at the evolutionary emphasis on the Pleistocene Age may t be warranted. Moreover, our ancestors probably did t have a wide range of partners to choose from; what ay have evolved is mate selection based on similarity and oximity. The central issue dividing evolutionary theo- ts and their critics is the length of the "genetic leash."

E GENETICS OF DIFFERENCE

havioral geneticists often study differences among indi- luals by using data from studies of adopted children and *identical* and *fraternal twins*. These data yield an estimate the *heritability* of traits and abilities—the extent to which fferences in a trait or ability within a group of individuals e accounted for by genetic differences.

eritability estimates do not apply to specific individuals to differences between groups. They apply only to dif- ences within a particular group living in a particular vironment; for example, heritability is higher for chil- en in affluent families than in impoverished ones. And en highly heritable traits can often be modified by the vironment.

R HUMAN DIVERSITY: THE CASE INTELLIGENCE

eritability estimates for intelligence (as measured by IQ sts) average about .40 to .50 for children and adolescents d .60 to .80 for adults. Identical twins are more similar in)-test performance than fraternal twins, and adopted ildren's scores correlate more highly with those of their ological parents than with those of their nonbiological latives. These results do not mean that genes determine telligence; the remaining variance in IQ scores must be ie largely to environmental influences.

s we saw in "Biology and Intellect," the total volume of ay matter in the brain (which is highly heritable) has en correlated with general intelligence. And in bright children, the cerebral cortex starts out thinner than in other children but develops more rapidly and for a longer time. Several genes may influence IQ performance, but each one, if confirmed, is likely to contribute just a tiny piece to the puzzle of genetic variation in intelligence.

- It is a mistake to draw conclusions about *group* differences from heritability estimates based on differences *within* a group. The available evidence fails to support genetic explanations of black–white differences in performance on IQ tests.
- Environmental factors such as poor prenatal care, malnutrition, exposure to toxins, and stressful family circumstances are associated with lower performance on intelligence tests. Conversely, a healthy and stimulating environment, and certain kinds of enrichment activities, can improve performance. IQ scores have been rising in many countries for several generations, most likely because of improved education, better health, and the increase in jobs requiring abstract thought.

BEYOND NATURE VERSUS NURTURE

- New discoveries about the role of noncoding DNA, and findings in the field of *epigenetics*, show that the interaction between genes and environment is far more complex than anyone once imagined. Genetic and environmental influences blend and become indistinguishable in the development of any individual.

TAKING PSYCHOLOGY WITH YOU

- When deciding whether to have genetic testing, critical thinkers will consider the personal and social consequences, such as whether test results can reveal a risk that has practical relevance, could be misused by their employer or insurance company, might stigmatize them if others knew about it, would help them accept and live with a problem, or could create a self-fulfilling prophecy.

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SUMMARY

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UNLOCKING THE SECRETS OF GENES

- In general, *evolutionary psychologists* study our commonalities and *behavioral geneticists* study our differences. Historically, *nativists* have emphasized "nature" and *empiricists* "nurture" in explaining human behavior, but scientists today understand that heredity and environment interact to produce our psychological traits and even most of our physical ones. This interaction works in both directions: Genes affect the environments we choose, and the environment affects the activity of genes over our lifetimes.
- *Genes*, the basic units of heredity, are located on *chromosomes*, which consist of strands of *DNA*. Our genes, together with noncoding DNA, make up the human *genome*. Within each gene, a sequence of four elements of DNA constitutes a chemical code that helps determine the synthesis of a particular protein. In turn, proteins affect virtually all the structural and biochemical characteristics of the organism.
- Most human traits depend on more than one gene pair, which makes tracking down the genetic contributions to a trait extremely difficult. However, advances in technology now permit scientists to survey many DNA elements at once. An older method, the use of *linkage studies*, involves looking for patterns of inheritance of *genetic markers* whose locations on the genes are already known. But locating a gene does not automatically tell us what it does or how it does it, or how multiple genes interact and influence behavior.

