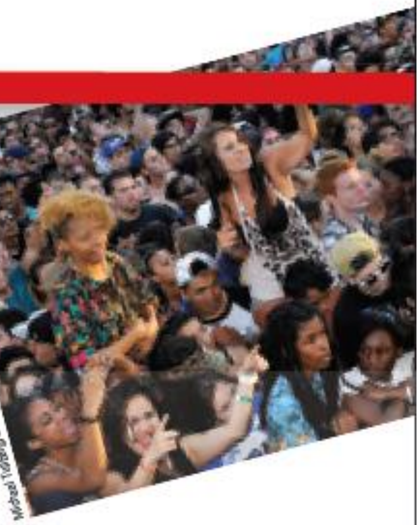
Module 14



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Behavior Genetics: Predicting Individual Differences

Module Learning Objectives

14-1 Define *genes*, and describe how behavior geneticists explain our individual differences.

14-2 Identify the potential uses of molecular genetics research.

14-3 Explain what is meant by heritability, and discuss how it relates to individuals and groups.

14-4 Discuss the interaction of heredity and environment.

Behind the story of our human brain—surely the most awesome thing on Earth—is the essence of our universal human attributes and our individual traits. What makes you *you?* In important ways, we are each unique. We look different. We sound different. We have varying personalities, interests, and cultural and family backgrounds.

We are also the leaves of one tree. Our human family shares not only a common biological heritage—cut us and we bleed—but also common behavioral tendencies. Our shared brain architecture predisposes us to sense the world, develop language, and feel hunger through identical mechanisms. Whether we live in the Arctic or the tropics, we prefer sweet tastes to sour. We divide the color spectrum into similar colors. And we feel drawn to behaviors that produce and protect offspring.

Our kinship appears in our social behaviors as well. Whether named Wong, Nkomo, Smith, or Gonzales, we start fearing strangers at about eight months, and as adults we prefer the company of those with attitudes and attributes similar to our own. Coming from different parts of the globe, we know how to read one another's smiles and frowns. As members of one species, we affiliate, conform, return favors, punish offenses, organize hierarchies of status, and grieve a child's death. A visitor from outer space could drop in anywhere and find humans dancing and feasting, singing and worshipping, playing sports and games, laughing and crying, living in families and forming groups. Taken together, such universal behaviors define our human nature.

What causes our striking diversity, and also our shared human nature? How much are human 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 current circumstances? By people's reactions to our genetic dispositions? This module and the next begin to tell the complex story of how our genes (nature) and environments (nurture) define us.

Courtesy of Kevin Feyen

The nurture of nature Parents everywhere wonder: Will my baby grow up to be peaceful or aggressive? Homely or attractive? 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.

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

environment every external 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; 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.

Genes: Our Codes for Life

14-1 What are genes, and how do behavior geneticists explain our individual differences?

If Jaden Agassi, son of tennis stars Andre Agassi and Steffi Graf, grows up to be a tennis star, should we attribute his superior talent to his Grand Slam genes? To his growing up in a tennis-rich environment? To high expectations? Such questions intrigue **behavior geneticists,** who study our differences and weigh the effects and interplay of heredity and **environment.**

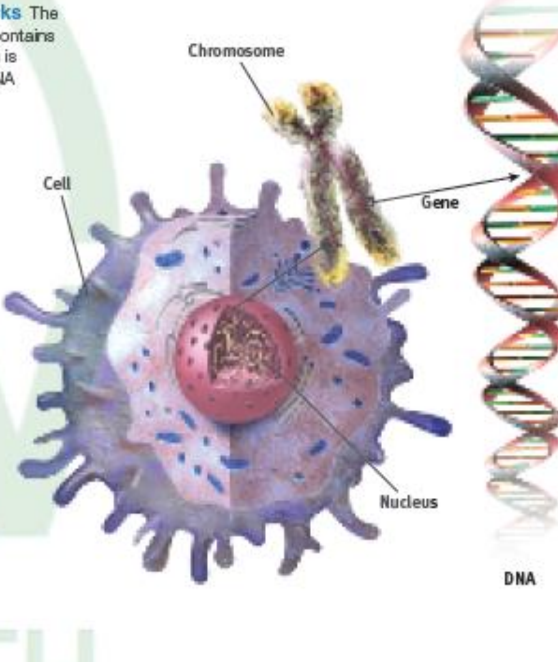
Barely more than a century ago, few would have guessed that every cell nucleus in your body contains the genetic master code for your entire body. It's as if every room in Dubai's Burj Khalifa (the world's tallest building) had a book containing the architect's plans for the entire structure. The plans 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 14.1**). All told, you have 20,000 to 25,000 genes. Genes can be either active *(expressed)* or inactive. Environmental events "turn on" genes, rather like hot water enabling a tea bag to express its flavor. When turned on, genes provide the code for creating *protein molecules,* our body's building blocks.

