CHAPTER THREE

GENES, ENVIRONMENT AND BEHAVIOUR

CHAPTER OUTLINE

The interaction of nature and circumstances is very close, and it is impossible to separate them with precision . . . (but) . . . we are perfectly justified in attempting to appraise their relative importance.

SIR FRANCIS GALTON

After being born in Trinidad, Oskar Stohr and Jack Yufe were raised rather differently. Jack remained in the Caribbean with his father, and was brought up as a Jew. He even lived for a time in Israel. Oskar, on the other hand, was brought up by his grandmother in Germany, as a Catholic and a Nazi, joining the Hitler Youth as a boy. Two different environments could hardly be imagined, but the similarities when they were reunited in their sixties were quite astonishing. They found that both kept elastic bands on their wrists, both had a habit of falling asleep in front of the television, both enjoyed spicy food, both enjoyed dipping buttered toast in their coffee and both had the habit of flushing the toilet before using it. Other twins also show amazing similarities even though not raised in the same environment.

Jim Lewis and Jim Springer first met in 1979 after 39 years of being separated. They had grown into adulthood oblivious to the existence of one another until Jim Lewis felt a need to learn more about his family of origin. After years of searching through court records, Jim Lewis finally found his twin brother, Jim Springer. When they met, Lewis described it as 'like looking into a mirror', but the similarities went far beyond their nearly identical appearance. When they shared their stories, they found that both had childhood dogs named Toy. Both had been nail biters and fretful sleepers, suffered from migraine headaches and had high blood pressure. Both Jims had married women named Linda, had been divorced and married second wives named Betty. Lewis named his first son James Allen, Springer named his James Alan. For years, they both had taken holidays at the same Florida beach. Both of the Jims worked as sheriff's deputies. They both drank Miller Lite, smoked Salem cigarettes, loved stock car racing, hated baseball, left regular love notes to their wives, made doll's furniture in their basements, and had constructed unusual circular benches around the trees in their backyards (see Fig. 3.1).

FIGURE 3.1

Jim Springer and Jim Lewis are identical twins who were separated when four weeks old and raised in different families. When reunited in adulthood, they showed striking similarities in personality, interests and behaviour.

Jim Springer and Jim Lewis became the first participants in a landmark University of Minnesota study of twins who had been separated early in life and reared apart. The Minnesota researchers found that the twins' habits, facial expressions, brainwaves, heartbeats and handwriting were nearly identical. When given a series of psychological tests, they were strikingly similar in intelligence and personality traits (Tellegen et al., 1988).

How can we explain the behavioural similarities in Jim Springer and Jim Lewis? In fact, they had been brought up quite differently; the Minnesota researchers found that the adoptive families of the Jim twins differed in important ways. What the Jims did have in common, however, were their identical genes. Although it is always possible that the behavioural commonalities of the Jim twins were coincidental, the Minnesota researchers found that other identical-twin pairs separated early in life also showed striking similarities. For example, when a pair of twin housewives from England met one another in Minneapolis for their week-long battery of psychological and medical tests, they found to their amazement that each was wearing seven rings, two bracelets on one wrist, and a watch and bracelet on the other. Whether raised together or apart, the identical twins were far more similar in personality and intelligence test scores than were siblings (including non-identical twins) raised in the same families (Tellegen et al., 1988). For psychologists, the connections between the twins' biological and behavioural similarities raise fascinating questions about factors that underlie human development.

It has been said that each of us is (1) what all humans are, (2) what some other humans are, and (3) what no other human in the history of the world has been, is or will be (Kluckhohn and Murray, 1953). In this chapter we examine important biological and environmental factors that produce the behavioural commonalities and differences among humans. First, we examine the role of the genes passed on to you at conception by your parents. Next, we explore how learning helps you adapt to your environment and how it is related to culture and evolution. We see that genetic and environmental factors interact to influence many of your psychological characteristics, including intelligence and personality. Finally, we explore the role of evolutionary forces that, millions of years before your birth, helped forge some of what you are today. We will see that biological and environmental factors interacted in complex ways, setting into place the pieces of the puzzle that is the human being and helping to account for both our similarities and our differences.

As we see throughout the book, this biological level of analysis provides us with key insights into behaviour and its causes. The knowledge gained in this chapter will give you the background needed to understand many behaviours in the chapters that follow.

GENETIC INFLUENCES ON BEHAVIOUR

From antiquity, humans have wondered how physical characteristics are transmitted from parents to their offspring. The answer was provided in the 1860s by Gregor Mendel (see Bateson, 1909), an Austrian monk trained in both physics and plant physiology. Mendel, renowned as a plant breeder, was fascinated with the variations he saw in plants of the same species. For example, the garden pea can have either white or purple flowers, yellow or green seeds, wrinkled or smooth skins, and different pod shapes (Fig. 3.2). Best of all from his research perspective, pea plants (which normally fertilize themselves) could be artificially cross-fertilized to combine the features of plants that differed in physical characteristics. In a series of elegantly controlled experiments, Mendel did exactly that, carefully recording the features of the resulting offspring. His beautifully conducted experiments showed that heredity must involve the passing on of specific organic factors, not a simple blending of the parents' characteristics. For example, if he fertilized a plant with purple flowers with pollen from a white-flowered plant, he did not get offspring with light purple flowers, but various percentages of purple and white-flowered plants. Moreover, these specific

FIGURE 3.2

The elegant experiments performed by Gregor Mendel revolutionized scientific thinking and spurred the development of the science of genetics. His research was done on the inheritance of physical characteristics in garden peas.

Focus 3.1

Differentiate between genotype and phenotype. How do genes regulate biological structures and functions?

genotype
the specific genetic make-up of the individual

phenotype
the individual's observable characteristics

chromosome
a double-stranded and tightly coiled molecule of deoxyribonucleic acid (DNA)

genes
the biological units of heredity

factors might produce visible characteristics in the offspring, or they might simply be carried for possible transmission to another generation. In any case, Mendel showed that in the humble pea plant, as in humans, the offspring of one set of parents do not all inherit the same traits, as is evident in the differences we see among brothers and sisters.

Early in the twentieth century, geneticists made the important distinction between **genotype**, the specific genetic make-up of the individual, and **phenotype**, the individual's observable characteristics. A person's genotype is like the commands in a computer software program. At a biological level, genes direct the process of development by programming the formation of protein molecules, which can vary in an infinite fashion. Some of the genes' directives are used on one occasion, some on another. Some are never used at all, either because they are contradicted by other genetic directives or because the environment never calls them forth. For example, geneticists discovered that chickens have retained the genetic code for teeth (Kollar and Fisher, 1980). Yet because the code is prevented from being phenotypically expressed (converted into a particular protein), there is not a chicken anywhere that can sink its teeth into a postal worker. Genotype is present from conception, but phenotype can be affected both by other genes and by the environment. Thus, genotype is like the software commands in your word processing program that allow you to type an email; phenotype is like the content of the email that appears on your computer screen.

CHROMOSOMES AND GENES

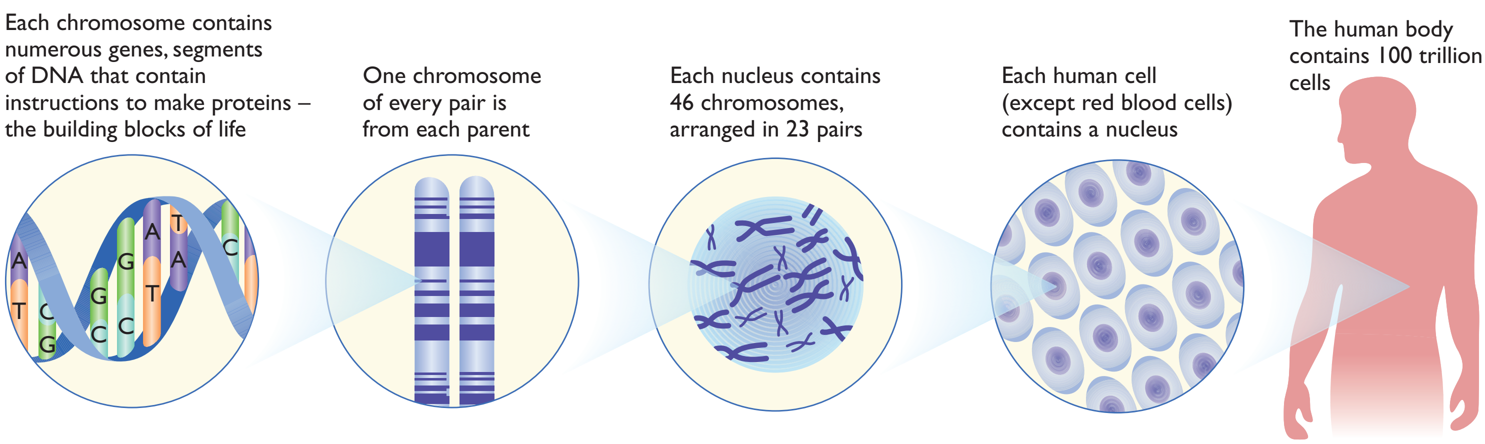
What exactly are Mendel's 'organic factors' and how are they transmitted from parents to offspring? The egg cell from the mother and sperm cell from the father carry within their nuclei the material of heredity in the form of rod-like units called *chromosomes*. A **chromosome** is a double-stranded and tightly coiled molecule of deoxyribonucleic acid (DNA). All of the information of heredity is encoded in the combinations of four chemical bases – adenine, thymine, guanine and cytosine – that occur throughout the chromosome. Within each DNA molecule, the sequence of the four letters of the DNA alphabet – A, T, G and C – creates the specific commands for every feature and function of your body. Human DNA has about 3 billion chemical base pairs, arranged as A-T or G-C units (Human Genome Project, 2007). The ordering of 99.9 per cent of these bases is the same in all people.

The DNA portion of the chromosome carries the **genes**, the biological units of heredity (Fig. 3.3). The average gene has about 3000 ATGC base pairs, but sizes vary greatly; the largest gene has 2.4 million bases. Each gene carries the ATGC codes for manufacturing specific proteins, as well as the codes for when and where in the body they will be made. These proteins can take many forms and functions, and they underlie every bodily structure and chemical process. It is estimated that about half of all genes target brain structure and functions (Kolb and Whishaw, 2003). Every moment of every day, the strands of DNA silently transmit their detailed instructions for cellular functioning.

FIGURE 3.3

The ladder of life.

Chromosomes consist of two long, twisted strands of DNA, the chemical that carries genetic information. With the exception of red blood cells, every cell in the body carries within its nucleus 23 pairs of chromosomes, each containing numerous genes that regulate every aspect of cellular functioning.



With one exception, every cell with a nucleus in the human body has 46 chromosomes. The exception is the *sex cell* (the egg or sperm), which has only 23. At conception, the 23 chromosomes from the egg combine with the 23 corresponding chromosomes from the sperm to form a new cell, the *zygote*, containing 46 chromosomes. Within each chromosome, the corresponding genes received from each parent occur in matched pairs. Every cell nucleus in your body contains the genetic code for your entire body, as if each house in your community contained the architect's plans for every building and road in the entire city.

Dominant, Recessive and Polygenic Effects

Alternative forms of a gene that produce different characteristics are called **alleles**. Thus, there is an allele that produces blue eyes and a different one that produces brown eyes. However, genotype and phenotype are not identical because some genes are dominant and some are recessive. If a gene in the pair received from both the mother and father is **dominant**, the particular characteristic that it controls will be displayed. If, however, a gene received from one parent is **recessive**, the characteristic will not show up unless the partner gene inherited from the other parent is also recessive. In humans, for example, brown eyes are dominant over blue eyes. A child will have blue eyes only if both parents have contributed recessive genes for blue eyes. If a child inherits a dominant gene for brown eyes from one parent and a recessive gene for blue eyes from the other, he will have brown eyes and the blue-eyed trait will remain hidden in his genotype. Eventually, the brown-eyed child may pass the recessive gene for blue eyes to his own offspring.

In a great many instances, a number of gene pairs combine their influences to create a single pheno-typic trait. This is known as **polygenic transmission**, and it complicates the straightforward picture that would occur if all characteristics were determined by one pair of genes. It also magnifies the number of possible variations in a trait that can occur. Despite the fact that about 99.9 per cent of human genes are identical among people, it is estimated that the union of sperm and egg can result in about 70 trillion potential genotypes, accounting for the great diversity of characteristics that occurs even among siblings.

The Human Genome

At present, our knowledge of phenotypes greatly exceeds our understanding of the underlying genotype, but that may soon change. In 1990, geneticists began the Human Genome Project, a co-ordinated effort to map the DNA, including all the genes, of the human organism. The genetic structure in every one of the 23 chromosome pairs has now been mapped by methods that allow the investigators to literally disassemble the genes on each chromosome and study their specific sequence of bases (A, T, G and C; see Fig. 3.3).

The first results of the genome project provided a surprise: The human genome consists of approximately 25 000 genes rather than the 100 000 previously estimated (Human Genome Project, 2007). That result told geneticists that gene interactions are even more complex than formerly believed and that it is highly unlikely that a single gene could account for a complex problem such as anorexia or schizophrenia. Even given this reduced number of genes, the 3.1 billion ATGC combinations in the entire human genome, if printed consecutively, would add about 150 000 pages to this book.

The 'book of life' revealed by the Human Genome Project has given us greater knowledge of which specific genes or gene combinations are involved in normal and abnormal characteristics (McGuffin et al., 2005). The location and structure of more than 80 genes that contribute to hereditary diseases have already been identified through gene mapping (Human Genome Project, 2007). On another front, behavioural scientists are exploring the gene combinations that underlie behaviour and, in some cases, are modifying those genes.

alleles
alternative forms of a gene that produce different characteristics

dominant
the particular characteristic that it controls will be displayed

recessive
the characteristic will not show up unless the partner gene inherited from the other parent is also recessive

Focus 3.2
Describe dominant, recessive and polygenic influences on phenotype.

polygenic transmission
when a number of gene pairs combine their influences to create a single phenotypic trait

A Genetic Map of the Brain

The mouse's brain is 99 per cent identical with the human brain and is therefore frequently used by neuroscientists to study human brain function. Using a robotic system to analyse 16 000 paper-thin brain slices per week, scientists have determined where in the brain 21 000 genes are turned on, or expressed, and a genetic atlas of the brain that is now available to all scientists online. (You can view the atlas at www.brain-map.org.) Almost every cell in the mouse body contains the full genotype. What a particular cell will become and how it will function is determined by which genes are switched on, so that a liver cell will look and function differently than will a skin cell, or a brain cell. The Allen Institute researchers discovered that about 80 per cent of all mouse genes are switched on somewhere in the brain, and that there are probably more cell types within the brain than in all the other organs of the body combined (Allen Institute for Brain Science, 2006). Using human cadaver brains and bits of living tissue removed by brain surgeons during tumour removal or aneurism repair, researchers next plan to develop a genetic map of the human cerebral cortex, the seat of our higher mental functions. Knowing where and how genes are switched on in the brain will provide new insights on both normal brain functions and diseases of the brain, and may herald the development of revolutionary new treatment and prevention techniques.

