DTC genetic testing could deliver is less about where we came from than where we might be going. My daughter, Laura, took the 23andMe genetic test to learn more about her health outlook. It confirmed her gluten allergy and revealed she has a slightly increased chance of age-related macular degeneration and late-onset Alzheimer's disease. This new knowledge has driven her to get more regular ➤

eye exams and it has increased her awareness of Alzheimer's therapeutics in the pipeline that might one day offer risk reduction for those with a genetic predisposition. She was also tested for three BRCA mutations that can increase breast cancer risk. Thankfully, it came back negative, but she learned from the experience that additional testing would be needed to rule out all BRCA mutations.

Rise of DTC Genetic Testing

In recent years, a growing array of DTC genetic testing companies have disrupted the healthcare system. These tests are part of the vision promised by precision medicine – that patients are at the center of decision-making, allowing them to take ownership of their personal health data and behavioral choices that could impact their health. According to a recent survey, 61 percent of respondents recognized genetic tests as the most widely known precision medicine-related term, even more so than “gene editing” or “precision medicine” itself.¹

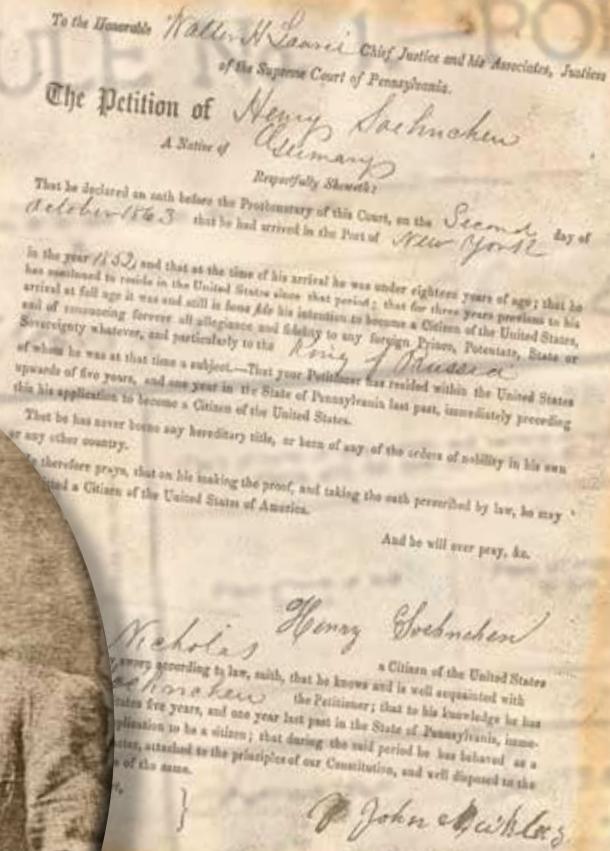
Leading voices in the field, including Food and Drug Administration (FDA) Commissioner Scott Gottlieb, have acknowledged how DTC genetic tests can change the healthcare landscape. “At a time when people are more aware of and engaged in their healthcare than ever before, genetic risk testing can provide helpful information about an individual’s predisposition for certain diseases and conditions,” he said. “These tests can prompt consumers to be more engaged in pursuing the benefits of healthy lifestyle choices and more aware of their health risks.”²

Of the myriad issues I encountered as a member of Congress for 12 years, perhaps none captured my imagination as thoroughly as the Human Genome Project. I sat on the House Energy and Commerce Committee that oversaw U.S. public involvement in the landmark research. I knew that sequencing the DNA of our species for the first time would be a watershed moment for molecular medicine,



with the potential to help us understand, prevent and defeat some of the most deadly and debilitating diseases that have beset the human race for centuries.