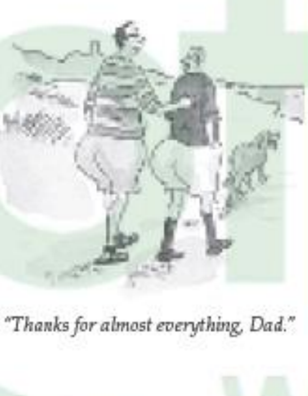
Genetically speaking, every other human is nearly your identical twin. Human **genome** researchers have discovered the common sequence within human DNA. It is this shared genetic profile that makes us humans, rather than chimpanzees or tulips.

Actually, we aren't all that different from our chimpanzee cousins; with them we share about 96 percent of our DNA sequence (Mikkelsen et al., 2005). At "functionally important" DNA sites, reported one molecular genetics team, the human-chimpanzee DNA similarity is 99.4 percent (Wildman et al., 2003). Yet that wee difference matters. Despite

"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

Figure 14.1
The human building blocks The nucleus of every human cell contains chromosomes, each of which is made up of two strands of DNA connected in a double helix.





"Thanks for almost everything, Dad."

some remarkable abilities, chimpanzees grunt. Shakespeare intricately wove 17,677 words to form his literary masterpieces.

Small differences matter among chimpanzees, too. Two species, common chimpanzees and bonobos, differ by much less than 1 percent of their genomes, yet they display markedly differing behaviors. Chimpanzees are aggressive and male dominated. Bonobos are peaceable and female led.

Geneticists and psychologists are interested in the occasional variations found at particular gene sites in human DNA. Slight person-to-person variations from the common pattern give clues to our uniqueness—why one person has a disease that another does not, why one person is short and another tall, why one is outgoing and another shy.

Most of our traits are influenced by many genes. 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 environment. Complex traits such as intelligence, happiness, and aggressiveness are similarly influenced by groups of genes. Thus our genetic predispositions—our genetically influenced traits—help explain both our shared human nature and our human diversity.

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

Twin and Adoption Studies

To scientifically tease apart the influences of environment and heredity, behavior geneticists would need to design two types of experiments. The first would control the home environment while varying heredity. The second would control heredity while varying the home environment. Such experiments with human infants would be unethical, but happily for our purposes, nature has done this work for us.

identical twins ***(monozygotic twins)*** twins who develop from a single fertilized egg that splits in two, creating two genetically identical organisms.

fraternal twins ***(dizygotic twins)*** twins who develop from separate fertilized eggs. They are genetically no closer than brothers and sisters, but they share a fetal environment.

Identical Versus Fraternal Twins

Identical *(monozygotic)* **twins** develop from a single fertilized egg that splits in two. Thus they are *genetically* identical—nature's own human clones (**FIGURE 14.2**). Indeed, they are clones who share not only the same genes but the same conception and uterus, and usually the same birth date and cultural history. Two slight qualifications:

- Although identical twins have the same genes, they don't always have the same *number of copies* of those genes. That helps explain why one twin may be more at risk for certain illnesses (Bruder et al., 2008).
- Most identical twins share a placenta during prenatal development, but one of every three sets has two separate placentas. One twin's placenta may provide slightly better nourishment, which may contribute to identical twin differences (Davis et al., 1995; Phelps et al., 1997; Sokol et al., 1995).

Fraternal *(dizygotic)* **twins** develop from separate fertilized eggs. As womb-mates, they share a fetal environment, but they are genetically no more similar than ordinary brothers and sisters.

Shared genes can translate into shared experiences. A person whose identical twin has Alzheimer's disease, for example, has a 60 percent risk of getting the disease; if the affected twin is fraternal, the risk is 30 percent (Plomin et al., 1997). To study the effects of genes and environments, hundreds of researchers have studied some 800,000 identical and fraternal twin pairs (Johnson et al., 2009).