BEHAVIOURAL GENETICS

behavioural genetics
how heredity and environmental factors influence psychological characteristics

The activities of genes lie behind every structure and process in the body, and behaviour reflects a continuous interplay between a biological being and the environment in which it operates. Researchers in the field of **behavioural genetics** study how heredity and environmental factors influence psychological characteristics. In contrast to evolutionary psychologists who are interested in the genetic commonalities among people, behavioural geneticists try to determine the relative influence of genetic and environmental factors in accounting for individual differences in behaviour. For example, a behavioural geneticist might ask, 'How important are genetic factors in aggression, intelligence, personality characteristics and various types of psychological disorders?'

The degree of relatedness to one another tells us how genetically similar people are. Recall that children get half of their genetic material from each parent. Thus the probability of sharing any particular gene with one of your parents is 50 per cent, or .50. If you have brothers and sisters, you also have a .50 probability of sharing the same gene with each of them, since they get their genetic material from the same parents. Of course, as we have seen, if you are an identical twin, you have a 1.00 probability of sharing any particular gene with your twin. And what about a grandparent? Here, the probability of a shared gene is .25 because, for example, your maternal grandmother passed half of her genes on to your mother, who passed half of hers on to you. Thus the likelihood that you inherited a specific gene from your grandmother is .50 × 50, or .25. The probability of sharing a gene is also .25 for half-siblings, who share half of their genes with the common biological parent but none with the other parent. If you have a first cousin, you share 12.5 of your genes with him or her. Theoretically, an adopted child differs genetically from his or her adoptive parents, and the same is true for unrelated people. These facts about genetic similarity give us a basis for studying the role of genetic factors in physical and behavioural characteristics. If a characteristic has higher **concordance**, or co-occurrence, in people who are more closely related to one another, this points to a possible genetic contribution, particularly if the people have lived in different environments.

concordance
co-occurrence

Adoption and Twin Studies

Knowing the level of genetic similarity among family and kin provides a basis for estimating the relative contributions of heredity and environment to a physical or psychological characteristic. As discussed earlier, family members and relatives differ in the percentages of genes they share. Many studies have shown that the more similar people are genetically, the more similar they are likely to be psychologically, although this level of similarity differs depending on the characteristic in question.

One research method used to estimate the influence of genetic factors is the **adoption study**, in which people who were adopted early in life are compared on some characteristic with both their biological parents, with whom they share genetic endowment, and with their adoptive parents, with whom they share no genes. If adopted people are more similar to a biological parent (with whom they share 50 per cent of their genes) than to an adoptive parent (with whom they share a common environment but no genes), a genetic influence on that trait is indicated. If they are more similar to their adoptive parents, environmental factors are judged to be more important for that particular characteristic.

In one such study, Kety and co-workers (1978) identified adoptees who were diagnosed with schizophrenia in adulthood. They then examined the backgrounds of the biological and adoptive parents and relatives to determine the rate of schizophrenia in the two sets of families. The researchers found that 12 per cent of biological family members had also been diagnosed with schizophrenia, compared with a concordance rate of only 3 per cent of adoptive family members, suggesting a hereditary link.

Twin studies, which compare trait similarities in identical and fraternal twins, are one of the more powerful techniques used in behavioural genetics. Because *monozygotic*, or identical, twins develop from the same fertilized egg, they are genetically identical (Fig. 3.4). Approximately one in 250 births produces identical twins. *Dizygotic*, or fraternal, twins develop from two fertilized eggs, so they share 50 per cent of their genetic endowment, like any other set of brothers and sisters. Approximately one in 150 births produces fraternal twins.

Twins, like other siblings, are usually raised in the same familial environment. Thus, we can compare **concordance rates**, or trait similarity, in samples of identical and fraternal twins.

Focus 3.3

How are adoption and twin studies used to estimate genetic and environmental determinants of behaviour?

adoption study
people who were adopted early in life are compared on some characteristic with both their biological parents, with whom they share genetic endowment, and with their adoptive parents, with whom they share no genes

twin studies
compare trait similarities in identical and fraternal twins

concordance rates
trait similarity

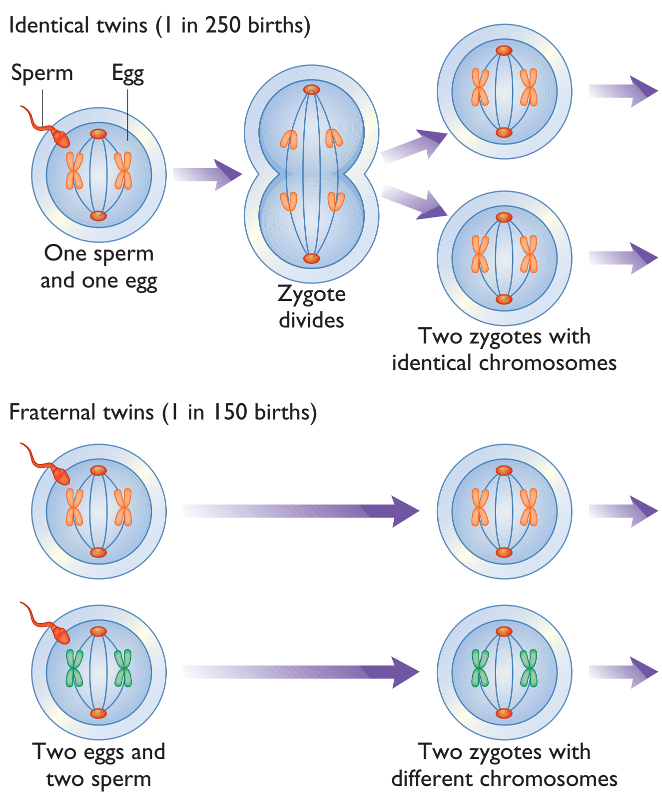


FIGURE 3.4
Identical (monozygotic) twins come from a single egg and sperm as a result of a division of the zygote. They have all of their genes in common. Fraternal (dizygotic) twins result from two eggs fertilized by two sperm. They share only half of their genes as a result.

We assume that if the identical twins are far more similar to one another than are the fraternal twins in a specific characteristic, a genetic factor is likely to be involved. Of course, the drawback is the possibility that because identical twins are more similar to one another in appearance than fraternal twins are, they are treated more alike and therefore share a more similar environment. This could partially account for greater behavioural similarity in identical twins.

Focus 3.4

Define heritability. How is heritability of a trait estimated?

To rule out this environmental explanation, behavioural geneticists have adopted an even more elegant research method. Sometimes, as in the University of Minnesota study in which the Jim twins participated, researchers are able to find and compare sets of identical and fraternal twins who were separated very early in life and raised in *different* environments (Bouchard et al., 1990). By eliminating environmental similarity, this research design permits a better basis for evaluating the respective contributions of genes and environment.

As we shall see, many (but not all) psychological characteristics, including intelligence, personality traits and certain psychological disorders, have a notable genetic contribution (Bouchard, 2004). Adopted children are typically found to be more similar to their biological parents than to their adoptive parents on these measures, and identical twins tend to be more similar to one another than are fraternal twins, even if they were separated early in life and reared in different environments (Loehlin, 1992; Lykken et al., 1992; Plomin and Spinath, 2004). On the other hand, identical twins reared together still tend to be somewhat more similar for some characteristics than those reared apart, indicating that the environment also makes a difference.

Heritability: Estimating Genetic Influence

heritability coefficient estimates the extent to which the differences, or variation, in a specific phenotypic characteristic within a group of people can be attributed to their differing genes

Using adoption and twin studies, researchers can apply a number of statistical techniques to estimate the extent to which differences among people are due to genetic differences. A **heritability coefficient** estimates the extent to which the differences, or variation, in a specific phenotypic characteristic within a group of people can be attributed to their differing genes. For example, propensity for divorce is relatively high, around 50 per cent. It is important that you understand what this .50 heritability coefficient does *not* mean. This result does *not* mean that 50 per cent of a particular person's propensity for divorce is due to genetic factors and the other 50 per cent to the environment. Heritability applies only to differences *within particular groups* (and estimates can and do vary, depending on the group).

Table 3.1 shows the wide range of heritability that has been found for a range of physical and psychological characteristics. Subtracting each heritability coefficient from 1 provides an estimate of the proportion of group variability that is attributable to the environment in which people develop. For height, environment accounts for only about 1 minus .9, a proportion of .1 (or 10 per cent), of the variation within groups, but for religious attitudes, environment accounts for virtually all differences among people.

Even while they try to estimate the contributions of genetic factors, behavioural geneticists realize that genes and environment are not really separate determinants of behaviour. Instead, they operate as a single, integrated system. Gene expression is influenced on a daily basis by the environment. For example, two children of equal intellectual potential may have differences in intelligence quotients (IQs) as great as 15 to 20 points if one is raised in an impoverished environment and the other in an enriched one (Plomin and Spinath, 2004). And high or low environmental stress can be responsible for turning on or off genes that regulate the production of stress hormones (Taylor, 2006a). Neumeister et al. (2004) have shown that the genetic influence on certain psychological disorders can be very significant indeed, and it is our genetics that provide some of us with a predisposition to suffer with a problem. This is certainly true of depression. Weissman et al. (1984) showed that having relatives that have suffered from depression before the age of 20 means that you are significantly (eight times) more likely to suffer yourself at some point in your life. Of course, as we see elsewhere in the book, a predisposition (or diathesis) to

TABLE 3.1 HERITABILITY ESTIMATES FOR VARIOUS HUMAN CHARACTERISTICS

Trait	Heritability estimate
Height	.80
Weight	.60
Likelihood of being divorced	.50
School achievement	.40
Activity level	.40
Preferred characteristics in a mate	.10
Religious attitudes	.00

SOURCES: Bouchard et al., 1990; Dunn and Plomin, 1990.

suffer with something does not mean that you certainly will, just that it may happen given the correct experiences, and environment.

Caspi et al. (2002) looked at how the environment and genetics interacted. The gene they were interested in was the MAOA gene, which they thought may relate to violent or aggressive behaviour. They genotyped a number of men from New Zealand. The reason they did this was that there had been previous evidence of violent behaviour in a Dutch family who had an MAOA mutation, so looking specifically at this gene made sense. The results were very interesting. They showed that the MAOA genotype did not, in itself, correlate with violent activity, but if low MAOA activity was coupled with a history of child abuse while younger, then the men were four times more likely to be convicted of a violent crime before the age of 24: nature (genetics) and nurture (the environment) interacting.

Focus 3.4

Define heritability. How are heritability coefficients estimated?

IN REVIEW

- Hereditary potential is carried in the genes, whose commands trigger the production of proteins that control body structures and processes. Genotype (genetic structure) and phenotype (outward appearance) are not identical, in part because some genes are dominant while others are recessive. Many characteristics are polygenic in origin, that is, they are influenced by the interactions of multiple genes.
- Behavioural geneticists study how genetic and environmental factors contribute to the development of psychological traits and behaviours. Adoption and twin studies are the major research methods used to disentangle hereditary and environmental factors. Especially useful is the study of identical and fraternal twins who were separated early in life and raised in different environments. Identical twins are more similar on a host of psychological characteristics, even when reared apart. Many psychological characteristics have appreciable heritability.

ADAPTING TO THE ENVIRONMENT: THE ROLE OF LEARNING

We encounter changing environments, each with its unique challenges, from the moment we are conceived. Some challenges, such as acquiring food and shelter, affect survival. Others, such as deciding where to go on a date, do not. But no matter what the challenge, we come into this world with biologically based abilities to respond adaptively. These mechanisms allow us to perceive our world, to think and problem solve, to remember past events and to profit from our experiences. If evolution can be seen as *species adaptation* to changing environments, then we can view learning as a process of *personal adaptation* to the circumstances of our lives. Learning allows us to use our biological heredity to profit from experience and adapt to our environment.

HOW DO WE LEARN? THE SEARCH FOR MECHANISMS

For a long time, the study of learning proceeded along two largely separate paths, guided by two different perspectives on behaviour: *behaviourism* (see Chapter 1) and *ethology* (Bolles and Beecher, 1988). Within psychology, behaviourism dominated learning research from the early 1900s through to the 1960s. Behaviourists assumed that there are laws of learning that apply to virtually all organisms. For example, each species they studied – whether birds, reptiles, rats, monkeys or humans – responded in predictable ways to patterns of reward or punishment.

Behaviourists treated the organism as a *tabula rasa*, or 'blank tablet', on which learning experiences were inscribed. Most of their research was conducted with non-human species in controlled laboratory settings. Behaviourists explained learning solely in terms of directly observable events and avoided speculating about an organism's mental state (as cognitive psychologists later did).

adaptive significance
how a behaviour influences an organism's chances of survival and reproduction in its natural environment

fixed action pattern
an unlearned response automatically triggered by a particular stimulus

Focus 3.5
Contrast the behaviouristic and ethological assumptions regarding the development of behaviour.

WHY DO WE LEARN? THE SEARCH FOR FUNCTIONS

While behaviourism flourished in early- to mid-twentieth-century America, a specialty area called *ethology* arose in Europe within the discipline of biology (Lorenz, 1937; Tinbergen, 1951). Ethologists focused on animal behaviour in the natural environment viewing the organism as much more than a blank tablet, arguing that because of evolution, every species comes into the world biologically prepared to act in certain ways. However, this is not to say that the ethologists denied that learning occurs. They rather focused on the *functions* of behaviour, particularly its **adaptive significance**, how a behaviour influences an organism's chances of survival and reproduction in its natural environment.

An example of the kinds of behaviours which the ethologists studied is that of young herring gulls' pecking behaviour. Newly hatched gulls beg for food by pecking at a red mark on their parents' bills. Parents respond by regurgitating food, which the hatchlings ingest. Seeing the red mark and long shape of a parent's bill automatically triggers the chicks' pecking. This behaviour is so strongly pre-wired that chicks will peck just as much at long inanimate models or objects with red dots or stripes (Fig. 3.5). Ethologists call this instinctive behaviour a **fixed action pattern**, an unlearned response automatically triggered by a particular stimulus.

