Introduction

Since the time of the ancient Greeks, men of science have pondered the biological and chemical interactions that make us distinctly human and that differentiate us from other species. But until the middle of the twentieth century, scientists knew very little about the inner workings of the human body and its functional unit, the cell. They had only a vague understanding of genes—the material that makes each person unique—and a similarly vague idea that perhaps genes were composed of a chemical called deoxyribonucleic acid (DNA).

But a pair of scientists—James Watson (1928–) and Francis Crick (1916–2004)—changed all that in the spring of 1953, when they announced that they had discovered the DNA double helix structure. The twisting ladder they described was composed on the two sides of sugar and phosphates, with steps made up of four chemical bases (adenine, guanine, cytosine, and thymine). The bases could unzip, allowing the double helix to replicate itself and pass along its genetic information.

Watson and Crick did not simply identify an obscure series of code within the DNA helix—they discovered the entire instructions for a human being. Their research, and the research of subsequent scientists in the field, revealed that the proteins for which DNA codes determine everything from an individual's height and hair color to his or her predisposition to certain diseases. For the first time, scientists could see the inner workings of heredity, and they could understand how genes are copied and passed from generation to generation.

At the time, Watson and Crick were seeking little more than knowledge of how proteins were made inside the cell. But as they celebrated their discovery at a pub in Cambridge, England, they must have had at least some sense of the historic implications of their discovery, as, according to Watson, Crick announced, "We have found the secret of life." Little did they know how prophetic those words would be. Within the century, their discovery would have monumental implications to scientists and citizens around the globe. It explained the mechanisms of heredity. It launched both the science of molecular biology and the multi-billion-dollar biotechnology industry. It enabled scientists to understand the genetic basis for disease, create tests to identify and even predict those diseases, and develop pioneer treatments that would have been unthinkable a half century ago.

Fifty years later, as the world celebrated the anniversary of Watson and Crick's finding, genetics had

moved from a vague pursuit of a few enterprising scientists to a focal point of international research. In just a half century, scientists had learned not only what our genes look like and how they are copied and transferred through familial generations, but they had sequenced the entire human genome.

In April 2003, almost fifty years to the day after Watson and Crick announced the discovery of the DNA double helix, scientists from the International Human Genome Sequencing Consortium made a similarly momentous announcement. They had completed the Human Genome Project—the more than thirteen-year effort to sequence the entire 3 billion DNA base pairs in the human genome. They had mapped 99 percent of the gene-containing regions in the human body to 99.9 percent accuracy. And what they had discovered had shifted—sometimes radically—our understanding of the human genome. Before the project was launched, scientists had believed that humans had some 100,000 genes. Now they realize humans possess only about a quarter of the original estimate—some 25,000 genes. To the scientific community, completion of the Human Genome Project was the equivalent of man's first walk on the Moon.

Within the past few years, scientists have not only unraveled our genetic code but also mapped the genetic sequence of mice, yeasts, fruit flies, and nematode worms. What they have been able to discover about our similarities—and differences—has shed new light on the process of human evolution and illuminated the processes of disease.

Now that we have a working map of our genes, what can they tell us? They can tell us where we came from and give us a window into our future. They can show us how our ancestors evolved and where they migrated. They can help doctors predict which individuals are at risk for diseases such as Alzheimer's or cancer, then assist in the efforts to come up with more effective treatments, or even cures, for those diseases. They can identify treatments targeted specifically to the individual, treatments so specific to a person's DNA that they could one day reduce or even eliminate the incidence of harmful drug side effects.

Genes can also be used to design more nutritious and disease-resistant crops, and to create insects that spread a life-saving vaccine rather than life-threatening diseases such as malaria. Genes can be used to make animals more like us to provide organs for the thousands of people who now wait on transplant lists to get to the top of the list and to find a matching donor.

Although we have learned much about our genes over the last century, there is still so much more to know. Once scientists have sequenced all of the twenty-four human chromosomes and the more than 3 billion base pairs of DNA found in the human genome, they will have the instructions to a complete human being. But they will still need to learn how to read the instructions and decipher their meaning and how to use the instructions to improve the way we live.

The articles in this anthology chronicle the development of modern genetics and the breakthroughs that have

transformed our understanding of the science that may one day reshape our lives. The authors included in this anthology (both scientists and science journalists) highlight significant points in the evolution of twentieth- and twenty-first-century genetic research—from Charles Darwin (1809–1882) and Gregor Mendel (1822–1884) to Watson and Crick and finally to the many scientists of the Human Genome Project. They reveal both the great simplicity and the incredible complexity of the human genome. And they show us just how far we've come in our understanding of the gene and how much more we still need to learn. *—SW*