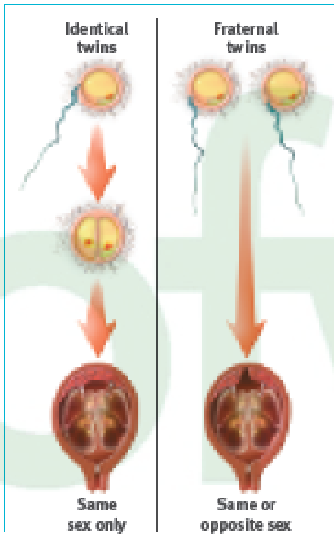


Figure 14.2
Same fertilized egg, same genes; different eggs, different genes Identical twins develop from a single fertilized egg, fraternal twins from two.



Ethel Wolvovitz/The Image Works; © Lee Snider / The Image Works; Bubbles Images/SuperStock

More twins Curiously, twinning rates vary by race. The rate among Caucasians is roughly twice that of Asians and half that of Africans. In Africa and Asia, most twins are identical. In Western countries, most twins are fraternal, and fraternal twins are increasing with the use of fertility drugs (Hall, 2003; Steinhauer, 1999).

Are identical twins, being genetic clones of each other, also behaviorally more similar than fraternal twins? Studies of thousands of twin pairs in Sweden, Finland, and Australia find that on both extraversion (outgoingness) and neuroticism (emotional instability), identical twins are much more similar than fraternal twins. If genes influence traits such as emotional instability, might they also influence the social effects of such traits? To find out, researchers studied divorce rates among 1500 same-sex, middle-aged twin pairs (McGue & Lykken, 1992). Their result: If you have a fraternal twin who has divorced, the odds of your divorcing are 1.6 times greater than if you have a not-divorced twin. If you have an identical twin who has divorced, the odds of your divorcing are 5.5 times greater. From such data, the researchers estimate that people's differing divorce risks are about 50 percent attributable to genetic factors.

Identical twins, more than fraternal twins, also report being treated alike. So, do their experiences rather than their genes account for their similarity? *No.* Studies have shown that identical twins whose parents treated them alike were not psychologically more alike than identical twins who were treated less similarly (Loehlin & Nichols, 1976). In explaining individual differences, genes matter.

Separated Twins

Imagine the following science fiction experiment: A mad scientist decides to separate identical twins at birth, then rear them in differing environments. Better yet, consider a *true* story:

On a chilly February morning in 1979, some time after divorcing his first wife, Linda, Jim Lewis awoke in his modest home next to his second wife, Betty. Determined that this marriage would work, Jim made a habit of leaving love notes to Betty around the house. As he lay in bed he thought about others he had loved, including his son, James Alan, and his faithful dog, Toy.

Jim was looking forward to spending part of the day in his basement woodworking shop, where he had put in many happy hours building furniture, picture frames, and other items, including a white bench now circling a tree in his front yard. Jim also liked to spend free time driving his Chevy, watching stock-car racing, and drinking Miller Lite beer.

Jim was basically healthy, except for occasional half-day migraine headaches and blood pressure that was a little high, perhaps related to his chain-smoking habit. He had become overweight a while back but had shed some of the pounds. Having undergone a vasectomy, he was done having children.

What was extraordinary about Jim Lewis, however, was that at that same moment (I am not making this up) there existed another man—also named Jim—for whom all these things (right down to the dog's name) were also true.[1] This other Jim—Jim Springer—just happened, 38 years earlier, to have been his fetal partner. Thirty-seven days after their birth, these genetically identical twins were separated, adopted by blue-collar families, and reared with no contact or knowledge of each other's whereabouts until the day Jim Lewis received a call from his genetic clone (who, having been told he had a twin, set out to find him).

FYI

Sweden has the world's largest national twin registry—140,000 living and dead twin pairs—which forms part of a massive registry of 600,000 twins currently being sampled in the world's largest twin study (Wheelwright, 2004; www.genomeutwin.org).

FYI

Twins Lorraine and Levinia Christmas, driving to deliver Christmas presents to each other near Flitcham, England, collided (Shepherd, 1997).

"In some domains it looks as though our identical twins reared apart are . . . just as similar as identical twins reared together. Now that's an amazing finding and I can assure you none of us would have expected that degree of similarity."
-Thomas Bouchard (1981)

[1] Actually, this description of the two Jims errs in one respect: Jim Lewis named his son James Alan. Jim Springer named his James Allan.

One month later, the brothers became the first twin pair tested by University of Minnesota psychologist Thomas Bouchard and his colleagues, beginning a study of separated twins that extends to the present (Holden, 1980a,b; Wright, 1998). Their voice intonations and inflections were so similar that, hearing a playback of an earlier interview, Jim Springer guessed "That's me." Wrong—it was his brother. Given tests measuring their personality, intelligence, heart rate, and brain waves, the Jim twins—despite 38 years of separation—were virtually as alike as the same person tested twice. Both married women named Dorothy Jane Scheckelburger. Okay, the last item is a joke. But as Judith Rich Harris (2006) notes, it is hardly weirder than some other reported similarities.