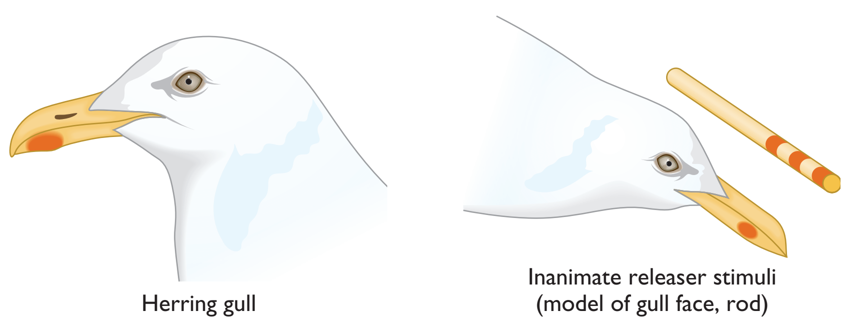


FIGURE 3.5
A herring gull hatchling will peck most frequently at objects that are long and have red markings, even if they are inanimate models and do not look like adult gulls. This innate fixed action pattern is present from birth and does not require learning. The stimuli that trigger a fixed action pattern, such as the red markings on the inanimate objects and on the beak of the real herring gull shown here, are called releaser stimuli.
SOURCE: adapted from Hailman, 1969.

As ethology research proceeded, several things became clear. First, some fixed action patterns are modified by experience. Unlike herring gull hatchlings, older chicks have learned what an adult gull looks like and will not peck at an inanimate object unless it resembles the head of an adult gull (Hailman, 1967). Second, in many cases what appears to be instinctive behaviour actually involves learning. For example, the indigo bunting is a songbird that migrates between North and Central America. As if by pure instinct, it knows which direction to fly by using the North Star to navigate. (The North Star is the only stationary star in the Northern Hemisphere that maintains a fixed compass position.) In autumn, the buntings migrate south by flying away from the North Star; they return in the spring by flying towards it.

To study whether any learning was involved in the buntings' navigational behaviour, Emlen (1975) raised birds in a planetarium with either a true sky or a false sky in which a star other than the North Star was the only stationary one. In the autumn, the buntings became restless in their cages as migration time approached. When the birds raised in the planetarium with the true sky were released, they flew away in the direction opposite the North Star. In contrast, those exposed to the false sky ignored the North Star and instead flew away in the direction opposite the 'false' stationary star. Emlen concluded that although the indigo bunting is genetically pre-wired to navigate by a fixed star, it has to learn through experience which specific star in the night sky is stationary.

LEARNING, CULTURE AND EVOLUTION

The separate paths of behaviourism and ethology have increasingly converged (Papini, 2002), reminding us that the environment shapes behaviour in two fundamental ways: through *species adaptation* and through *personal adaptation*. Our personal adaptation to life's circumstances occurs through the laws of learning that the behaviourists and other psychologists have examined, and it results from our interactions with immediate and past environments.

When you drive or go out on a date, your behaviour is influenced by the immediate environment (e.g., traffic, your girlfriend's or boyfriend's smiles) and by capabilities you acquired through past experiences (e.g., driving skills, social skills). Because culture plays an ongoing role in shaping our present and past experiences, it strongly affects what we learn. Cultural socialization influences our beliefs and perceptions, our social behaviour and sense of identity, the skills that we acquire, and countless other characteristics (Fig. 3.6).

FIGURE 3.6
People in different cultures learn specific behaviours in order to adapt to their environment. Even the same general skill will take on different forms, depending on unique environmental features and demands.

The environment also influences species adaptation. Over the course of evolution, environmental conditions faced by each species help shape its biology. This does not occur directly. Learning, for example, does not modify an organism's genes, and therefore learned behaviours do not pass genetically from one generation to the next. But through natural selection, genetically based characteristics that enhance a species' ability to adapt to the environment – and thus to survive and reproduce – are more likely to be passed on to the next generation. Eventually, as physical features (e.g., the red mark on the adult gull's beak) and behavioural tendencies (e.g., the chick pecking the mark) influenced by those genes become more common, they become a part of a species' very nature.

Focus 3.6

Discuss the relation of evolution and culture to learning. What are the basic adaptive things that organisms must learn?

Theorists propose that as the human brain evolved, it acquired adaptive capacities that enhanced our ability to learn and solve problems (Chiappe and MacDonald, 2005; Cosmides and Tooby, 2002). In essence, we have become pre-wired to learn. Of course, so have other species. Because all species face some common adaptive challenges, we might expect some similarity in their library of learning mechanisms. Every environment is full of events, and each organism must learn:

- which events are, or are not, important to its survival and well-being
- which stimuli signal that an important event is about to occur
- whether its responses will produce positive or negative consequences.

These adaptive capacities are present to varying degrees in all organisms. Even the single-celled paramecium can learn to jerk backward in its avoidance pattern in response to a vibration that has been paired with electric shock (Hennessey et al., 1979). As we move up the phylogenetic scale from simpler to more complex animals, learning abilities become more sophisticated, reaching their highest level in humans. Learning is the mechanism through which the environment exerts its most profound effects on behaviour, and we explore learning processes in depth in Chapter 7. For now, let's explore a few key concepts surrounding environmental influences.

Shared and Unshared Environments

Environment is a very broad term, referring to everything from the pre-natal world of the womb and the simplest physical environment to the complex social systems in which we interact with multiple people, places and things. Some of these environments, such as our family household or school classroom, are shared with other people, such as our siblings and class-mates. This is called a **shared environment** because the people who reside in these experience many of their features in common. Siblings living in the same home are exposed to a common physical environment, the availability or unavailability of books, a television or a computer. They share the quality of food in the home, exposure to the attitudes and values transmitted by parents, and many other experiences. However, each of us also has experiences that are unique to us, or an **unshared environment**. Even children living in the same home have their own unique experiences, including distinct relationships with their parents and siblings.

shared environment
the people who reside in these experience many of their features in common

unshared environment
experiences that are unique to us

Twin studies (especially those that include twins raised together and apart) are particularly useful in estimating the extent to which genotype, shared environment and unshared environment contribute to group variance on a particular characteristic (see Fig. 3.7). As we shall see, such studies have provided new insights on the factors that influence a wide range of human characteristics.

Focus 3.7

How large a factor is heritability in individual differences in intelligence?

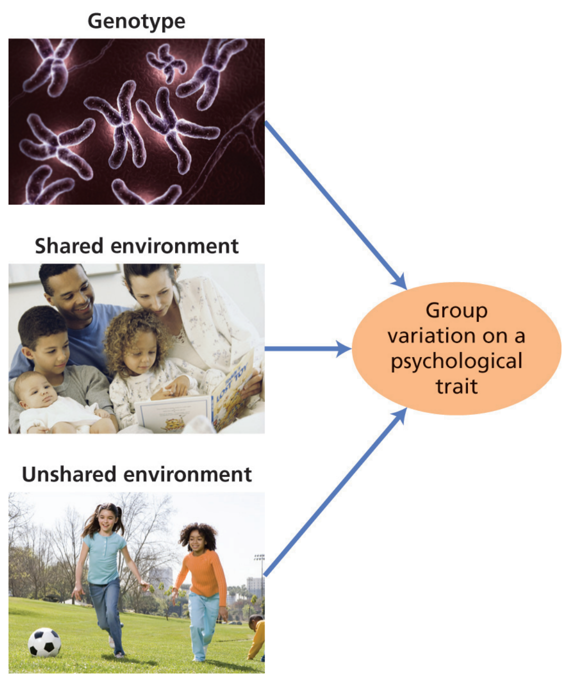


FIGURE 3.7

Behavioural genetics research methods permit the estimation of three sources of variation in a group's scores on any characteristics. It is therefore possible to estimate from results of twin and adoption studies the contributions of genetic factors and of shared and unshared environmental factors.

IN REVIEW

- The environment exerts its effects largely through processes of learning that are made possible by innate biological mechanisms. Humans and other organisms can learn which stimuli are important and which responses are likely to result in goal attainment.
- Since learning always occurs within environments, it is important to distinguish between different kinds of environments. Behavioural genetics researchers make an important distinction between shared and unshared environmental influences.

BEHAVIOURAL GENETICS, INTELLIGENCE AND PERSONALITY

Of the many psychological characteristics that we possess, few if any are more central to our personal identity and our successful adaptation than intelligence and personality. Although we consider these topics in much greater detail in Chapters 10 and 15, respectively, intelligence and personality are particularly relevant to our current discussion because the genetic and environmental factors that influence them have been the subject of considerable research.

GENES, ENVIRONMENT AND INTELLIGENCE

To what extent are differences in intelligence (as defined by an IQ score derived from a general intelligence test) due to genetic factors? This seemingly simple question has long been a source of controversy and, at times, bitter debate. The answer has important social as well as scientific consequences.

Heritability of Intelligence

Let us examine the genetic argument. Suppose that intelligence were totally heritable, that is, suppose that 100 per cent of the intellectual variation in the population were determined by genes. (No psychologist today would maintain that this is so, but examining the extreme view can be instructive.) In that case, any two individuals with the same genotype would have identical intelligence test scores, so the correlation in IQ between identical (monozygotic) twins would be 1.00. Non-identical brothers and sisters (including fraternal twins, who result from two fertilized eggs) share only half of their genes. Therefore, the correlation between the test scores of fraternal twins and other siblings should be substantially lower. Extending the argument, the correlation between a parent's test scores and his or her children's scores should be about the same as that between siblings, because a child inherits only half of his or her genes from each parent.

What do the actual data look like? Table 3.2 summarizes the results from many studies. As you can see, the correlation between the test scores of identical twins is substantially higher than any other correlations in the table (but they are not 1.00). Identical twins separated early in life and reared apart are of special interest because they have identical genes but experienced different environments. Note that the correlation for identical twins raised apart is nearly as high as that for identical twins reared together. It is also higher than that for fraternal twins raised together. This pattern of findings is a powerful argument for the importance of genetic factors (Bouchard et al., 1990; Plomin et al., 2007).

Adoption studies are also instructive. As Table 3.2 shows, IQs of adopted children correlate as highly with their biological parents' IQs as they do with the IQs of the adoptive parents who reared them. Overall, the pattern is quite clear: the more genes people have in common, the more

TABLE 3.2 CORRELATIONS IN INTELLIGENCE AMONG PEOPLE WHO DIFFER IN GENETIC SIMILARITY AND WHO LIVE TOGETHER OR APART

Relationship	Percentage of shared genes	Correlation of IQ scores
Identical twins reared together	100	.86
Identical twins reared apart	100	.75
Non-identical twins reared together	50	.57
Siblings reared together	50	.45
Siblings reared apart	50	.21
Biological parent – offspring reared by parent	50	.36
Biological parent – offspring not reared by parent	50	.20
Cousins	25	.25
Adopted child–adoptive parent	0	.19
Adopted children reared together	0	.32

SOURCES: based on Bouchard and McGue, 1981; Bouchard et al., 1990; Scarr, 1992.

similar their IQs tend to be. This is very strong evidence that genes play a significant role in intelligence, accounting for 50 to 70 per cent of group variation in IQ (Petrill, 2003; Plomin and Spinath, 2004). However, analysis of the human genome shows that there clearly is not a single 'intelligence' gene (Plomin and Craig, 2002). The diverse abilities measured by intelligence tests are undoubtedly influenced by large numbers of interacting genes, and different combinations seem to underlie specific abilities (Luciano et al., 2001; Plomin and Spinath, 2004).

Environmental Determinants

Because genotype accounts for only 50 to 70 per cent of the IQ variation among individuals, genetics research provides a strong argument for the contribution of environmental factors to intelligence (Plomin and Spinath, 2004). Good places to look for such factors are in the home and school environments.

Focus 3.8

Describe the shared and unshared environmental influences on intelligence.

Shared family environment How important to intelligence level is the shared environment of the home in which people are raised? If home environment is an important determinant of intelligence, then children who grow up together should be more similar than children who are reared apart. As Table 3.2 shows, siblings who are raised together are indeed more similar to one another than those reared apart, whether they are identical twins or biological siblings. Note also that there is a correlation of .32 between unrelated adopted children reared in the same home. Overall, it appears that between a quarter and a third of the population's individual differences in intelligence can be attributed to shared environmental factors.

The home environment clearly matters, but there may be an important additional factor. Recent research suggests that differences within home environments are much more important at lower socio-economic levels than they are in upper-class families. This may be because lower socio-economic families differ more among themselves in the intellectual richness of the home environment than do upper-class families (Turkheimer et al., 2003). Indeed, a lower-income family that has books in the house, cannot afford video games and encourages academic effort may be a very good environment for a child with good intellectual potential.

Environmental enrichment and deprivation Another line of evidence for environmental effects comes from studies of children who are removed from deprived environments and placed in middle- or upper-class adoptive homes. Typically, such children show a gradual increase in IQ on the order of 10 to 12 points (Scarr and Weinberg, 1977; Schiff and Lewontin, 1986). Conversely, when deprived children remain in their impoverished environments, they either show no improvement in IQ or they actually deteriorate intellectually over time (Serpell, 2000). Scores on general intelligence tests correlate around .40 with the socio-economic status of the family in which a child is reared (Lubinski, 2004).

Educational experiences As we might expect, educational experiences, perhaps best viewed as a non-shared variable, can also have a significant impact on intelligence. Many studies have shown that school attendance can raise IQ and that lack of attendance can lower it. A small decrease in IQ occurs over summer holidays, especially among low-income children. Intelligence quotient scores also drop when children are unable to start school on time owing to teacher shortages or strikes, natural disasters, or other reasons (Ceci and Williams, 1997). It appears that exposure to an environment in which children have the opportunity to practice mental skills is important in solidifying those skills.

Where intelligence is concerned, we have seen that genetic factors, shared environment and unique experiences all contribute to individual differences in intelligence. Do the same factors apply to personality differences?

PERSONALITY DEVELOPMENT

'Like father, like son' is a saying which young and even quite old men hear very often. But if this old saying has validity, what causes similarities in personality between fathers and sons (and mothers and daughters)? Is it genes, environment, or both?

Heritability of Personality

Behavioural genetics studies on personality have examined genetic and environmental influences on relatively broad personality traits. One prominent personality trait theory is called the five factor model (see Chapter 15). Five factor theorists like Robert McCrae and Paul Costa (2003) believe that individual differences in personality can be accounted for by variation along five broad personality dimensions or traits known as the Big Five: (1) *extraversion–introversion* (sociable, outgoing, adventuresome, spontaneous versus quiet, aloof, inhibited, solitary), (2) *agreeableness* (co-operative, helpful, good natured versus antagonistic, uncooperative, suspicious); (3) *conscientiousness* (responsible, goal-directed, dependable versus undependable, careless, irresponsible); (4) *neuroticism* (worrying, anxious, emotionally unstable versus well adjusted, secure, calm); and (5) *openness to experience* (imaginative, artistically sensitive, refined versus unreflective, crude and boorish, lacking in intellectual curiosity).