THE GENETICS OF SIMILARITY

- Evolutionary psychologists argue that many fundamental human similarities can be traced to the processes of *evolution*, especially the process of *natural selection*. They draw inferences about the behavioral tendencies that might have been selected because they helped our forebears solve survival problems and enhanced reproductive fitness; they then do research to see if such tendencies actually exist throughout the world.
- Many evolutionary psychologists believe that the mind is not a general-purpose computer, but instead evolved as a collection of specialized *mental modules* to handle specific survival problems. Among the candidates for such modules are inborn reflexes, an attraction to novelty, a motive to explore and manipulate objects, an impulse to play, and the capacity for certain basic cognitive skills, including a rudimentary understanding of number. However, because some behavior or trait exists does not necessarily mean that it is adaptive or the product of natural selection.

OUR HUMAN HERITAGE: LANGUAGE

- Human beings are the only species that uses language to express and comprehend an infinite number of novel utterances. Noam Chomsky argued that the ability to take the *surface structure* of any utterance and apply rules of syntax to infer its underlying *deep structure* must depend on an innate faculty for language, a mental module that is sensitive to a *universal grammar* (features common to all languages). Many findings support this view: Children from different cultures go through similar stages of language development; children's language is full of *overregularizations* reflecting grammatical rules; adults do not consistently correct their children's syntax; groups of children who have never been exposed to adult language often invent their own; and young infants are able to derive linguistic rules from strings of sounds. An innate capacity for language may have evolved in humans because it enhanced the chances of survival and the establishment of social bonds.
- On the other hand, some scientists have devised models of language acquisition that do not assume an innate capacity (*computer neural networks*). Some argue that instead of inferring grammatical rules, children learn the statistical probability that any given word or syllable will follow another and learn syntactic patterns from the co-occurrence of nonadjacent words. And it seems clear that parental practices, such as recasting a child's incorrect sentence, do aid in language acquisition. It is likely, therefore, that biological readiness and experience interact in the development of language.

OUR HUMAN HERITAGE: COURTSHIP AND MATING

- *Sociobiologists* and evolutionary psychologists argue tha males and females have evolved different sexual an courtship strategies in response to survival problems face in the distant past. In this view, it has been adaptive f males to be promiscuous, to be attracted to young par ners, and to want sexual novelty; and for females to l monogamous, to be choosy about partners, and to pref security to novelty.
- Critics argue that evolutionary explanations of infidel and monogamy are based on simplistic stereotypes of ge der differences; that they rely too heavily on answers questionnaires, which often do not reflect real-life choic that convenience samples used in questionnaire studies not necessarily representative of people in general; a

SUMMARY

Neuropsychologists and other scientists study the brain because it is the bedrock of consciousness, perception, memory, and emotion.

THE NERVOUS SYSTEM: A BASIC BLUEPRINT

The function of the nervous system is to gather and process information, produce responses to stimuli, and coordinate the workings of different cells. Scientists divide it into the *central nervous system* (CNS) and the *peripheral nervous system* (PNS). The CNS, which includes the brain and *spinal cord*, receives, processes, interprets, and stores information and sends out messages destined for muscles, glands, and organs. The PNS transmits information to and from the CNS by way of *sensory* and *motor nerves*.

The peripheral nervous system consists of the *somatic nervous system*, which permits sensation and voluntary actions, and the *autonomic nervous system*, which regulates blood vessels, glands, and internal (visceral) organs. The autonomic system usually functions without conscious control. The autonomic nervous system is further divided into the *sympathetic nervous system*, which mobilizes the body for action, and the *parasympathetic nervous system*, which conserves energy.

COMMUNICATION IN THE NERVOUS SYSTEM

Neurons are the basic units of the nervous system. They are held in place by *glial cells*, which nourish, insulate, and protect them, and enable them to function properly. Each neuron consists of *dendrites*, a *cell body*, and an *axon*. In the peripheral nervous system, axons (and sometimes dendrites) are collected together in bundles called *nerves*. Many axons are insulated by a *myelin sheath* that speeds up the conduction of neural impulses and prevents signals in adjacent cells from interfering with one another.