Aided by publicity in magazine and newspaper stories, Bouchard (2009) and his colleagues located and studied 74 pairs of identical twins reared apart. They continued to find similarities not only of tastes and physical attributes but also of personality (characteristic patterns of thinking, feeling, and acting), abilities, attitudes, interests, and even fears.

In Sweden, Nancy Pedersen and her co-workers (1988) identified 99 separated identical twin pairs and more than 200 separated fraternal twin pairs. Compared with equivalent samples of identical twins reared together, the separated identical twins had somewhat less identical personalities. Still, separated twins were more alike if genetically identical than if fraternal. And separation shortly after birth (rather than, say, at age 8) did not amplify their personality differences.

Stories of startling twin similarities do not impress Bouchard's critics, who remind us that "the plural of *anecdote* is not *data*." They contend that if any two strangers were to spend hours comparing their behaviors and life histories, they would probably discover many coincidental similarities. If researchers created a control group of biologically unrelated pairs of the same age, sex, and ethnicity, who had not grown up together but who were as similar to one another in economic and cultural background as are many of the separated twin pairs, wouldn't these pairs also exhibit striking similarities (Joseph, 2001)? Bouchard replies that separated fraternal twins do not exhibit similarities comparable to those of separated identical twins.

Even the more impressive data from personality assessments are clouded by the reunion of many of the separated twins some years before they were tested. Moreover, identical twins share an appearance, and the responses it evokes. Adoption agencies also tend to place separated twins in similar homes. Despite these criticisms, the striking twin-study results helped shift scientific thinking toward a greater appreciation of genetic influences.

FYI

Bouchard's famous twin research was, appropriately enough, conducted in Minneapolis, the "Twin City" (with St. Paul), and home to the Minnesota Twins baseball team.

FYI

Coincidences are not unique to twins. Patricia Kern of Colorado was born March 13, 1941, and named Patricia Ann Campbell. Patricia DiBiasi of Oregon also was born March 13, 1941, and named Patricia Ann Campbell. Both had fathers named Robert, worked as bookkeepers, and at the time of this comparison had children ages 21 and 19. Both studied cosmetology, enjoyed oil painting as a hobby, and married military men, within 11 days of each other. They are not genetically related. (From an AP report, May 2, 1983.)

St. Bonaventure University

The twin friars Julian and Adrian Reister—two "quiet, gentle souls"—both died of heart failure, at age 92, on the same day in 2011.

Biological Versus Adoptive Relatives

For behavior geneticists, nature's second real-life experiment—adoption—creates two groups: *genetic relatives* (biological parents and siblings) and *environmental relatives* (adoptive parents and siblings). For any given trait, we can therefore ask whether adopted children are more like their biological parents, who contributed their genes, or their adoptive parents, who contribute a home environment. While sharing that home environment, do adopted siblings also come to share traits?

The stunning finding from studies of hundreds of adoptive families is that people who grow up together, whether biologically related or not, do not much resemble one another in personality (McGue & Bouchard, 1998; Plomin, 2011; Rowe, 1990). In traits such as extraversion and agreeableness, adoptees are more similar to their biological parents than to their caregiving adoptive parents.

"We carry to our graves the essence of the zygote that was first us." -Mary Pipher, *Seeking Peace: Chronicles of the Worst Buddhist in the World*, 2009

The finding is important enough to bear repeating: *The environment shared by a family's children has virtually no discernible impact on their personalities.* Two adopted children reared in the same home are no more likely to share personality traits with each other than with the child down the block. Heredity shapes other primates' personalities, too. Macaque monkeys raised by foster mothers exhibit social behaviors that resemble their biological, rather than foster, mothers (Maestripieri, 2003). Add all this to the similarity of identical twins, whether they grow up together or apart, and the effect of a shared rearing environment seems shockingly modest.