Focus 3.9

Describe the heritability of personality and the role of shared and unshared environmental influences on personality differences.

What results are obtained if we compare the Big Five traits, described above, in identical and fraternal twins who were raised together and those who were raised apart? Table 3.3 shows heritability estimates of the Big Five personality factors described above. These results are consistent with studies of other personality variables as well, indicating that between 40 and 50 per cent of the personality variations among people are attributable to genotype differences (Bouchard, 2004). Although personality characteristics do not show as high a level of heritability as the .70 figure found for intelligence, it is clear that genetic factors account for a significant amount of personality difference.

Environment and Personality Development

If genetic differences account for only about 40 to 50 per cent of variations in personality, then surely environment is even more important than it is in the case of intelligence. Researchers

TABLE 3.3 HERITABILITY OF THE BIG FIVE PERSONALITY FACTORS BASED ON TWIN STUDIES

Trait	Heritability coefficient
Extraversion	.54
Neuroticism	.48
Conscientiousness	.49
Agreeableness	.42
Openness to experience	.57

SOURCE: Bouchard, 2004.

expected that the shared environment might be even more important for personality than it is for intelligence. Over the years, virtually every theory of personality has embraced the assumption that experiences within the family, such as the amount of love expressed by parents and other child-rearing practices, are critical determinants of personality development. Imagine, therefore, the shock waves generated by the findings from twin studies that shared features of the family environment account for little or no variance in major personality traits (Bouchard et al., 2004; Plomin, 1997). The key finding was that twins raised together and apart, whether identical or fraternal, did not differ in their degree of personality similarity (although identical twins were always more similar to one another than were fraternal twins). In fact, researchers have found that pairs of children who are raised within the same family are as different from one another as are pairs of children who are randomly selected from the population (Plomin and Caspi, 1999).

Adoption studies support a similar conclusion. In adoption studies, the average correlation for personality variables between adopted siblings who are genetically dissimilar but do share much of their environment, including the parents who raise them, the schools they attend, the religious training they receive, and so on, is close to .00 (Plomin et al., 2007). Except at child-rearing extremes, where children are abused or seriously neglected, parents probably get more credit when children turn out well personality-wise – and more blame when they do not – than they deserve (Scarr, 1992).

However, the surprising findings concerning shared environments does not mean that experience is not important. Rather than the general family environment, it seems to be the individual's unique or unshared environment, such as his or her unique school experiences (for example, being in Mr Jones's classroom, where conscientiousness and openness to experience were stressed) and interactions with specific peers (such as Jeremy, who fostered extraverted relationships with others) that account for considerable personality variance. Even within the same family, we should realize, siblings have different experiences while growing up, and each child's relationship with his or her parents and siblings may vary in important ways. It is these unique experiences that help shape personality development. Whereas behavioural geneticists have found important shared-environment effects in intelligence, attitudes, religious beliefs, occupational preferences, notions of masculinity and femininity, political attitudes, and health behaviours such as smoking and drinking (Larson and Buss, 2007), these shared-environment effects do not extend to general personality traits such as the Big Five. At this point, we do not know whether there are some crucial unshared-environmental variables that researchers have missed because of their preoccupation with shared-environmental factors, or whether there are countless small variables that make the difference. This question is of key importance to personality research.

IN REVIEW

- Intelligence has a strong genetic basis, with heritability coefficients in the .50 to .70 range. Shared family environment is also important (particularly at lower socio-economic levels), as are educational experiences.
- Personality also has a genetic contribution, though not as strong as that for intelligence. In contrast to intelligence, shared family environment seems to have no impact on the development of personality traits. Unshared individual experiences are far more important environmental determinants.

GENE–ENVIRONMENT INTERACTIONS

Genes and environment both influence intelligence, personality and other human characteristics. But, as we've stressed throughout this chapter, they rarely operate independently. Even the pre-natal environment can influence how genes express themselves, as when the mother's drug use or malnutrition retards gene-directed brain development. In the critical periods following birth, enriched environments, including the simple touching or massaging of newborns, can influence the unfolding development of premature infants (Field, 2001) and the future 'personality' of young monkeys (Harlow, 1958). Although they cannot modify the genotype itself, environmental conditions can influence how genetically based characteristics express themselves phenotypically throughout the course of development (Plomin et al., 2007).

Just as environmental effects influence phenotypic characteristics, genes can influence how the individual will experience the environment and respond to it (Hernandez and Blazer, 2007; Plomin and Spinath, 2004). Let us examine some of these interactions between genes and experience.

HOW THE ENVIRONMENT CAN INFLUENCE GENE EXPRESSION

First, genes produce a range of potential outcomes. The concept of *reaction range* provides one useful framework for understanding gene–environmental interactions. The **reaction range** for a genetically influenced trait is the range of possibilities – the upper and lower limits – that the genetic code allows. For example, to say that intelligence is genetically influenced does not mean that intelligence is fixed at birth. Instead, it means that an individual inherits a *range* for potential intelligence that has upper and lower limits. Environmental effects will then determine where the person falls within these genetically determined boundaries.

reaction range
the range of possibilities – the upper and lower limits – that the genetic code allows

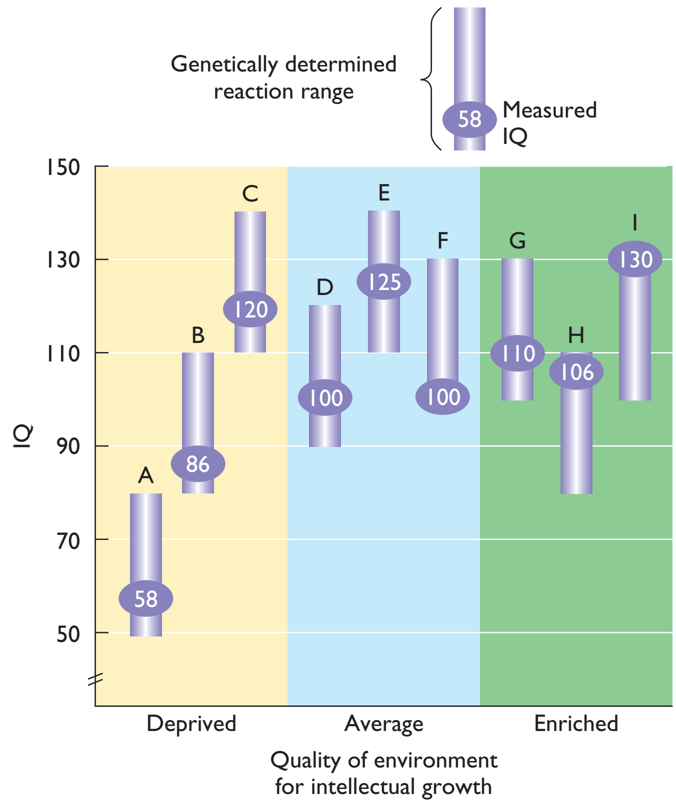
Focus 3.10
Describe reaction range and its hypothesized effects on the genetic expression of intelligence.

At present, genetic reaction ranges cannot be measured directly, and we do not know if their sizes differ from one person to another. The concept has been applied most often in the study of intelligence. There, studies of IQ gains associated with environmental enrichment and adoption programmes suggest that the ranges could be as large as 15 to 20 points on the IQ scale (Dunn and Plomin, 1990). If this is indeed the case, then the influence of environmental factors on intelligence would be highly significant. A shift this large can move an individual from a below-average to an average intellectual level, or from an average IQ that would not predict college success to an above-average one that would predict success.

Some practical implications of the reaction range concept are illustrated in Figure 3.8. First, consider persons B and H. They have identical reaction ranges, but person B develops in a very deprived environment and H in an enriched environment with many cultural and educational advantages. Person H is able to realize her innate potential and has an IQ that is 20 points higher than person B's. Now compare persons C and I. Person C actually has greater intellectual potential than person I but ends up with a lower IQ as a result of living in an environment that does

FIGURE 3.8

Reaction range is an example of how environmental factors can influence the phenotypic expression of genetic factors. Genetic endowment is believed to create a range of possibilities within which environment exerts its effects. Enriched environments are expected to allow a person's intelligence to develop to the upper region of his or her reaction range, whereas deprived environments may limit intelligence to the lower portion of the range. Where intelligence is concerned, the reaction range may cover as much as 15 to 20 points on the IQ scale.



not allow that potential to develop. Finally, note person G, who was born with high genetic endowment and reared in an enriched environment. His slightly-above-average IQ of 110 is lower than we would expect, suggesting that he did not take advantage of either his biological capacity or his environmental advantages. This serves to remind us that intellectual growth depends not only on genetic endowment and environmental advantage, but also on interests, motivation and other personal characteristics that affect how much we apply ourselves or take advantage of our gifts and opportunities.

As noted earlier, heritability estimates are not universal by any means. They can vary, depending on the sample being studied, and they may be influenced by environmental factors. This fact was brought home forcefully in research by Turkheimer and colleagues (2003), mentioned previously. They found in a study of 7-year-old identical and fraternal twins that the proportions of IQ variation attributable to genes and environment varied by social class. In impoverished families, fully 60 per cent of the IQ variance was accounted for by the shared (family) environment, and the contribution of genes was negligible. In affluent families, the result was almost the reverse, with shared environment accounting for little variance and genes playing an important role. Clearly, genes and social-class environment seem to be interacting in their contribution to IQ.

It seems quite likely that there are genetically based reaction ranges for personality factors as well. This would mean that, personality-wise, there are biological limits to how malleable, or changeable, a person is in response to environmental factors. However, this hardly means that biology is destiny. Depending on the size of reaction ranges for particular personality characteristics – and even, perhaps, for different people – individuals could be quite susceptible to the impact of unshared environmental experiences.

HOW GENES CAN INFLUENCE THE ENVIRONMENT

Reaction range is a special example of how environment can affect the expression of genetically influenced traits. But there are other ways in which genetic and environmental factors can interact with one another. Figure 3.9 shows three ways in which genotype can influence the environment, which, in turn, can influence the development of personal characteristics (Scarr and McCartney, 1983).

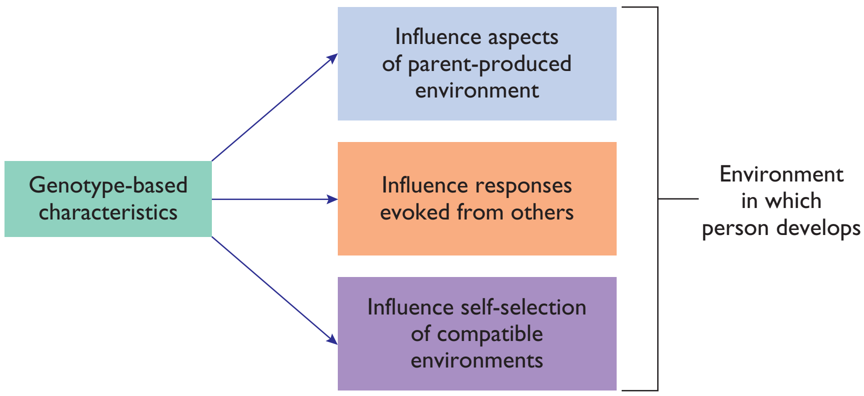


FIGURE 3.9

Three ways in which a person's genotype can influence the nature of the environment in which the person develops.

SOURCE: based on Scarr and McCartney, 1983.

First, genetically based characteristics may influence aspects of the environment to which the child is exposed. For example, we know that intelligence has strong heritability. Thus, a child born to highly intelligent parents is also likely to have good intellectual potential. If, because of their own interests in intellectual pursuits, these parents provide an intellectually stimulating environment with lots of books, educational toys, computers, and so on, this environment may help foster the development of mental skills that fall at the top of the child's reaction range. The resulting bright child is thus a product of both the genes shared with the parents and of his or her ability to profit from the environment they provide.

A second genetic influence on the environment is called the **evocative influence**, meaning that a child's genetically influenced behaviours may evoke certain responses from others. For example, some children are very cuddly, sociable and outgoing almost from birth, whereas others are more aloof, shy and do not like to be touched or approached. These characteristics are in part genetically based (Kagan, 1999; Plomin et al., 2007). Think of how you yourself would be most likely to respond to these two types of babies. The outgoing children are likely to be cuddled by their parents and evoke lots of friendly responses from others as they mature, creating an environment that supports and strengthens their sociable and extraverted tendencies. In contrast, shy, aloof children typically evoke less positive reactions from others, and this self-created environment may strengthen their genotypically influenced tendency to withdraw from social contact.

evocative influence
a child's genetically influenced behaviours may evoke certain responses from others

In both of these examples, genotype helped create an environment that reinforces already existing biologically based tendencies. However, a behaviour pattern can also evoke an environment that counteracts the genetically favoured trait and discourages its expression. We know, for example, that activity level has moderate heritability of around .40 (Table 3.1). Thus, parents of highly active 'off the wall' children may try to get them to sit still and calm down, or those of inactive children may press the child into lots of physical activities designed to increase physical well-being, in both instances opposing the natural tendencies of the children. Thus, the environment may either support or discourage the expression of a person's genotype.

Focus 3.11
Describe three ways that genotype can affect environmental influences on behaviour.

Finally, people are not simply passive responders to whatever environment happens to come their way. We actively seek out certain environments and avoid others. Genetically based traits may therefore affect the environments that we select, and these environments are likely to be compatible with our traits. Thus, a large, aggressive boy may be attracted to competitive sports with lots of physical contact, a highly intelligent child will seek out intellectually stimulating environments, and a shy, introverted child may shun social events and prefer solitary activities or a small number of friends. These varied self-selected environments may have very different effects on subsequent development. We therefore see that how people develop is influenced by both biology and experience, and that these factors combine in ways that are just beginning to be understood.

IN REVIEW

- Genetic and environmental factors rarely operate alone; they interact with one another in important ways. Genetic factors may influence how different people experience the same environment, and the environment can influence how genes express themselves.
- Genetic factors can influence the environment in three important ways. First, genes shared by parents and children may be expressed in the parents' behaviours and the environment they create. Second, genes may produce characteristics that influence responses evoked from others. Finally, people may self-select or create environments that are consistent with their genetic characteristics.