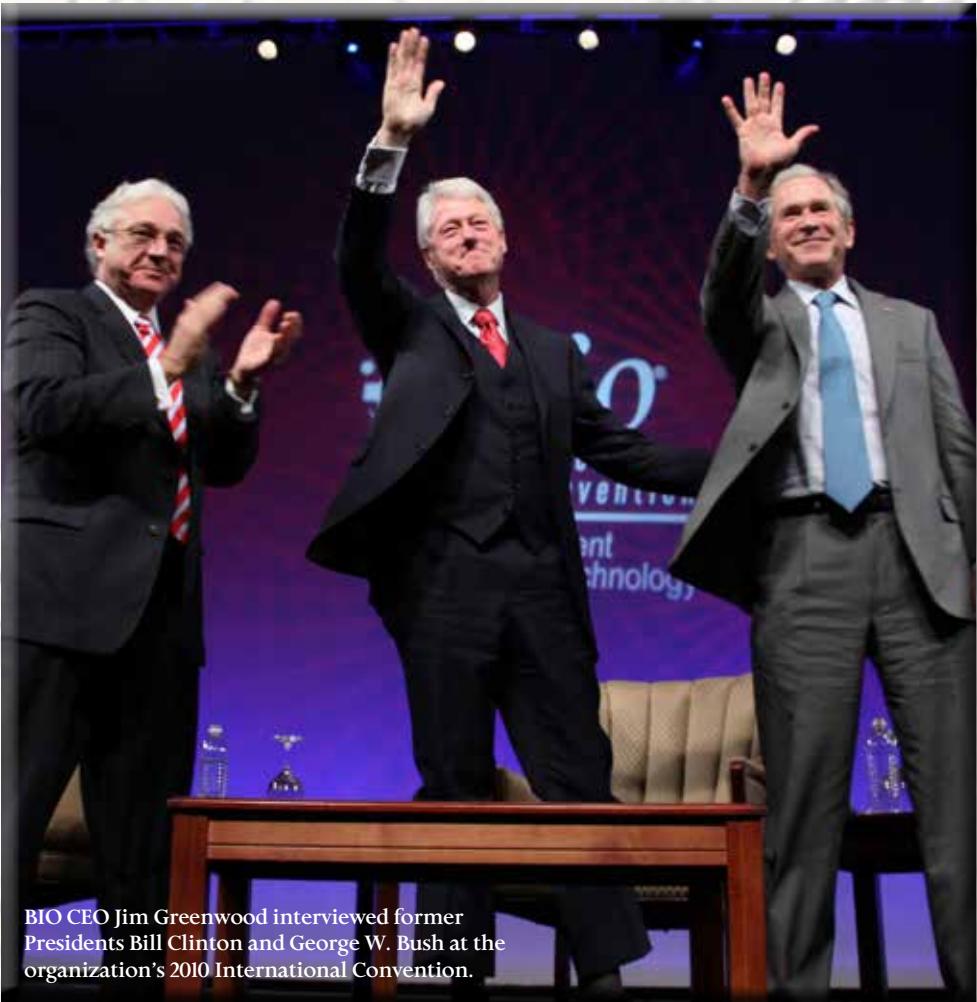
It took researchers 13 years and more than \$2.7 billion to sequence the first human genome. Some 15 years later, genetic sequencing breakthroughs have increased speed while decreasing costs, so now one individual genome can be sequenced in less than an hour for under \$1,000. New innovative technologies are incorporating algorithms and gate arrays that could soon lower the time to 20 minutes and the cost to \$100.^{5,6} This is a vivid illustration of how public investment in the scientific enterprise can produce benefits for society.



Through old-fashioned genealogical research, we discovered my dad's great, great grandfather, Henry Jacob Soehnschen, immigrated to New York from Germany in 1852 and enlisted in the Union Army in 1861 as first sergeant. His regiment fought in the Battle of Gettysburg.

Since the mapping of the first human genome, the private sector has seen a boom in DTC genetic testing with the growth of companies like 23andMe, Ancestry.com, Color Genomics, Myriad Genetics and Helix. Indeed, 23andMe alone has already sequenced more than 5 million individual genomes.³

The global DTC genetic testing market was valued at \$117 million last year and is expected to grow to \$611 million by 2026, according to a recent report.⁴ North America has more than 45 percent of the current market, while Asia Pacific economies comprise the fastest-growing region for DTC genetic testing with annual sales growth above 20 percent, largely attributable to improvements in healthcare infrastructure and the increasing availability of DTC test kits.►



BIO CEO Jim Greenwood interviewed former Presidents Bill Clinton and George W. Bush at the organization's 2010 International Convention.

The primary factors fueling the rise of DTC genetic testing are the public's inquisitiveness about early intervention in diseases, their lineage and their health risks. The resulting health reports from these tests allow the consumer to glean a wide range of information, such as carrier status, ancestry, wellness, potential health risks for hereditary diseases and interesting personal traits informed by your DNA. For instance, 23andMe can analyze whether you have genetic susceptibility to mosquito bites, a fear of heights, or tone-deaf musical pitch.

DTC companies' business models are typically structured to charge a fee for consumer access to sequencing technology that can provide insights into a person's unique genetic profile.

Consumers can use the information to make healthier lifestyle choices or inform disease prevention strategies.

Consumers may opt in to allow use of their genetic data to further scientific research. Notably, some 80 percent of 23andMe's users allow their genetic data to be aggregated for the good of humankind.³ These vast, new genetic data banks are a veritable bonanza for the medical research community. Drug developers are partnering with DTC genetic testing companies to gain new insights and find new genetic associations. Once the data is anonymized, scientists may analyze it to identify treatment targets and accelerate the discovery of new medicines. This was always the great hope of the Human Genome

Project – to further the genetic understanding of ourselves so we can heal the sick and prevent disease.