"Mom may be holding a full house while Dad has a straight flush, yet when Junior gets a random half of each of their cards his poker hand may be a loser." -David Lykken (2001)

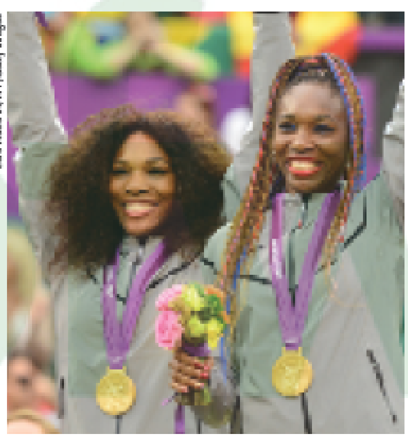
What we have here is perhaps "the most important puzzle in the history of psychology," contended Steven Pinker (2002): *Why are children in the same family so different?* Why does shared family environment have so little effect on children's personalities? Is it because each sibling experiences unique peer influences and life events? Because sibling relationships ricochet off each other, amplifying their differences? Because siblings—despite sharing half their genes—have very different combinations of genes and may evoke very different kinds of parenting? Such questions fuel behavior geneticists' curiosity.

FYI

The greater uniformity of adoptive homes—mostly healthy, nurturing homes—helps explain the lack of striking differences when comparing child outcomes of different adoptive homes (Stoolmiller, 1999).

The minimal shared-environment effect does not mean that adoptive parenting is a fruitless venture. The genetic leash may limit the family environment's influence on personality, but parents do influence their children's attitudes, values, manners, faith, and politics (Reifman & Cleveland, 2007). A pair of adopted children or identical twins *will*, especially during adolescence, have more similar religious beliefs if reared together (Koenig et al., 2005). Parenting matters!

Moreover, in adoptive homes, child neglect and abuse and even parental divorce are rare. (Adoptive parents are carefully screened; natural parents are not.) So it is not surprising that, despite a somewhat greater risk of psychological disorder, most adopted children thrive, especially when adopted as infants (Loehlin et al., 2007; van IJzendoorn & Juffer, 2006; Wierzbicki, 1993). Seven in eight report feeling strongly attached to one or both adoptive parents. As children of self-giving parents, they grow up to be more self-giving and altruistic than average (Sharma et al., 1998). Many score higher than their biological parents on intelligence tests, and most grow into happier and more stable adults. In one Swedish study, infant adoptees grew up with fewer problems than were experienced by children whose biological mothers had initially registered them for adoption but then decided to raise the children themselves (Bohman & Sigvardsson, 1990). Regardless of personality differences between parents and their adoptees, most children benefit from adoption.



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Nature or nurture or both? When talent runs in families, as with the Williams sisters for tennis, how do heredity and environment together do their work?

The New Frontier: Molecular Genetics

14-2 What is the promise of molecular genetics research?

Behavior geneticists have progressed beyond asking, "Do genes influence behavior?" The new frontier of behavior-genetics research draws on "bottom-up" **molecular genetics** as it seeks to identify *specific genes* influencing behavior.

molecular genetics the subfield of biology that studies the molecular structure and function of genes.

As we have already seen, most human traits are influenced by teams of genes. For example, twin and adoption studies tell us that heredity influences body weight, but there is no single "obesity gene." More likely, some genes influence how quickly the stomach tells the brain, "I'm full." Others might dictate how much fuel the muscles need, how many calories are burned off by fidgeting, and how efficiently the body converts extra calories into fat (Vogel, 1999). Given that genes typically are not solo players, a goal of *molecular behavior genetics* is to find some of the many genes that together orchestrate traits such as body weight, sexual orientation, and extraversion (Holden, 2008; Tsankova et al., 2007).

Genetic tests can now reveal at-risk populations for many dozens of diseases. The search continues in labs worldwide, where molecular geneticists are teaming with psychologists to pinpoint genes that put people at risk for such genetically influenced disorders as learning disorder, depression, schizophrenia, and alcohol use disorder. (In Module 67, for example, we will take note of a worldwide research effort to sleuth the genes that make people vulnerable to the emotional swings of bipolar disorder, formerly called manic-depressive disorder.) To tease out the implicated genes, molecular behavior geneticists find families that have had the disorder across several generations. They draw blood or take cheek swabs from both affected and unaffected family members. Then they examine their DNA, looking for differences. "The most powerful potential for DNA," note Robert Plomin and John Crabbe (2000), "is to predict risk so that steps can be taken to prevent problems before they happen."

Aided by inexpensive DNA-scanning techniques, medical personnel are becoming able to give would-be parents a readout on how their fetus' genes differ from the normal pattern and what this might mean. With this benefit come risks. Might labeling a fetus "at risk for a learning disorder" lead to discrimination? Prenatal screening poses ethical dilemmas. In China and India, where boys are highly valued, testing for an offspring's sex has enabled selective abortions resulting in millions—yes, millions—of "missing women."