GENETIC MANIPULATION AND CONTROL

Focus 3.12

Describe some of the gene modification methods used to study causes of behaviour.

Until recently, genetics researchers had to be content with studying genetic phenomena occurring in nature. Aside from selectively breeding plants and animals for certain characteristics or studying the effects of genetic mutations, they had no ability to influence genes directly. Today, however, technological advances have enabled scientists not only to map the human genome but also to duplicate and modify the structures of genes themselves (Aldridge, 1998).

Some gene-manipulation research involves transplanting genes from one species into another. Such studies have shown how closely we humans are related to other living creatures. For example, both humans and insects have eyes; although the eyes differ markedly in their structural characteristics (see Fig. 3.10). Some years ago, geneticists identified a human gene called *Pax6*

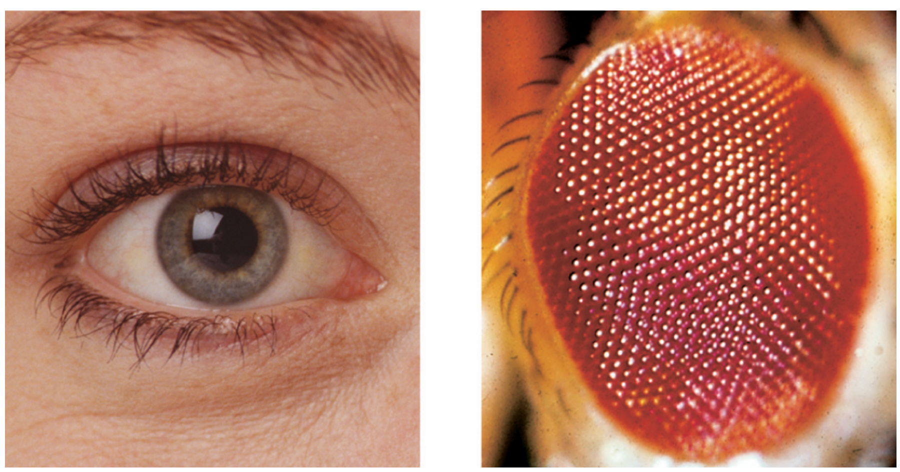


FIGURE 3.10

When the human *Pax6* gene that initiates eye development in people is implanted in the fruit fly *Drosophila*'s side, it produces a multifaceted eye that looks like the eye of the insect itself, showing how the biological environment in which a gene operates can influence its expression. This demonstration also shows the relatedness of species as dissimilar as insects and humans.

that is responsible for eye development. If this gene is not switched on at a critical time in development, people do not develop eyes. What do you think would happen if we were to transplant human *Pax6* genes at various locations along the body of a fruit fly and let them express themselves within that biological environment? Amazingly, numerous small eyes that looked just like the multifaceted eye of the insect itself appeared on the fruit fly's body, demonstrating how the biological environment in which a gene resides can determine its phenotypic expression (Hartwell et al., 2008). Studies of many other genes have shown that organisms as different as fruit flies and humans use the same genes to turn on the development of structures that may differ phenotypically but retain their ancestral roots.

The importance of finding relatedness and unity across a wide range of organisms cannot be overstated. It means that in many cases, the experimental manipulation of organisms known as *model organisms* can shed light on important processes in humans. Human functions cannot only be studied in such model organisms as rats, mice and monkeys, but also in such distant organisms as fruit flies.

In another gene-manipulation approach, researchers use certain enzymes (proteins that create chemical reactions) to cut the long threadlike molecules of genetic DNA into pieces, combine it with DNA from another organism, and insert it into a host organism such as a bacterium. Inside the host, the new DNA combination continues to divide and produce many copies of itself. Researchers can also insert new genetic material into viruses that can infiltrate the brain and modify the genetic structure in brain tissue.

Recent gene-modification research by psychologists has focused on processes such as learning, memory, emotion and motivation. One procedure done with animals (typically mice) is to alter a specific gene in a way that prevents it from carrying out its normal function. This is called a **knockout procedure** because that particular function of the gene is knocked out, or eliminated. The effects on behaviour are then observed. For example, psychologists can insert genetic material that will prevent neurons from responding to a particular brain chemical, or neurotransmitter. They can then measure whether the animal's ability to learn or remember is subsequently affected. This can help psychologists determine the importance of particular transmitters in relation to the behaviours of interest (Jang et al., 2003; Thomas and Palmiter, 1997). Researchers can also use a **knock-in procedure** to insert a new gene into an animal during the embryonic stage and study its impact on behaviour. Gene-modification techniques may one day enable us to alter genes that contribute to psychological disorders, such as depression and schizophrenia (McGuffin et al., 2005). Behavioural geneticists Robert Plomin and John Crabbe (2000) proclaim, '[We] predict that DNA will revolutionize psychological research and treatment early in the twenty-first century' (p. 806).

knockout procedure
that particular function of the gene is knocked out, or eliminated

knock-in procedure
insert a new gene into an animal during the embryonic stage and study its impact on behaviour

Focus 3.13
Describe some of the ethical and societal issues that attend the use of genetic screening and counselling.

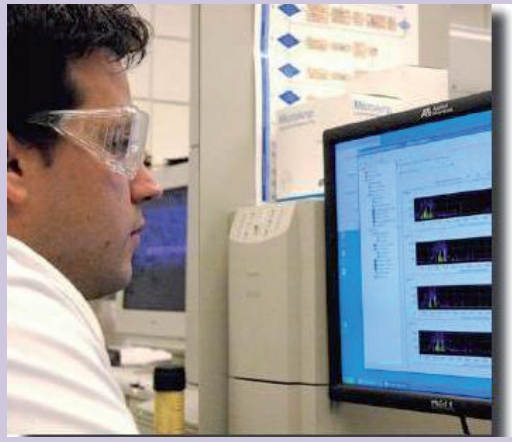
APPLYING PSYCHOLOGICAL SCIENCE

THINKING CRITICALLY ABOUT GENETIC SCREENING

Technical advances in the field of molecular genetics allow the direct analysis of a person's genes. A DNA sample can be obtained from any tissue, including blood (Pupecki, 2006). Using an automated DNA sequencer (Fig. 3.11), it is possible to analyse the one copy of a gene present in a single cell, including a sperm cell that might be used in artificial insemination or one from a human embryo that has not yet been implanted in a woman. This technology allows the detection of many human traits, including the advance diagnosis of diseases such as sickle-cell anaemia, cystic fibrosis and Down syndrome, which produces mental

FIGURE 3.11

An automated DNA sequencer is used to analyse an individual's genotype. A modern sequencer like this one can analyse about 350 000 DNA base pairs per day. Typically, specific genes are targeted for screening. More than 900 specific genetic screens are now available through testing laboratories.



retardation, and Huntington's disease, a degenerative brain disorder that kills within five to 15 years after symptoms appear. By detecting mutated base sequences in a person's genome, genetic screening provides a means of identifying people, born and unborn, who are genetic carriers of the trait in question. But this capability brings with it some serious practical, ethical and life-altering issues that may confront you in your lifetime. Here are a few of them.

1. *What are the potential benefits of genetic screening*? There are at present more than 900 genetic tests available from testing laboratories (Human Genome Project, 2007). Proponents argue that screening can provide information that will benefit people. Early detection of a treatable condition can save lives. For example, were you to find through genetic screening that you have a predisposition to develop heart disease, you could alter your lifestyle with exercise and dietary measures to improve your chances of staying healthy. Screening could also affect reproductive decisions that reduce the probability of having children affected by a genetic disease. In a New York community, Hasidic Jews from Eastern Europe had a high incidence of Tay-Sachs disease, a fatal, genetically based neurological disorder. A genetic screening programme allowed rabbis to counsel against child-bearing in marriages involving two carriers of the abnormal allele, virtually eliminating the disease in offspring.

2. *Should private employers and insurance carriers be allowed to test their employees and clients?* Some employers say they would like to screen their employees in order to place them into job positions that would reduce risks of occupational diseases. Critics of employee screening see a more ominous motive behind the screening, including non-hiring or exclusion of employees whose future health might reduce company productivity. Likewise, insurance companies might well deny coverage to people whose screens indicate the presence of inherited medical disorders, or even a slightly increased likelihood of developing such disorders. This is exactly what occurred when test results from a genetic screening programme for the presence of the sickle-cell anaemia allele was made available to employers and insurance companies in the early 1970s. Many medical ethicists recommend the passing of laws that ensure that genetic information be confidential, disclosed only at the discretion of the tested person. France is one country which has already passed such a law.

3. *How accurate are the screens?* Another issue is whether an inaccurate screen may result in fateful decisions. Although screens for various diseases exceed 90 per cent accuracy, it is still possible that there can be a false positive result (an indication that a genetic predisposition to a disorder is present when it is not). Thus, a person may decide not to have children on the basis of an erroneous test that indicates a high risk of having a mentally retarded child. Alternatively, a false negative test may indicate that a predisposition is not present when in fact it is. Moreover, some tests, called *susceptibility tests*, simply tell you that you are more likely than others to develop a particular disorder, with no assurance that that will indeed occur.

4. *How should people be educated and counselled about test results?* Because of the importance of decisions that might be made on the basis of genetic screening, there is strong agreement that clients should be educated and counselled by specially trained counsellors. In the sickle-cell anaemia screening of the 1970s, follow-up education was inadequate, the result being that some African-American men who were informed that they were carriers of the sickle-cell allele elected to remain childless because they were not told that the disorder would not occur in their offspring if their mates were non-carriers of the allele. The genetic counsellor's role is to help the person, couple or family to decide whether to be screened, to help them to fully understand the meaning of the test results, and to assist them during what might well be a difficult and traumatic time.

As you can see, many complex issues swirl around the area of genetic screening. What kinds of guidelines would you like to see established to ensure that information gained from genetic screening is used appropriately? Such guidelines may well affect you at some time in the future as the tools of molecular genetics are more broadly applied.

IN REVIEW

- Genetic and environmental factors interact in complex ways to influence phenotypic characteristics. Genetic reaction range sets upper and lower limits for the impact of environmental factors. Where intelligence is concerned, environmental factors may create differences as large as 20 IQ points. Genotype can influence the kind of environments to which children are exposed, as when intelligent parents create an enriched environment. Genetically influenced behaviour patterns also have an evocative influence, influencing how the environment responds to the person. Finally, people often select environments that match genetically influenced personal characteristics.
- Genetic manipulation allows scientists to duplicate and alter genetic material or, potentially, to repair dysfunctional genes. These procedures promise ground-breaking advances in understanding genetic mechanisms and in treating physical and psychological disorders. Moreover, our ability to analyse people's genotypes allows for genetic screening and raises a host of practical and ethical issues.

EVOLUTION AND BEHAVIOUR: INFLUENCES FROM THE DISTANT PAST

In the misty forests and verdant grasslands of past eons, our early human ancestors faced many environmental challenges as they struggled to survive. If even one of your ancestors had not behaved effectively enough to survive and reproduce, you would not be here to contemplate your existence. In this sense, each of us is an evolutionary success story. As descendants of those successful forebears, we carry within us genes that contributed to their adaptive and reproductive success.

The vast majority (99.9 per cent) of genes we share with all other humans creates the 'human nature' that makes us like all other people. We enter the world with innate **biologically based mechanisms** that enable and predispose us to perceive, behave, feel, and think in certain ways (Stearns and Hoekstra, 2005). In humans, these inborn capacities allow us to learn, to remember, to speak a language, to perceive certain aspects of our environment at birth, to respond with universal emotions, and to bond with other humans. Most scientists view these biological

biologically based mechanisms
enable and predispose us to perceive, behave, feel, and think in certain ways

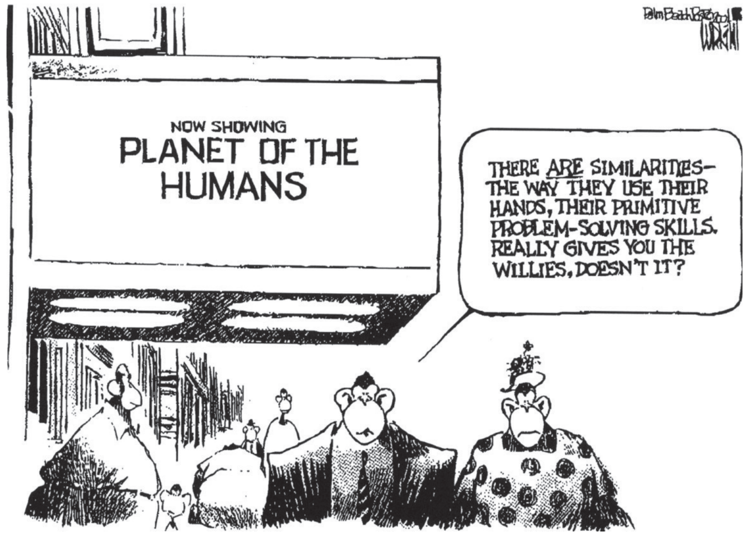


FIGURE 3.12
These days, evolutionary principles are widely discussed.

evolution
a change over time in the frequency with which particular genes – and the characteristics they produce – occur within an interbreeding population

mutations
random events and accidents in gene reproduction during the division of cells

natural selection
characteristics that increase the likelihood of survival and reproduction within a particular environment will be more likely to be preserved in the population and therefore will become more common in the species over time

characteristics as products of an evolutionary process. Evolutionary theorists (see Fig. 3.12) also believe that important aspects of social behaviour, such as aggression, altruism, sex roles, protecting kin, and mate selection are influenced by biological mechanisms that have evolved during the development of our species. Evolutionary psychologist David Buss says: 'Humans are living fossils – collections of mechanisms produced by prior selection pressures' (1995, p. 27).

EVOLUTION OF ADAPTIVE MECHANISMS

Evolution is a change over time in the frequency with which particular genes – and the characteristics they produce – occur within an interbreeding population. As particular genes become more or less frequent in a population, so do the characteristics they influence. Some genetic variations arise in a population through **mutations**, random events and accidents in gene reproduction during the division of cells. If mutations occur in the cells that become sperm and egg cells, the altered genes will be passed on to offspring. Mutations help create variation within a population's physical characteristics. It is this variation that makes evolution possible.

FIGURE 3.13
Human-initiated selective breeding over a number of generations produced this tiny horse. A similar process could occur through natural selection if for some reason a particular environment favoured the survival and reproductive ability of smaller members of the equine population.

Natural Selection

Long before Charles Darwin published his theory of evolution in 1859, people knew that animals and plants could be changed over time by selectively breeding members of a species that shared desired traits (see Fig. 3.13). A visit to a dog show illustrates the remarkably varied products of selective breeding of pedigree animals.

