are our individual differences shaped by our differing genes? And how much by our environment—by every external influence, from maternal nutrition while in the womb to social support while nearing the tomb? To what extent are we formed by our upbringing? By our culture? By our gender? By our current circumstances? By people's reactions to our genetic dispositions? By our own choices and efforts? Modules 10, 11, and 12 tell the scientific story of how our genes (nature) and environments (nurture) together knit us.

MODULE 10

Behavior Genetics: Predicting Individual Differences

A Thousand Words Photography by Erica Comer

The nurture of nature Parents everywhere wonder: Will my baby grow up to be agreeable or aggressive? Successful or struggling at every step? What comes built in, and what is nurtured—and how? Research reveals that nature and nurture together shape our development—every step of the way.

"We share half our genes with the banana."
— Evolutionary biologist Robert May, president of Britain's Royal Society, 2001

"Your DNA and mine are 99.9 percent the same. . . . At the DNA level, we are clearly all part of one big worldwide family."
— Francis Collins, Human Genome Project director, 2007

LEARNING OBJECTIVE QUESTION LOQ 10-1 What are *chromosomes, DNA, genes,* and the human *genome*? How do behavior geneticists explain our individual differences?

So, if Beyoncé and JAY-Z's eldest daughter, Blue Ivy, grows up to be a popular recording artist, should we attribute her musical talent to her "superstar genes"? To her growing up in a musically rich environment? To high expectations? Such questions intrigue **behavior geneticists,** who study our differences and weigh the effects and the interplay of **heredity** and **environment.** Genetic, environmental + social explanations

Genes: Our Codes for Life

Behind the story of our body and its brain—surely the most awesome thing on our little planet—is the heredity that interacts with our experience to create both our universal nature and our individual and social diversity. On the eve of the twentieth century, few would have guessed that every cell nucleus in your body contains the genetic master code for your entire body. It's as if every room in Dubai Creek Tower (the world's tallest structure) contained a book detailing the architect's plans for the entire structure. The plans for your own book of life run to 46 chapters—23 donated by your mother's egg and 23 by your father's sperm. Each of these 46 chapters, called a **chromosome,** is composed of a coiled chain of the molecule **DNA (deoxyribonucleic acid). Genes,** small segments of the giant DNA molecules, form the words of those chapters (**FIGURE 10.1**). Altogether, you have some 20,000 genes, which are either active (*expressed*) or inactive. Environmental events "turn on" genes. When turned on, genes provide the code for creating *protein molecules,* our body's building blocks.

Genetically speaking, every other human is nearly our identical twin. Human **genome** researchers have discovered a common sequence within human DNA. This shared genetic profile is what makes us humans, rather than tulips, bananas, or chimpanzees.

Yet we aren't all that different from our chimpanzee cousins. At a genetic level, humans and chimpanzees are 96 percent identical (Mikkelsen et al., 2005). At "functionally important" DNA sites, this number reaches 99.4 percent (Wildman et al., 2003)! Yet that wee 0.6 percent difference matters. It took a human, Shakespeare, to do what a chimpanzee cannot—intricately weave 17,677 words into literary masterpieces.

Small differences matter among other species, too. Common chimpanzees and bonobos resemble each other in many ways. They should—their genomes differ by much less than 1 percent. But they display markedly differing behaviors. Chimpanzees are aggressive and male dominated. Bonobos are peaceable and female led.

The occasional variations found at particular gene sites in human DNA fascinate geneticists and psychologists. Slight person-to-person variations from the common pattern give clues to our uniqueness—why one person has a disability that another does not, why one person is tall and another short, why one is anxious and another calm. Should people use newly available gene-editing technologies to reduce their unborn children's risk of disease? Only 26 percent of Americans approve (Scheufele et al., 2017).

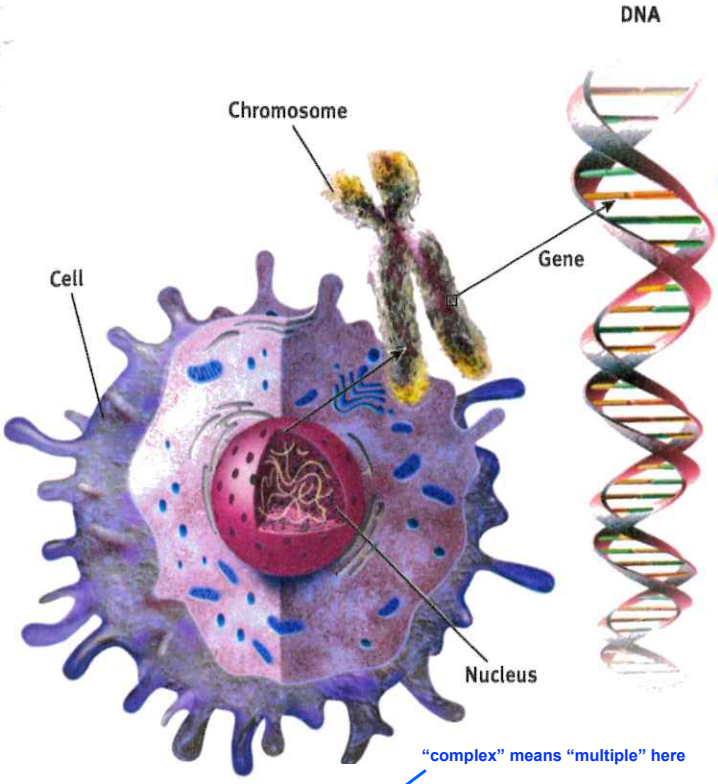

FIGURE 10.1
The life code The nucleus of every human cell contains chromosomes, each of which is made up of two strands of DNA connected in a double helix. Genes are DNA segments that, when expressed (turned on), direct the development of proteins that influence a person's individual development.

behavior genetics the study of the relative power and limits of genetic and environmental influences on behavior.

heredity the genetic transfer of characteristics from parents to offspring.

environment every nongenetic influence, from prenatal nutrition to the people and things around us.

chromosomes threadlike structures made of DNA molecules that contain the genes.

DNA (deoxyribonucleic acid) a complex molecule containing the genetic information that makes up the chromosomes.

genes the biochemical units of heredity that make up the chromosomes; small segments of DNA capable of synthesizing proteins.

genome the complete instructions for making an organism, consisting of all the genetic material in that organism's chromosomes.

"complex" means "multiple" here

Most of our traits have complex genetic roots. How tall you are, for example, reflects the size of your face, vertebrae, leg bones, and so forth—each of which may be influenced by different genes interacting with your specific environment. Traits such as intelligence, happiness, and aggressiveness are each similarly influenced by a whole orchestra of genes (Holden, 2008). Indeed, one of the big take-home findings of today's behavior genetics is that there is no single gene that predicts your smarts, sexual orientation, or personality. And gene analyses of more than 800,000 people have identified 269 genes associated with depression (Howard et al., 2019). Another study of 1.1 million people identified 1271 gene variations that together predicted about 12 percent of the differences in people's years of schooling (Lee et al., 2018). *The bottom line:* Our differing traits are *polygenetic*—they are influenced by "many genes of small effect" (Lee et al., 2018; Matoba et al., 2019; Plomin, 2018).

So, our many genes help explain both our shared human nature and our human diversity. But—another take-home finding—knowing our heredity tells only part of our story. To form us, environmental influences interact with our genetic predispositions.

Charles Sykes/AP Images

Nature or nurture or both?
When talent runs in families, as with Wynton Marsalis, Branford Marsalis, and Delfeayo Marsalis, how do heredity and environment together do their work?