Assuming it were possible, should prospective parents take their eggs and sperm to a genetics lab for screening before combining them to produce an embryo? Should we enable parents to screen their fertilized eggs for health—and for brains or beauty? Progress is a double-edged sword, raising both hopeful possibilities and difficult problems. By selecting out certain traits, we may deprive ourselves of future Handels and van Goghs, Churchills and Lincolns, Tolstoys and Dickinsons—troubled people all.

"I thought that sperm-bank donors remained anonymous."

Heritability

14-3 What is heritability, and how does it relate to individuals and groups?

Using twin and adoption studies, behavior geneticists can mathematically estimate the **heritability** of a trait—the extent to which variation among individuals can be attributed to their differing genes. As Modules 63 and 64 will emphasize, if the heritability of intelligence is, say, 50 percent, this does *not* mean that *your* intelligence is 50 percent genetic. (The heritability of height is 90 percent, but this does not mean that a 60-inch-tall woman can credit

heritability the proportion of variation among individuals that we can attribute to genes. The heritability of a trait may vary, depending on the range of populations and environments studied.

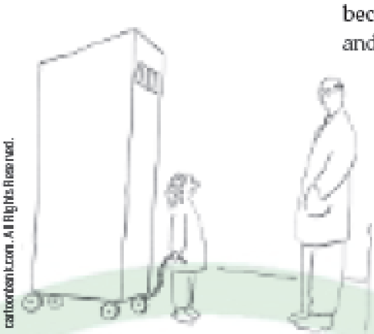
AP® Exam Tip

Heritability is likely to show up on the AP® exam because it's confusing. The key thing to remember is that heritability refers to variation within a group. It does not refer to the impact of nature on an individual. Be clear on both what it is and what it isn't.

her genes for 54 inches and her environment for the other 6 inches.) Rather, it means that genetic influence explains 50 percent of the observed *variation among people*. This point is so often misunderstood that I repeat: We can never say what percentage of an *individual's* personality or intelligence is inherited. It makes no sense to say that your personality is due *x* percent to your heredity and *y* percent to your environment. Heritability refers instead to the extent to which *differences among people* are attributable to genes.

Even this conclusion must be qualified, because heritability can vary from study to study. Consider humorist Mark Twain's (1835–1910) fantasy of raising boys in barrels to age 12, feeding them through a hole. If we were to follow his suggestion, the boys would all emerge with lower-than-normal intelligence scores at age 12. Yet, given their equal environments, their test score differences could be explained only by their heredity. In this case, heritability—differences due to genes—would be near 100 percent.

As environments become more similar, heredity as a source of differences necessarily becomes more important. If all schools were of uniform quality, all families equally loving, and all neighborhoods equally healthy, then heritability would *increase* (because differences due to environment would *decrease*). At the other extreme, if all people had similar heredities but were raised in drastically different environments (some in barrels, some in luxury homes), heritability would be much lower.



"The title of my science project is 'My Little Brother: Nature or Nurture.'"

Can we extend this thinking to differences between groups? If genetic influences help explain individual diversity in traits such as aggressiveness, for example, can the same be said of group differences between men and women, or between people of different races? Not necessarily. Individual differences in height and weight, for example, are highly heritable; yet nutritional rather than genetic influences explain why, as a group, today's adults are taller and heavier than those of a century ago. The two groups differ, but not because human genes have changed in a mere century's eyeblink of time. Although height is 90 percent heritable, South Koreans, with their better diets, average six inches taller than North Koreans, who come from the same genetic stock (Johnson et al., 2009).

As with height and weight, so with personality and intelligence scores: Heritable individual differences need not imply heritable group differences. If some individuals are genetically disposed to be more aggressive than others, that needn't explain why some groups are more aggressive than others. Putting people in a new social context can change their aggressiveness. Today's peaceful Scandinavians carry many genes inherited from their Viking warrior ancestors.

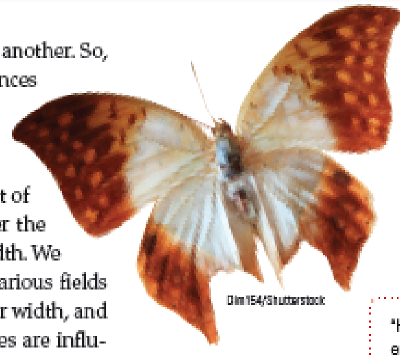
Gene-Environment Interaction

14-4 How do heredity and environment work together?