Just as plant and animal breeders 'select' for certain characteristics, so too does nature. According to Darwin's principle of **natural selection**, characteristics that increase the likelihood of survival and reproduction within a particular environment will be more likely to be preserved in the population and therefore will become more common in the species over time. As environmental changes produce new and different demands, various new characteristics may contribute to survival and the ability to pass on one's genes (Barrow, 2003). In this way, natural selection acts as a set of filters, allowing certain characteristics of survivors to become more common. Conversely, characteristics of non-survivors become less common and, perhaps, even extinct over time. The filters also allow neutral variations that neither facilitate nor impede fitness to be preserved in a population. These neutral variations, sometimes called *evolutionary noise*, could conceivably become important in meeting some future environmental demand. For example, people differ in their ability to tolerate radiation (Vral et al., 2002). In today's world, these variations are of limited importance, but they clearly could affect survivability if future nuclear war were to increase levels of radioactivity around the world. As those who could tolerate higher levels of radiation survived and those who could not perished, the genetic basis for high-radiation tolerance would become increasingly more common in the human species. Thus, for natural selection to work, there must be individual variation in a species characteristic that influences survival or the ability to reproduce (Workman and Reader, 2008).

Principles of natural selection in psychology The histories of evolutionary theory and psychology are inextricably intertwined. In addition to his works on natural selection, Darwin also wrote an 1877 paper entitled 'A biographical sketch of the infant'. This represents an early, observational study in developmental psychology. Darwin was influential to, and himself influenced by, early psychologists.

However, the application of principles of natural selection to psychology has not been without controversy. For example, E.O. Wilson's *Sociobiology* (1975) describes research in which the behaviours of humans and non-humans are investigated in terms of their functionality or usefulness. Evolutionary theory suggests that if something is not useful or functional then it will not occur with such frequency in later generations. The controversy in Wilson's work in was applying explanations of non-human animal behaviour to humans. Explanations of promiscuity in a male as a means of ensuring the progression of his genetic make-up may not be easy reading for people who feel that reason or morality underlies their behaviour.

There is a great danger in the misapplication of Darwin's thinking. For example, Francis Galton argued that certain traits which might have been functional and useful in the past were not so in modern Victorian England. He coined the term 'eugenics' to describe a practice of improving the human race by encouraging 'desirable' human traits through selective breeding. Those who had these 'desirable' traits should be encouraged to have children; those who did not (criminals) should be discouraged or prevented. Bitter experience has taught us that the principles of eugenics can be taken even further with horrifying consequences; Hitler's attempts to improve society with eugenics resulted in the death of millions in Nazi Germany (see later 'Beneath the surface').

Focus 3.14
Define evolution and explain how genetic variation and natural selection produce adaptations.

It is clear, then, that the relationships between evolution, and evolutionary psychology have been entwined with controversy. Nonetheless, it is also clear that the principles of evolution are not only extremely interesting, but one of the greatest scientific contributions ever made.

Evolutionary adaptations The products of natural selection are called **adaptations**, physical or behavioural changes that allow organisms to meet recurring environmental challenges to their survival, thereby increasing their reproductive ability. In the final analysis, the name of the natural selection game is to pass on one's genes, either personally or through kin who share at least some of them (Dawkins, 2006). Evolutionary theorists believe this is why animals and humans may risk, or even sacrifice, their lives in order to protect their kin and the genes they carry.

adaptations
physical or behavioural changes that allow organisms to meet recurring environmental challenges to their survival, thereby increasing their reproductive ability

In the animal kingdom, we find fascinating examples of adaptation to specific environmental conditions. For example, the tendency for one species of cannibalistic spider to eat its own kind decreases markedly if other food supplies are available. Genetically identical butterflies placed in different environments can take on completely different physical appearances depending on local climactic conditions during the larval stage of development. And in several species of tropical fish, imbalances in the ratio of males to females can actually result in males changing

Focus 3.15

How does brain evolution illustrate the natural selection of biological mechanisms?

into females or females into males (Schaller, 2006). If environmental factors can trigger such profound changes in insects and fish, should we be surprised if a species as remarkably flexible as humans would also adapt to environmental changes and evolve over time?

Applying concepts of natural selection and adaptation to human evolution begins with the notion that an organism's biology determines its behavioural capabilities, and that its behaviour (including its mental abilities) determines whether or not it will survive. In this sense, a discussion of the evolution of our biology, and our neurobiology, directly relates to the evolution of behaviour.

One theory is that when dwindling vegetation in some parts of the world forced ape-like animals down from the trees and required that they hunt for food on open, grassy plains, chances for survival were greater for those capable of *bipedal locomotion* (walking on two legs). By freeing the hands, bipedalism fostered the development and use of tools and weapons that could kill at a distance (Lewin, 1998). Hunting in groups and avoiding dangerous predators encouraged social organization, which required the development of specialized social roles (such as 'hunter and protector' in the male and 'nurturer of children' in the female) that still exist in most cultures. These environmental challenges also favoured the development of language, which enhanced social communication and the transmission of knowledge. In this manner, successful human behaviour evolved together with a changing body (Geary, 2005; Tooby and Cosmides, 1992).

Brain evolution Tool use, bipedal locomotion and social organization put new selection pressures on many parts of the body. These included the teeth, the hands and the pelvis, all of which changed over time in response to the new dietary and behavioural demands. But the greatest pressure was placed on the brain structures involved in the abilities most critical to the emerging way of life: attention, memory, language and thought. These mental abilities became important to survival in an environment that required quick learning and problem solving. In the evolutionary progression from *Australopithecus* (an early human ancestor who lived about 4 million years ago) through *Homo erectus* (1.6 million to 100 000 years ago) to the human subspecies Neanderthal of 75 000 years ago, the brain tripled in size, and the most dramatic growth occurred in the parts of the brain that are the seat of the higher mental processes (Fig. 3.14). Thus, evolved changes in behaviour seem to have contributed to the development of the brain, just as the growth of the brain contributed to evolving human behaviour (Striedter, 2005).

Surprisingly, perhaps, today's human brain does not differ much from the Stone Age brain of our ancient ancestors. Yet the fact that we perform mental activities that could not have been imagined

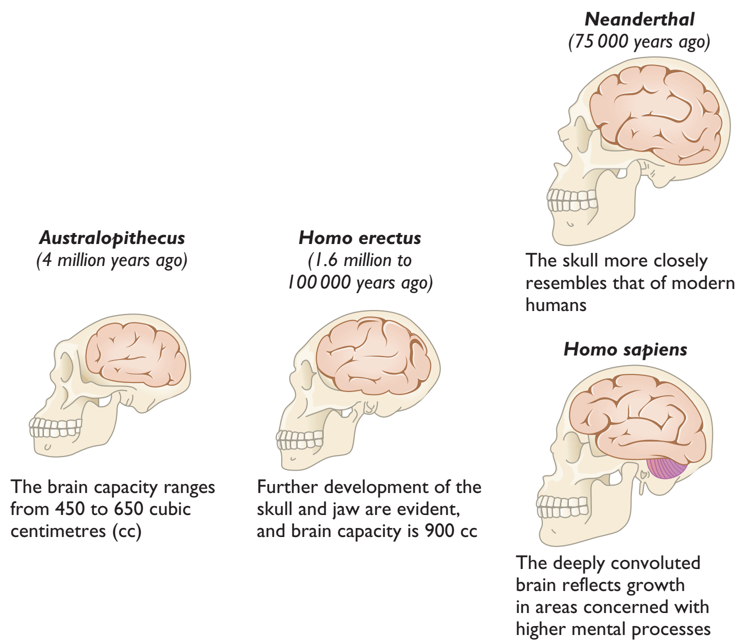


FIGURE 3.14

The human brain evolved over a period of several million years. The greatest growth occurred in those areas concerned with the higher mental processes, particularly memory, thought, and language. Current thought is that Neanderthal man took a different evolutionary route from Homo erectus, and is thus not our ancestor.

in those ancient times tells us that human capabilities are not solely determined by the brain; cultural evolution is also important in the development of adaptations. From an evolutionary perspective, culture provides important environmental inputs to evolutionary mechanisms (Boyd and Richerson, 2005). It is still debated, but there is general agreement among evolutionists that during early evolution, after *Homo erectus*, there came two separate strands in the evolutionary path. *Homo sapiens* took one path, and Neanderthal man another such that Neanderthals are not our evolutionary ancestor, but rather an evolutionary 'cousin' with whom we shared a common ancestor. Quite why Neanderthal man became extinct is unknown. Perhaps their abilities to adapt to climate changes and other environmental pressures were not as robust as those skills in *Homo sapiens*.

In a study of brain size across a variety of primate species Robin Dunbar (1993) observed that the average size of the neocortex in a given species is strongly related to the size of the social group that species can maintain. Dunbar thus suggests that the main reason for evolving larger brain is in order to maintain larger social groups. As part of his 'social brain hypothesis' he formulated a value called *Dunbar's Number* which describes the theoretical maximum size of social group that an individual can maintain. The number in humans is 150. Dunbar says that we can, theoretically at least, have, and maintain, a social grouping of up to 150 people in which we can fully understand their relationships with others in the group. Dunbar thus suggests that our social lives are constrained by the size of our neocortex (Dunbar, 1993).

Evoked culture According to the evolutionary concept of **evoked culture**, cultures may themselves be the product of biological mechanisms that evolved to meet specific adaptation challenges faced by specific groups of people in specific places at specific times. Through this process, a culture could develop in a setting in which survival depended on the male's success in hunting game that differed in important ways from a culture in a farming community in which women shared the 'breadwinner' role (Gangestad et al., 2006). In the shared-breadwinner culture, we might expect less sharply defined sex roles. Once established by successful adaptation, a culture is transmitted to future members through social learning, as has occurred for all of us in our own process of development. This serves to remind us of another truism: the creation of new environments through our own behaviour is another important part of the evolutionary equation (Boyd and Richerson, 2005). Through our own behaviours, humans can create environments that influence subsequent natural selection of biological traits suited to the new environment (Bandura, 1997).

evoked culture
the product of biological mechanisms that evolved to meet specific adaptation challenges faced by specific groups of people in specific places at specific times

WHAT DO YOU THINK?

NATURAL SELECTION AND GENETIC DISEASES

If Darwin was right about natural selection, then why do we have so many harmful genetic disorders? Consider, for example, cystic fibrosis, a hereditary disorder of European origin that clogs one's lungs with mucus and prevents digestion, typically causing death before age 30. Another example is sickle-cell anaemia, which causes early deaths in many people of African descent. Can you reconcile the existence of such disorders with 'survival of the fittest'? Think about it, then see p. 121.

EVOLUTION AND HUMAN NATURE

To evolutionary psychologists, what we call human nature is the expression of inborn biological tendencies that have evolved through natural selection. There exists a vast catalogue of human characteristics and capabilities that unfold in a normally developing human being. Consider, for example, this brief preview of commonalities in human behaviour that are discussed in greater detail in later chapters.

1. Infants are born with an ability to acquire any language spoken in the world (see Chapter 9). The specific languages learned depend on which ones they are exposed to. Deaf children have a similar ability to acquire any sign language, and their language acquisition pattern parallels the learning of spoken language. Language is central to human thought and communication.
2. Newborns are pre-wired to perceive specific stimuli (see Chapter 5). For example, they are more responsive to pictures of human faces than to pictures of the same facial features arranged in a random pattern (Johnson et al., 1991). They are also able to discriminate the odour of their mother's milk from that of other women (McFarlane, 1975). Both adaptations improve human bonding with caregivers.
3. At one week of age, human infants show primitive mathematical skills, successfully discriminating between two and three objects. These abilities improve with age in the absence of any training. The brain seems designed to make 'greater than' and 'less than' judgements, which are clearly important in decision making (Geary, 2005).
4. According to Robert Hogan (1983), establishing co-operative relationships with a group was critical to the human species' survival and reproductive success. Thus humans seem to have a need to belong and strongly fear being ostracized from the group (see Chapter 11). Social anxiety (fear of social disapproval) may be an adaptive mechanism to protect against doing things that will prompt group rejection (Baumeister and Tice, 1990).
5. As a species, humans tend to be altruistic and helpful to one another, especially to children and relatives (see Chapter 14). Research shows that altruism increases with degree of relatedness. Evolutionary theorists suggest that helping family members and relatives increases the likelihood that those people will be able to pass on the genes they share with you. People are also more likely to help younger people than older ones (Burnstein et al., 1994), perhaps because, from a species perspective, younger people have more reproductive value than do older people.
6. As we will see in Chapter 11, there is much evidence for a set of basic emotions that are universally recognized (Ekman, 1973). Smiling, for example, is a universal expression of happiness and goodwill that typically evokes positive reactions from others (Fig. 3.15). Emotions are important means of social communication that trigger mental, emotional and behavioural mechanisms in others (Ketellar, 1995).
7. In virtually all cultures, males are more violent and more likely to kill others (particularly other males) than are females. The differences are striking, with male–male killings outnumbering female–female killings, on average, by about 30 to one (Daly and Wilson, 1988). Evolutionary researchers suggest that male–male violence is rooted in hunting, establishing dominance hierarchies and competing successfully for the most fertile mates, all of which enhanced personal and reproductive survival as our species evolved.

Focus 3.16

How have evolutionary principles been used to account for diverse cultures?

Focus 3.17

Do genetically based diseases provide an argument against natural selection?

FIGURE 3.15

The human smile seems to be a universal expression of positive emotion and is universally perceived in that way. Evolutionary psychologists believe that expressions of basic emotions are hard-wired biological mechanisms that have adaptive value as methods of communication.

Having sampled from the wide range of behavioural phenomena that have been subjected to an evolutionary analysis, let us focus in greater detail on two areas of current theorizing that relate to both commonalities and differences among people – sex and self. Before doing so, however, we should emphasize a most important principle: *behaviour does not occur in a biological vacuum; it always involves a biological organism acting within (and often, in response to) an environment*. That environment may be inside the body in the form of interactions with other genes, influencing how genes and the protein molecules through which they operate express themselves. It may be inside the mother's womb, or it may be 'out there', in the form of a physical environment or a culture. Although everyone agrees that biological and environmental factors interact with one another, most of the debates in evolutionary psychology concern two issues: (1) how general or specific are the biological mechanisms that have evolved? and (2) how much are these mechanisms influenced in their expression by the environment?

Focus 3.18

Describe examples of human behaviour that suggest innate evolved mechanisms. Differentiate between remote and proximate causal factors.