Game-Changer for Drug Development

Genetic datasets have the potential to transform drug development. Biopharmaceutical companies face a 90 percent failure rate for novel drug candidates in the clinical pipeline,⁷ but those that utilize genetic data have a higher likelihood of achieving clinical success for their drug candidates. Thanks to the Human Genome Project, scientists can now mine the data and identify clinically relevant genetic targets – or biomarkers – to target with precision treatments. A 2016 analysis found that the probability of clinical success increases from 8.4 percent with no biomarkers to 25.9 percent with biomarkers.⁷ Of the 46 new molecular entities approved by the FDA in 2017, sixteen new molecular entities and three gene therapies referenced specific biomarkers that were identified through diagnostic testing.⁸ These precision medicines represented more than 30 percent of all new drug approvals last year.

DTC genetic testing companies have begun to partner with biopharmaceutical companies to capture synergies in drug development. GlaxoSmithKline (GSK) recently took a \$300 million equity stake in 23andMe in exchange for access to genetic data volunteered by millions of people who agree to share their anonymized genetic profiles.⁹ The partnership will combine 23andMe's data expertise with GSK's clinical development know-how to facilitate speedier development of precision treatments. GSK is using the data to identify new drug targets and develop a potential treatment for a specific mutation of Parkinson's disease.⁹

While proprietary data will be a boon for drug development, public investments in genetic databanks will also be fruitful, as seen ➤



in the *All of Us* Research Program. Launched under President Obama as the Precision Medicine Initiative, the rebranded *All of Us* is a National Institutes of Health project to gather phenotypic and genetic health data from at least one million people. The program has adopted important objectives that fill needs unmet by proprietary databases, namely having a diverse set of participants. Similar to DTC genetic testing, the project will anonymize subject data and make it publicly available for researchers to uncover new paths toward delivering precision medicines.

Mitigating privacy concerns is a critical, ongoing challenge for genetic research that utilizes consumer data. For instance, civil liberties advocates raised questions when law enforcement used a genetic database to match samples taken from a crime scene to apprehend the “Golden State Killer”. In public surveys, 52 percent of Americans reported concerns that their test results might be used to deny life insurance or coverage for a medical treatment. But there are federal

statutes, such as the Genetic Information Nondiscrimination Act, in place to prevent employers or health insurers from using genetic test results to inform coverage decisions; however, only 10 percent of Americans are aware of it.

The increasing availability of health data provides a new set of privacy and data security challenges that will require ongoing attention and consumer education.

Genetic Literacy and Consumer Education

Since DTC genetic testing provides information directly to the consumer without a consultation with a medical expert, genetic literacy education is critical. Consumers must be able to understand what they are reading when their test results come back. Patient advocacy groups have raised concerns that some people could misinterpret genetic test results without the assistance of a healthcare professional or genetic counselor.

Some consumers may receive genetic testing results with the belief that a particular

Using more modern DTC genetic testing, we found dozens of long-lost relatives on my mother's side and started a Facebook group together.

negative test result or low-risk assessment may be interpreted as a clean bill of health. However, DTC genetic tests are not able to definitively rule out the presence of genetic variants that may impact disease risk. A particular genetic test may only report on a subset of known genetic mutations that may increase risk for a specific disease. Negative results from one test may lead some to believe that they do not have an elevated genetic risk for a given disease when they may have other mutations that were not included as part of that test. This may lead consumers who receive negative results to wrongly avoid risk-reducing measures such as screenings or surgery.

Furthermore, genetics are not the only risk factor driving disease susceptibility. Environmental factors such as exposure to toxins and pathogens – or a person’s diet, physical activity or stress level – can impact their risk level, regardless of their genetic susceptibilities.

FDA Commissioner Gottlieb noted that while “these tests can offer significant amounts of personal risk information, they’re not

without their own risks – especially if they provide consumers with incorrect or misleading information that may be used to make health choices without considering the advice of a medical professional. Consider the consequences of a person who is told they're not at risk for coronary heart disease and incorrectly opts to forgo dietary changes or drugs that reduce their risk of heart attack and death.”²

DTC genetic testing companies are grappling with this issue and emphasize that their tests are not substitutes for rigorous diagnostic screenings or clinical testing overseen by healthcare professionals. Where possible, consumers should work with their healthcare providers to interpret the results and help develop an overall health plan that may include additional testing. Yet only 1 in 10 Americans report that their doctor has discussed or recommended genetic testing.¹

Some DTC genetic testing companies have embraced their responsibility to provide quality consumer education to combat genetic illiteracy, working alongside groups such as the American Society of Human Genetics and

My great, great grandfather William Everal Marsden's Civil War muster roll shows that he served as a private in the Union Army's 27th Pennsylvania Regiment. The Marsden family settled in Philadelphia after escaping famine in England due to a global volcanic winter caused by the eruption of Mount Tambora in Indonesia in 1815.



the Genetic Literacy Project. 23andMe started a program to advance genetics education starting at the grade-school level. The increased uptake of DTC genetic testing has also led to a rise in genetic counseling companies, such as Counsy and Gene by Gene, that offer a range of companion services for consumers.