Among our similarities, the most important—the behavioral hallmark of our species—is our enormous adaptive capacity. Some human traits, such as having two eyes, develop the same in virtually every environment. But other traits are expressed only in particular environments. Go barefoot for a summer and you will develop toughened, callused feet—a biological adaptation to friction. Meanwhile, your shod neighbor will remain a tenderfoot. The difference between the two of you is, of course, an effect of environment. But it is also the product of a biological mechanism—adaptation. Our shared biology enables our developed diversity (Buss, 1991).

"Men's natures are alike; it is their habits that carry them far apart." -Confucius, *Analects*, 500 b.c.e.

An analogy may help: Genes and environment—nature and nurture—work together like two hands clapping. Genes are *self-regulating*. Rather than acting as blueprints that lead to the same result no matter the context, genes react. An African butterfly that is green in summer turns brown in fall, thanks to a temperature-controlled genetic switch. The genes that produce brown in one situation produce green in another. So, too, people with identical genes but differing experiences will have similar but not identical minds. One twin may fall in love with someone quite different from the co-twin's love.



Dim154/Shutterstock

Asking whether our personality is more a product of our genes or our environment is like asking whether the area of a field is more the result of its length or its width. We could, however, ask whether the differing areas of various fields are more the result of *differences* in their length or their width, and also whether person-to-person personality differences are influenced more by nature or nurture.

"Heredity deals the cards; environment plays the hand." -Psychologist Charles L. Brewer (1990)

To say that genes and experience are *both* important is true. But more precisely, they **interact.** Imagine two babies, one genetically predisposed to be attractive, sociable, and easygoing, the other less so. Assume further that the first baby attracts more affectionate and stimulating care and so develops into a warmer and more outgoing person. As the two children grow older, the more naturally outgoing child more often seeks activities and friends that encourage further social confidence.

interaction the interplay that occurs when the effect of one factor (such as environment) depends on another factor (such as heredity).

epigenetics the study of environmental influences on gene expression that occur without a DNA change.

What has caused their resulting personality differences? Neither heredity nor experience dances alone. Environments trigger gene activity. And our genetically influenced traits *evoke* significant responses in others. Thus, a child's impulsivity and aggression may evoke an angry response from a teacher who reacts warmly to the child's model classmates. Parents, too, may treat their own children differently; one child elicits punishment, another does not. In such cases, the child's nature and the parents' nurture interact. Neither operates apart from the other. Gene and scene dance together.

Evocative interactions may help explain why identical twins reared in different families recall their parents' warmth as remarkably similar—almost as similar as if they had had the same parents (Plomin et al., 1988, 1991, 1994). Fraternal twins have more differing recollections of their early family life—even if reared in the same family! "Children experience us as different parents, depending on their own qualities," noted Sandra Scarr (1990). Moreover, a selection effect may be at work. As we grow older, we select environments well suited to our natures.

Recall that genes can be either active (expressed, as the hot water activates the tea bag) or inactive. A new field, **epigenetics** (meaning "in addition to" or "above and beyond" genetics), is studying the molecular mechanisms by which environments trigger genetic expression. Although genes have the potential to influence development, environmental triggers can switch them on or off, much as your computer's software directs your printer. One such *epigenetic mark* is an organic methyl molecule attached to part of a DNA strand (**FIGURE 14.3**). It instructs the cell to ignore any gene present in that DNA segment, thereby preventing the DNA from producing the proteins coded by that gene.

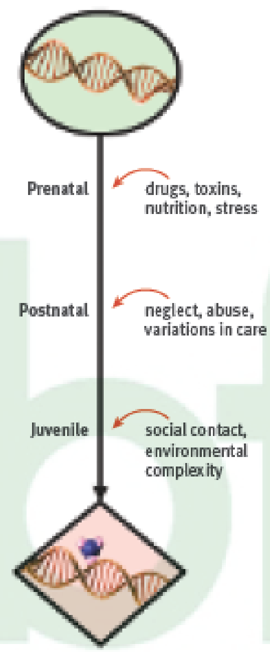


Figure 14.3
Epigenetics influences gene expression Life experiences beginning in the womb lay down *epigenetic marks*—often organic methyl molecules—that can block the expression of any gene in the associated DNA segment (from Champagne, 2010).