Sexuality and Mate Preferences

The purpose of evolution is to continue the species, and the only way this can occur is through reproduction. In order to pass on one's genes and maintain the species, people must mate. We should not be surprised, therefore, that evolutionary theorists and researchers have devoted great attention to sexuality, differences between men and women, and mate-seeking. This topic also has generated considerable debate about the relative contributions of evolutionary and sociocultural factors to this domain of behaviour.

One of the most important and intimate ways that humans relate to one another is by seeking a mate. Marriage seems to be universal across the globe (Buss and Schmitt, 1993). In seeking mates, however, women and men display different mating strategies and preferences. Compared with women, men typically show more interest in short-term mating, prefer a greater number of short-term sexual partners, and have more permissive sexual attitudes and more sexual partners over their lifetimes (Schmitt et al., 2001). In one study of 266 undergraduates, two-thirds of the women said that they desired only one sexual partner over the next 30 years, but only about half of the men shared that goal (Pedersen et al., 2002). These attitudinal differences also extend to behaviour. In research done at three different universities, Russell Clark and Elaine Hatfield (1989; Clark, 1990) sent male and female research assistants of average physical attractiveness out across the campus. Upon seeing an attractive person of the opposite sex, the assistant approached the person, said he or she found the person attractive, and asked, 'Would you go to bed with me tonight?'

Women approached in this manner almost always reacted very negatively to the overture and frequently dismissed the assistants as 'sleaze' or 'pervert'. Not a single woman agreed to have sex. In contrast, three in every four men enthusiastically agreed, some asking why it was necessary to wait until that night. Other findings show that men think about sex about three times more often than women do, desire more frequent sex and initiate more sexual encounters than do women (Baumeister et al., 2001; Laumann et al., 1994). Men also are much more likely to interpret a woman's friendliness as a sexual come-on, apparently projecting their own sexual desires onto the woman (Johnson et al., 1992).

Despite these differences, most men and women make a commitment at some point in their lives to a long-term mate. What qualities do women and men seek in such a mate? Once again, we see sex differences. Men typically prefer women somewhat younger than themselves, whereas women prefer somewhat older men. This tendency is exaggerated in the 'trophy wives' sometimes exhibited by wealthy and famous older men. In terms of personal qualities, Table 3.4 shows the overall results of a worldwide study of mate preferences in 37 cultures (Buss et al., 1990). Men and women again show considerable overall agreement, but some differences emerge. Men place greater value on a potential mate's physical attractiveness and domestic skills, whereas women place greater value on a potential mate's earning potential, status and ambitiousness. But why might this be? Evolutionary psychologists have an answer.

TABLE 3.4 CHARACTERISTICS OF A MATE

Women and men rated each characteristic on a 4-point scale. From top to bottom, the following numbers represent the order (rank) of most highly rated to least highly rated items for Buss's worldwide sample. How would you rate their importance?

Characteristic desired in a mate	Rated by	
	Women	Men
Mutual attraction/love	1	1
Dependable character	2	2
Emotional stability/maturity	3	3
Pleasing disposition	4	4
Education/intelligence	5	6
Sociability	6	7
Good health	7	5
Desire for home/children	8	8
Ambition	9	11
Refinement	10	9
Similar education	11	14
Good financial prospect	12	13
Good looks	13	10
Social status	14	15
Good cook/housekeeper	15	12
Similar religion	16	17
Similar politics	17	18
Chastity	18	16

SOURCE: Based on Buss et al., 1990.

sexual strategies theory (and a related model called **parental investment theory**)
mating strategies and preferences reflect inherited tendencies, shaped over the ages in response to different types of adaptive problems that men and women faced

According to an evolutionary viewpoint called **sexual strategies theory** (and a related model called **parental investment theory**), mating strategies and preferences reflect inherited tendencies, shaped over the ages in response to different types of adaptive problems that men and women faced (Buss and Schmitt, 1993; Trivers, 1972). In evolutionary terms, our most successful ancestors were those who survived and passed down the greatest numbers of their genes to future generations. Men who had sex with more partners increased the likelihood of fathering more children, so they were interested in mating widely. Men also may have taken a woman's youth and attractive, healthy appearance as signs that she was fertile and had many years left to bear his children (Buss, 1989).

In contrast, ancestral women had little to gain and much to lose by mating with numerous men. They were interested in mating wisely, not widely. In humans and other mammals, females typically make a greater investment than males: they carry the foetus, incur health risks and possible birth-related death, and nourish the newborn. Engaging in short-term sexual relationships with multiple males can in the end create uncertainty about who is the father, thereby decreasing a male's willingness to commit resources to helping a mother raise the child. For these reasons, women maximized their reproductive success – and the survival chances of themselves and their offspring – by being selective and choosing mates who were willing and able to commit time, energy and other resources (e.g., food, shelter, protection) to the family. Women increased their likelihood of passing their genes into the future by mating wisely, and men by mating widely. Through natural selection, according to evolutionary psychologists, the differing qualities that maximized men's and women's reproductive success eventually became part of their biological nature (Buss, 2007).

Focus 3.19

Contrast sexual strategies and social structure explanations for mate preferences, citing results from cross-cultural research.

Steven Gangestad, Martie Haselton, and David Buss (2006) found that some of these mate preference patterns are more pronounced in parts of the world with historically high levels of pathogens (disease-causing germs) that endangered survival than in areas that had historically low levels of pathogens. Where diseases like malaria, plague and yellow fever are more prevalent, male factors such as physical attractiveness and robustness, intelligence and social dominance – all presumably signs of biological fitness – seem especially important to women even today. Gangestad et al. suggest that in such environments, women seem willing to sacrifice some degree of male investment in their offspring in favour of a mate who has a higher probability of giving them healthy children. To men, a woman's attractiveness and healthiness (and that of her family) also is more important in high-pathogen environments, presumably because these historically were signs of a woman who would be more likely to give birth to healthy children and live long enough to rear them.

Not all scientists have bought into this evolutionary explanation for human mating patterns and other social behaviours. Again, the disagreement revolves around the relative potency of interacting biological and environmental factors. In the case of mate selection, proponents of **social structure theory** maintains that men and women display different mating preferences not because nature impels them to do so, but because society guides them into different social roles (Eagly and Wood, 1999; 2006). Adaptive behaviour patterns may have been passed from parents to children not through genes but through learning. Social structure theorists point out that despite the shift over the past several decades towards greater gender equality, today's women still have generally less power, lower wages and less access to resources than do men. In a two-income marriage, the woman is more likely to be the partner who switches to part-time work or becomes a full-time homemaker after childbirth. Thus, society's division of labour still tends to socialize men into the breadwinner role and women into the homemaker role.

social structure theory

men and women display different mating preferences not because nature impels them to do so, but because society guides them into different social roles

Given these power and resource disparities and the need to care for children, it makes sense for women to seek men who will be successful wage earners and for men to seek women who can have children and fulfil the domestic-worker role. An older male–younger female age gap is favourable because older men are likely to be further along in earning power and younger women are more economically dependent, and this state of affairs conforms to cultural expectations of marital roles. This division-of-labour hypothesis does not directly address why men emphasize a mate's physical attractiveness more than women do, but Alice Eagly and Wendy Wood (1999) speculate that attractiveness is viewed as part of what women 'exchange' in return for a male's earning capacity (see Fig. 3.16).

We now have two competing explanations for sex differences in mating behaviour: the evolution-based sexual strategies approach and the social structure view. Our 'Research close-up' looks at one attempt to compare predictions derived from the two theories.

FIGURE 3.16

Marriages in which the woman is much younger than the man are far more common than are marriages in which the woman is far older. Is the tendency for woman to marry men older than themselves a remnant of evolutionary influences or a product of sociocultural forces?

RESEARCH CLOSE-UP

SEX DIFFERENCES IN THE IDEAL MATE: EVOLUTION OR SOCIAL ROLES?

SOURCES: D.M. Buss (1989) Sex differences in human mate preferences: evolutionary hypotheses tested in 37 cultures, *Behavioral and Brain Sciences*, Vol. 12, pp. 1–49; A. Eagly and W. Wood (1999) The origins of sex differences in human behavior: evolved dispositions versus social roles, *American Psychologist*, Vol. 54, pp. 408–23.

INTRODUCTION

How can we possibly test the hypothesis that, over the ages, evolution has shaped the psyches of men and women to be inherently different? Evolutionary psychologist David Buss proposes that, as a start, we can examine whether gender differences in mating preferences are similar across cultures. If they are, this would be consistent with the view that men and women follow universal, biologically based mating strategies that transcend culture. Based on principles of evolutionary psychology, Buss hypothesized that *across cultures*, men will prefer to marry younger women because such women have greater reproductive capacity; men will value a potential mate's attractiveness more than women will because men use attractiveness as a sign of health and fertility; and women will place greater value than men on a potential mate's earning potential because this provides survival advantages for the woman and her offspring.

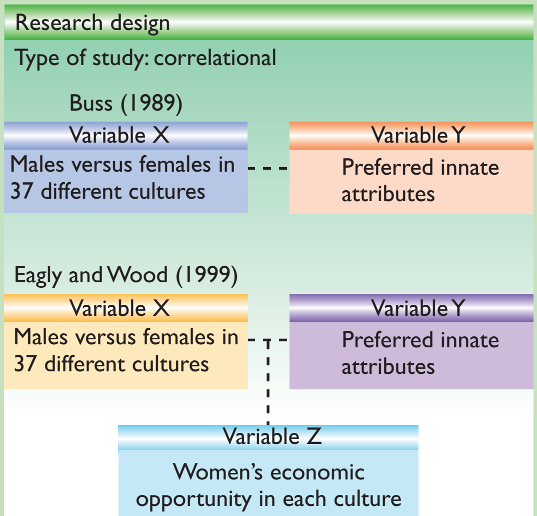
METHOD

Buss's team of 50 scientists administered questionnaires to women and men from 37 cultures around the globe. Although random sampling could not be used, the sample of 10 047 participants was ethnically, religiously and socio-economically diverse. Participants reported the ideal ages at which they and a spouse would marry, rank-ordered (from 'most desirable' to 'least desirable') a list of 13 qualities that a potential mate might have, and rated the importance of 18 mate qualities on a second list (see Table 3.4).

Alice Eagly and Wendy Wood wondered if men's and women's mate preferences might be influenced by a third variable, namely, cultural differences in gender roles and power differentials. To find out, they reanalysed Buss's data, using the United Nations Gender Empowerment Measure to assess the degree of gender equality in each of the cultures. This measure reflects women's earned income relative to men's, seats in parliament, and share of administrative, managerial, professional and technical jobs.

RESULTS

In all 37 cultures, men wanted to marry younger women. Overall, they believed that the ideal ages for men and women to marry were 27.5 and 24.8 years, respectively. Similarly, women preferred older men, reporting on average an ideal marriage age of 28.8 for husbands and 25.4 for wives. In every culture, men valued having a physically attractive mate more than women did, and in 36 of 37 cultures, women attached more importance than men did to a mate's earning potential.



EVOLUTIONARY AND SOCIAL ROLES INTERPRETATIONS

David Buss concluded that the findings strongly supported the predictions of evolutionary (sexual strategies) theory. Subsequently, Alice Eagly and Wendy Wood analysed Buss's data further in order to test two key predictions derived from their social structure theory:

1. Men place greater value than women on a mate's having good domestic skills because this is consistent with culturally defined gender roles.
2. If economic and power inequalities cause men and women to attach different values to a mate's age, earning potential and domestic skills, then these gender differences should be smaller in cultures where there is less inequality between men and women.

As reported by Buss, the potential-mate characteristic 'good cook/housekeeper' produced large overall gender differences, with men valuing it more highly. Could this overall trend, however, depend on differences in cultural roles or power differentials? As predicted by the social structure model, Eagly and Wood found that in cultures with greater gender equality, men showed less of a preference for younger women, women displayed less of a preference for older men, and the gender gap decreased in mate preferences for a 'good cook/housekeeper' and 'good financial prospect'. On the other hand, cultural gender equality did not influence the finding that men value physical attractiveness more than women; that gender difference was *not* smaller in cultures with greater gender equality.

DISCUSSION

Both Buss (Gangestad et al., 2006) and Eagly and Wood (2006) share an interactionist perspective on mate selection that simultaneously takes nature and nurture into account. They differ, however, on how specific and strongly programmed the biological dispositions are thought to be. When Buss found remarkably consistent sex differences in worldwide mate preferences, he interpreted this cross-cultural consistency as evidence that men and women follow universal, biologically based mating strategies. Yet Eagly and Wood (1999; 2006) insist that consistency in behaviour across cultures does not, by itself, demonstrate *why* those patterns occur. They view the mate selection preferences not as biologically pre-programmed, but rather as reflecting evolved but highly flexible dispositions that depend heavily on social input for their expression. In support of this position, they found that a commonly found social condition across cultures, gender inequality, accounts for some – but not all – of the sex differences in mating preferences.

In science, such controversy stimulates opposing camps to find more sophisticated ways to test their hypotheses. Ultimately, everyone's goal is to arrive at the most plausible explanation for behaviour. This is why scientists make their data available to one another, regardless of the possibility that their peers may use the data to bolster an opposing point of view.

Although men and women differ in some of their mating preferences and strategies, the similar overall order of mate preferences shown in Table 3.4 indicates that we are talking once again about shades of the same colour, not different colours. In fact, Buss and his co-workers (1990) found that 'there may be more similarity between men and women from the same culture than between men and men or women and women from different cultures' (p. 17).

evolutionary personality theory looks for the origin of presumably universal personality traits in the adaptive demands of our species' evolutionary history

Focus 3.20
How does evolutionary theory account for the universal nature of the Big Five personality traits and of variation on each of them?

Evolutionary Approaches To Personality

Personality is an especially interesting topic to consider from an evolutionary perspective because traditionally, evolutionary approaches are geared to explaining the things we have in common. An approach called **evolutionary personality theory** looks for the origin of presumably universal personality traits in the adaptive demands of our species' evolutionary history. It asks the basic question, 'Where did the personality traits exhibited by humans come from in the first place?' The focus here is on the traits that we (and other animals) have in common. But evolutionary personality theory also tries to account for the core question in the field of personality: why do we differ from one another in these personality traits?

Previously in this chapter, we described the five factor model of personality, the leading current trait theory. Because these five trait dimensions – extraversion, agreeableness, conscientiousness, neuroticism and openness to experience – have been found in people's descriptions of themselves and others in virtually all cultures, some theorists regard them as universal among humans (Nettle, 2006). And because evolutionary theory addresses human universals, the Big Five traits have been the major focus of evolutionary personality theory.