The scientific community has a responsibility to properly educate the public on the benefits and limitations of these tests. We must set appropriate and explicit expectations to help consumers make informed choices. And we should advocate for smart public policy that encourages innovation while educating consumers and safeguarding their genetic data.

Balanced Public Policy

The FDA traditionally evaluates test products for safety and efficacy, as well as analytical and clinical validity. In 2013, the FDA acted to reduce the risk that consumers might misinterpret their genetic test results.

Specifically, the agency ordered 23andMe to stop issuing health-related reports due to concerns that results were not mediated by healthcare professionals.¹⁰ The agency warned against taking medical actions based on DTC genetic test results, stating that treatment decisions and surgical procedures should go through the normal process of confirmatory diagnostic testing. As a result of FDA's action, 23andMe scaled back its offerings to only sell tests for ancestry and other non-health related topics.

However, four years later the FDA's new leader modified the agency's position. Commissioner Gottlieb acknowledged that DTC genetic tests do not fit squarely into the FDA's traditional, risk-based approach to diagnostics regulation. He announced the agency would seek to strike an appropriate balance between the benefits and risks of DTC genetic testing. 23andMe responded by submitting peer-reviewed ➤

studies demonstrating links between certain biomarkers and heightened disease risk. It also verified that more than 90 percent of its customers were able to understand their test results.

In 2017, FDA granted premarket authorization for 23andMe to issue 10 genetic health risk reports. Gottlieb noted the move was the first time the U.S. government had ever explicitly authorized DTC genetic testing to gauge disease risk, meaning consumers could get genetic health risk reports without a doctor's prescription. The FDA went a step further and allowed 23andMe to sell similar tests directly to consumers without submitting them for pre-market review, so long as FDA safety and efficacy requirements were met. The agency is now outlining a pathway that would allow other firms to follow suit.

For 13 years, I've led the Biotechnology Innovation Organization (BIO), the world's largest biotech trade and advocacy organization. As stewards of sound science, our responsibility is to ensure that lawmakers and other public officials embrace smart policy that helps facilitate biomedical innovation for patients. This means that accurate and clinically meaningful test results should reach the healthcare marketplace in a timely manner and that consumers should be protected from false or misleading information. This cannot happen without transparent, science-based validation processes to protect patient safety. Additionally, privacy protections governing sensitive consumer genetic data should be faithfully enforced.

Transformative New Tool

My father would have been astounded to see how much we can learn now about our genetic heritage from a simple swab of the mouth. Biotechnology innovation is helping us learn more about ourselves than any other generation. In the information age, conscientious consumers have a greater ability than ever before to educate themselves

and make lifestyle and treatment choices that increase their odds of living longer, healthier lives.

The proliferation of DTC genetic testing is a disruption of the existing healthcare system, but one that holds the promise to accelerate scientific discoveries that lead to new precision treatments. But with this new capability comes new responsibilities. As the general public is exposed to more complex genetic information, the biotechnology industry has a shared responsibility to educate consumers about what their test results mean and what they do not.

DTC genetic testing empowers patients, enables researchers and provides society with true precision medicine. It can help us move away from a one-size-fits-all healthcare system to a new paradigm that can locate patients' mutations at the genetic level to find specific drug treatments shown to work on them. This endeavor is not without its risks and challenges but nothing worthwhile ever is. As someone who served as a lawmaker for 24 years and has led BIO for the last 13, I'm confident that government and industry can work together to create a policy environment that allows our loved ones to reap the immeasurable benefits of this transformative tool. ■

Jim Greenwood joined BIO as President and CEO in 2005. BIO is the world's largest trade association representing biotechnology companies and organizations, representing about 1,000 member companies and organizations in more than 30 countries. Greenwood represented Pennsylvania's eighth district in the U.S. House of Representatives from 1993 to 2005 where he served as chairman of the House Energy and Commerce Committee Subcommittee on Oversight and Investigation. He served six years in the Pennsylvania General Assembly (1981-86) and six years in the Pennsylvania Senate (1987-1992). Greenwood began his career as a social services caseworker assisting abused and neglected children.

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