Environmental factors such as diet, drugs, and stress can affect the epigenetic molecules that regulate gene expression. In one experiment, infant rats deprived of their mothers' normal licking had more molecules that blocked

Gene-environment interaction Biological appearances have social consequences. People respond differently to recording artist Nicki Minaj and concert violinist Hilary Hahn.

access to the "on" switch for developing the brain's stress hormone receptors. When stressed, the animals had more free-floating stress hormones and were more stressed out (Champagne et al., 2003; Champagne & Mashoodh, 2009). Child abuse may similarly affect its victims. Humans who have committed suicide exhibit the same epigenetic effect if they had suffered a history of child abuse (McGowan et al., 2009). Researchers now wonder if epigenetics might help solve some scientific mysteries, such as why only one member of an identical twin pair may develop a genetically influenced mental disorder, and how experience leaves its fingerprints in our brains.

So, from conception onward, we are the product of a cascade of interactions between our genetic predispositions and our surrounding environments (McGue, 2010). Our genes affect how people react to and influence us. Biological appearances have social consequences. So, forget nature *versus* nurture; think nature *via* nurture.

Before You Move On

▶ ASK YOURSELF

Would you want genetic tests on your unborn offspring? What would you do if you knew your child would be destined for hemophilia (a medical condition that interferes with blood clotting)? A specific learning disorder? A high risk of depression? Do you think society would benefit or lose if such embryos were aborted?

▶ TEST YOURSELF

What is *heritability*?

Answers to the Test Yourself questions can be found in Appendix E at the end of the book.

Module 14 Review

14-1 What are genes, and how do behavior geneticists explain our individual differences?

- *Genes* are the biochemical units of heredity that make up *chromosomes*, the threadlike coils of *DNA*.
- When genes are "turned on" (expressed), they provide the code for creating the proteins that form our body's building blocks.
- Most human traits are influenced by many genes acting together.
- *Behavior geneticists* seek to quantify genetic and *environmental* influences on our traits, in part through studies of *identical* (monozygotic) *twins, fraternal* (dizygotic) *twins*, and adoptive families.
- Shared family environments have little effect on personality, and the stability of personality suggests a genetic predisposition.

14-2 What is the promise of molecular genetics research?

- *Molecular geneticists* study the molecular structure and function of genes, including those that affect behavior.
- Psychologists and molecular geneticists are cooperating to identify specific genes—or more often, teams of genes—that put people at risk for disorders.

14-3 What is heritability, and how does it relate to individuals and groups?

- *Heritability* describes the extent to which variation among members of a group can be attributed to genes.
- Heritable individual differences (in traits such as height or intelligence) do not necessarily imply heritable group differences. Genes mostly explain why some people are taller than others, but not why people are taller today than they were a century ago.

14-4 How do heredity and environment work together?

- Our genetic predispositions and our surrounding environments *interact*. Environments can trigger gene activity, and genetically influenced traits can evoke responses from others.
- The field of *epigenetics* studies the influences on gene expression that occur without changes in DNA.

Multiple-Choice Questions

1. Human genome (DNA) researchers have discovered that

a. chimpanzees are completely different than humans, sharing a small DNA sequence percentage.
b. the occasional variations found at particular gene sites in human DNA are of no interest to science.
c. many genes do not influence most of our traits.
d. nearly every other human is your genetically identical twin.
e. genetic predispositions do not help explain our shared human nature and our human diversity.

2. One reason that identical twins might show slight differences at birth is

a. they did not develop from a single fertilized egg.
b. one twin's placenta may have provided slightly better nourishment.
c. they develop from different sperm.
d. one twin gestated much longer in the uterus than the other.
e. their relative positions in the uterus.

3. Generally speaking, heritability is the extent to which

a. differences among people are accounted for by genes.
b. an individual's specific traits are due to genes or the environment.
c. differences among people are due to the environment.
d. differences among people are due to their cultural heritage.
e. an individual's height is related to the height of his or her parents.

4. Which of the following is most closely associated with the idea of epigenetics?

a. Eye color
b. Gene display based on environmental factors
c. IQ as a function of educational experiences
d. Height at birth
e. Shoe size

5. Which of the following is an example of gene-environment interaction?

a. Yeh Lin experiences flushing syndrome, which mostly occurs in those of Asian heritage.
b. Alfonso gets food poisoning from eating undercooked meat.
c. Ted gets diabetes, which runs in his family, because he eats too much sugary food.
d. Samantha has a food allergy to shellfish.
e. Jordan has an autoimmune disorder that causes him to lose hair.

Practice FRQs

1. Explain the two positions in the nature–nurture debate.

Answer (2 points)

2. What does it mean to say that the heritability of height is 90 percent? What does that tell us about the contribution of genetics to any one person's height?