Why should these traits be found so consistently in the languages and behaviours of cultures around the world? According to David Buss (1999), they exist in humans because they have helped us achieve two overriding goals: physical survival and reproductive success. Traits such as extraversion and emotional stability would have been helpful in attaining positions of dominance and mate selection. Conscientiousness and agreeableness are important in group survival, as well as in reproduction and the care of children. Finally, because openness to experience may be the basis for problem solving and creative activities that could affect the ultimate survival of the species, there has always been a need for intelligent and creative people. Evolutionary theorists therefore regard the behaviours underlying the Big Five as sculpted by natural selection until they ultimately became part of human nature.

The five personality factors also may reflect the ways in which we are biologically programmed to think about and discriminate among people. Lewis Goldberg (1981) suggests that over the course of evolution, people have had to ask some very basic questions when interacting with another person, questions that have survival and reproductive implications:

1. Is person X active and dominant or passive and submissive? Can I dominate X, or will I have to submit to X?
2. Is X agreeable and friendly or hostile and uncooperative?
3. Can I count on X? Is X conscientious and dependable?

4. Is X sane (stable, rational, predictable) or crazy (unstable, unpredictable, possibly dangerous)?
5. How smart is X, and how quickly can X learn and adapt?

Not surprisingly, according to Goldberg, these questions relate directly to the Big Five factors. He believes that this is the reason analyses of trait ratings reveal Big Five consistency across very diverse cultures.

So much for commonalities in the personality traits that people exhibit. But what about the individual differences in these traits that we witness every day, and that define individual personalities? If natural selection is a winnowing process that favours certain personal characteristics over others, would we not expect people to become more alike over time and personality differences to be minimal? Here we turn to another important evolutionary concept called **strategic pluralism**, the idea that multiple – even contradictory – behavioural strategies (for example, introversion and extraversion) might be adaptive in certain environments and would therefore be maintained through natural selection. Thus, Daniel Nettle (2006) theorizes that we see variation in the Big Five traits because all of them have adaptive trade-offs (a balance of potential benefits and costs) in the outcomes they may produce.

strategic pluralism
the idea that multiple – even contradictory – behavioural strategies might be adaptive in certain environments and would therefore be maintained through natural selection

Take extraversion, for example. Nettle (2006) reviewed research showing that scores on personality tests that measure extraversion are positively related to the number of sexual partners that males have and to their willingness to abandon sexual relationships with women in order to pursue a more desirable partner. These behaviours should increase the prospects for reproducing lots of offspring. Compared with introverts, extraverts also have more social relationships, more positive emotions, greater social support, and are more adventurous and risk-taking, all of which can have benefits. The trade-offs, however, are greater likelihood of risk-produced accidents or illnesses, and a higher potential for antisocial behaviour (which in the ancestral environment might have resulted in ostracism or even death and in the current environment, imprisonment). For a woman, the outgoing demeanour of the extravert may facilitate attracting a mate, but also may lead to impulsive sexual choices that are counterproductive for her and her offspring. The trait of agreeableness brings with it the benefits of harmonious social relationships and the support of others, but also the risks of being exploited or victimized by others. Another potential cost of agreeableness arises from not sufficiently pursuing one's own personal interests; a little selfishness can be adaptive. Even neuroticism, which is generally viewed as a negative trait, has both costs and benefits that could relate to survival. On the cost side, neuroticism involves anxiety, depression and stress-related illness that could shorten the lifespan and drive potential mates away. But the fitness trade-off of neuroticism is a vigilance to potential dangers that could be life-saving, as well as fear of failing and a degree of competitiveness that could have adaptive achievement outcomes. Nettle believes that these trade-offs favour evolutionary variation in the Big Five traits and that the specific environment in which our ancestors evolved made it more or less adaptive to be an extravert or an introvert, agreeable or selfish, fearful or fearless, conscientious or immoral, and so on. This would help account for genes favouring individual differences on personality dimensions and for the great diversity we see in personality trait patterns.

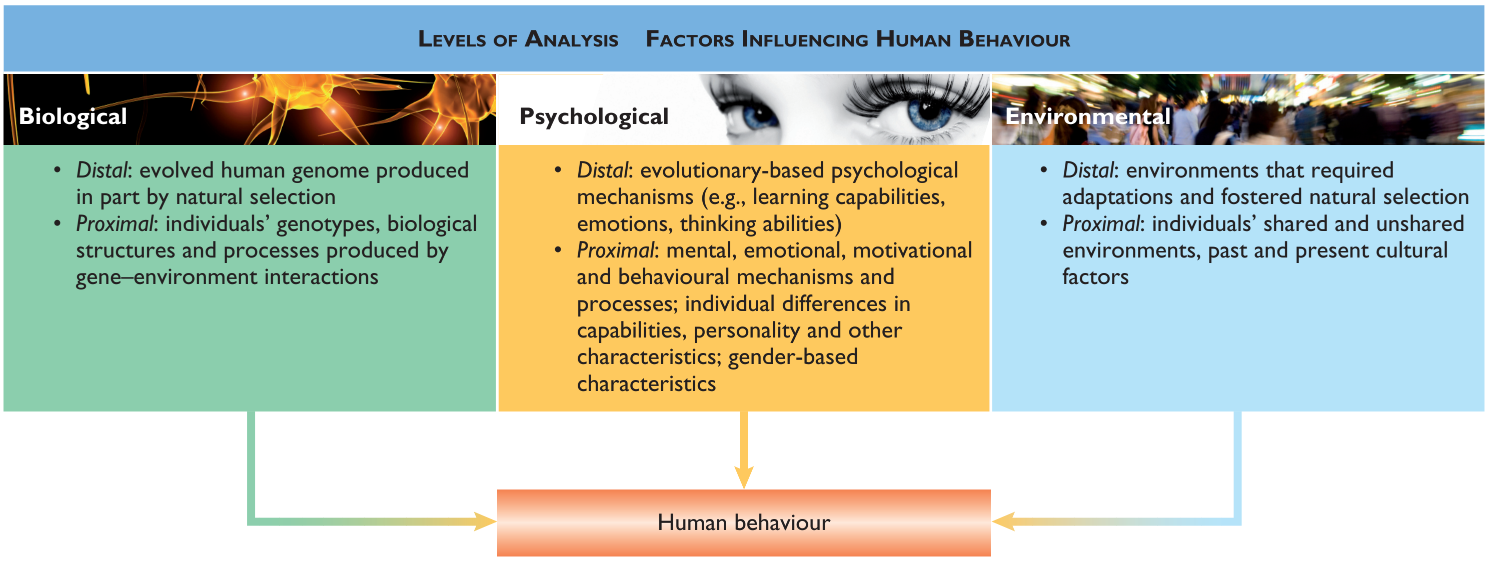
Evolutionary theorists also account for individual differences in personality traits by focusing on gene–environment interactions. Evolution may provide humans with species-typical behaviour patterns, but environmental inputs influence how they are manifested. For example, dominance may be the behaviour pattern encouraged by innate mechanisms in males, but an individual male who has many early experiences of being subdued or dominated may develop a submissive personality. For evolutionists who assume that the innate female behaviour pattern is submissiveness, an individual female who has the resources of high intelligence and physical strength may be quite willing and able to behave in a competitive and dominant fashion.

Focus 3.21
Describe some of the fallacies that can arise from misinterpreting evolutionary theory.

As we have seen throughout this chapter, genetic factors underlie evolutionary changes, and they strongly influence many aspects of our human behaviour. Genes do not act in isolation, however, but in concert with environmental factors, some of which are created by nature and some of which are of human origin. Together, these forces have forged the human psychological capabilities and processes that are the focus of psychological science. Figure 3.17 shows how the causes of behaviour can be studied at biological, psychological and environmental levels of analysis.

FIGURE 3.17

Levels of analysis: interacting biological, environmental, and psychological factors.



BENEATH THE SURFACE

HOW *NOT* TO THINK ABOUT EVOLUTIONARY THEORY

Evolutionary theory is an important and influential force in modern psychology. However, as we have seen, it is not without its controversial issues, which are both scientific and philosophical in nature. There also exist some widespread misconceptions about evolutionary theory.

First, some scientific issues. One has to do with the standards of evidence for or against evolutionary psychology. Adaptations are forged over a long period of time – perhaps thousands of generations – and we cannot go back to prehistoric times and determine with certainty what the environmental demands were. For this reason, evolutionary theorists are often forced to infer the forces to which our ancestors adapted, leading to after-the-fact speculation that is difficult to prove or disprove. A challenge for evolutionary theorists is to avoid the logical fallacy of circular reasoning: 'Why does behavioural tendency X exist?' 'Because of environmental demand Y.' 'How do we know that environmental demand Y existed?' 'Because otherwise behaviour X would not have developed.'

Evolutionary theorists also remind us that it is fallacious to attribute every human characteristic to natural selection (Clark and Grunstein, 2005; Lloyd and Feldman, 2002). In the distant past, as in the present, people created environments that shape behaviour, and those behaviours are often passed down through cultural learning instead of through natural selection. Likewise, a capability that evolved in the past for one reason may now be adaptive for something else. For example, the ability to discern shapes was undoubtedly advantageous for prehistoric hunters trying to spot game in the underbrush. Today, however, few humans in our culture need to hunt in order to survive, but those shape-discriminating capabilities are critical in perceiving letters and learning to read.

Evolutionary theorists have sometimes been accused of giving insufficient weight to cultural learning factors, and many debates about evolutionary explanations centre around this issue (Regal, 2005). Witness, for example, the dizzying changes that have occurred in world culture in the past 50 years as humans have altered their own environment. Modern evolutionary theorists acknowledge the role both of *remote causes* (including past evolutionary pressures that may have prompted natural selection) and *proximate* (more recent) *causes*, such as cultural learning and the immediate environment, that influence current behaviour. Human culture evolves as both a cause and an effect of brain and behavioural evolution (Boyd and Richerson, 2005). In other words, genes and environment affect one another over time.

In thinking about behaviour from an evolutionary point of view, it is important to avoid two other fallacies. One is **genetic determinism**, the idea that genes have invariant and unavoidable effects that cannot be altered. It makes no sense to conclude that because something in nature (such as males' greater tendency to be violent) is influenced by our genes, it is either unavoidable, natural or morally right. Although evolutionary theorists themselves argue against this view, it has been used to defend the status quo and also to conclude that if 'survival of the fittest' (a term actually coined by Herbert Spencer, not by Darwin) is the rule of nature, then those at the top of the social ladder are somehow the most fit of all and therefore 'the best people'. This notion of genetic superiority has had destructive consequences, not the least of which was the *eugenics* movement of the early twentieth century to prevent the 'less biologically fit' (particularly immigrants) from breeding, and Nazi Germany's programme of selective breeding designed to produce a 'master race'. As for the notion that genetically based behaviours are unalterable and therefore must be accepted, we should remember that all behaviours are a function of both the person's biology and the environment. In many cases, what we consider to be self-control or morality requires that we override 'natural' biologically based inclinations. Our ability to regulate our own behaviour and to exercise moral control is often just as important to our survival (i.e., as adaptive) as are our biological tendencies. Likewise, we can choose to alter the environment in order to override undesired behavioural tendencies, and many of the laws and sanctions that societies enact serve exactly that purpose.

genetic determinism
the idea that genes have invariant and unavoidable effects that cannot be altered

The second fallacy is the view that evolution is purposive, or 'has a plan'. There is, in fact, no plan in evolutionary theory; there is only adaptation to environmental demands and the natural selection process that results. The 'nature's plan' concept has sometimes been used to support the morality of certain acts, even destructive ones. The usual strategy is for proponents of some idea to find an example of what they believe to be a comparable behaviour occurring in the natural world and to use that example to support their own behaviour or cause as 'in accord with nature'. To use this argument to define what is ethically or morally correct is not appropriate. Although there are regularities in natural events that define certain 'laws of nature', judgements of morality are most appropriately based on cultural standards and philosophical considerations, and not on biological imperatives.

IN REVIEW

- Evolutionary psychology focuses on biologically based mechanisms sculpted by evolutionary forces as solutions to the problems of adaptation faced by species. Some of these genetically based mechanisms are general (e.g., the ability to learn from the consequences of our behaviour), whereas others are thought to be domain-specific, devoted to solving specific problems, such as mate selection.
- Evolution is a change over time in the frequency with which particular genes, and the characteristics they produce, occur within an interbreeding population. Evolution represents an interaction between biological and environmental factors.
- The cornerstone of Darwin's theory of evolution is the principle of natural selection. According to this principle, biologically based characteristics that contribute to survival and reproductive success increase in the population over time because those who lack the characteristics are less likely to pass on their genes. The concept of evoked culture implies that cultures also develop in response to adaptive demands specific to various human populations.
- Among the aspects of human behaviour that have received evolutionary explanations are human mate selection and personality traits. In research on mate selection, evolutionary explanations have been tested against hypotheses derived from social structure theory, which emphasizes the role of cultural factors.
- Critical thinking helps counter circular reasoning about evolutionary causes and effects, and challenges genetic determinism. We should also recognize that harmful genetically based behaviour tendencies can be overridden by human decision and self-control.

KEY TERMS AND CONCEPTS

Each term has been boldfaced and defined in the chapter on the page indicated in parentheses.

WHAT DO YOU THINK?

NATURAL SELECTION AND GENETIC DISEASES (p. 109)

Genetics research shows that in most cases, there's not a one-to-one relation between a particular gene and a particular trait. Most traits involve the influence of many genes, and a given gene can contribute to many traits. Traits, therefore, come in packages, with some of the traits in the package being adaptive and others maladaptive. In fact, cystic fibrosis (CF) is one such example. Cystic fibrosis is the most commonly inherited disorder among people of European descent. Why would such a damaging genetic trait survive in the gene pool? Geneticists have found that people with CF also have a trait that slows the release of salts into the intestine. Some scientists believe that this related trait might have helped save carriers from severe dehydration and death from the diarrhoeal diseases that killed seven out of every 10 newborns in medieval Europe. Perhaps CF was preserved in the population because another part of the trait package made carriers more likely to survive and pass on their genes.

Let us consider sickle-cell anaemia. Many people of African descent suffer from this genetically caused blood disorder that lowers life expectancy. Why would a disorder that decreases survival be preserved in a population? The answer may be that despite its negatives, the sickle cell gene has an important redeeming quality: it makes people more resistant to malaria, the most lethal disease in the African environment. Because it enhanced survival from malaria, the sickle cell trait became more common among Africans and can therefore be seen as a product of natural selection. This example shows us that we should be careful not to oversimplify the concept of adaptation and assume that any trait that survives, whether physical or psychological, is of immediate benefit to the species.