Research has disproven two old assumptions: that neurons in the human central nervous system cannot be induced to regenerate and that no new neurons form after early infancy. In the laboratory, neurons have been induced to regenerate. And scientists have learned that *stem cells* in brain areas associated with learning and memory continue to divide and mature throughout adulthood, giving rise to new neurons. A stimulating environment seems to enhance this process of *neurogenesis*.

- Communication between two neurons occurs at the *synapse*. Many synapses have not yet formed at birth. During development, axons and dendrites continue to grow as a result of both physical maturation and experience with the world, and throughout life, new learning results in new synaptic connections in the brain. Thus, the brain's circuits are not fixed and immutable but are continually changing in response to information, challenges, and changes in the environment, a phenomenon known as *plasticity*. In some people who have been blind from an early age, brain regions usually devoted to vision are activated by sound—a dramatic example of plasticity.
- When a wave of electrical voltage (*action potential*) reaches the end of a transmitting axon, *neurotransmitter* molecules are released into the *synaptic cleft*. When these molecules bind to *receptor sites* on the receiving neuron, that neuron becomes either more likely to fire or less so. The message that reaches a final destination depends on how frequently particular neurons are firing, how many are firing, what types are firing, their degree of synchrony, and where they are located.
- Neurotransmitters play a critical role in mood, memory, and psychological well-being. Abnormal levels of neurotransmitters have been implicated in several disorders, such as Alzheimer's disease and Parkinson's disease.
- *Endorphins*, which act primarily by modifying the action of neurotransmitters, reduce pain and promote pleasure. Endorphin levels seem to shoot up when an animal or person is afraid or is under stress. Endorphins have also been linked to the pleasures of human attachment.
- *Hormones*, produced mainly by the *endocrine glands*, affect and are affected by the nervous system. Psychologists are especially interested in *melatonin*, which promotes sleep and helps regulate bodily rhythms; *oxytocin* and *vasopressin*, which play a role in attachment and trust; *adrenal hormones* such as *epinephrine* and *norepinephrine*, which are involved in emotions and stress; and the *sex hormones*, which are involved in the physical changes of puberty, the menstrual cycle (*estrogens* and *progesterone*), sexual arousal (*testosterone*), and some nonreproductive functions—including, some researchers believe, mental functioning.

MAPPING THE BRAIN

- Researchers study the brain by observing patients with brain damage; by using the lesion method with animals; and by

Some bioethicists and neuroscientists feel that cognitive enhancement is perfectly fine, because it is human nature for people to try to improve themselves and society will benefit when people learn faster and remember more. After all, we use eyeglasses to improve vision and hearing aids to improve hearing; why not use pills to improve our memories and other mental skills? One team of scientists has argued that improving brain function with pills is no more objectionable than eating right or getting a good night's sleep. They wrote, "In a world in which human workspans and lifespans are increasing, cognitive enhancement tools . . . will be increasingly useful for improved quality of life and extended work productivity, as well as to stave off normal and pathological age-related cognitive declines" (Greely et al., 2008).

Other scientists and social critics, however, consider cosmetic neurology to be a form of cheating that will give those who can afford the drugs an unfair advantage and increase socioeconomic inequalities. They think the issue is no different from the (prohibited) use of performance-enhancing steroids in athletics. Yes, people wear glasses and hearing aids, but glasses and hearing aids do not have side effects or interact negatively with other treatments. Many neuroethicists also worry that ambitious parents will start giving these medications to their children to try to boost the child's academic performance, despite possible hazards for the child's developing brain. One reporter covering the pros and cons of neuroenhancers concluded, "All this may be leading to the kind of society I'm not sure I want to live in: a society where we're even more overworked and driven by technology than we already are, and where we have to take drugs to keep up" (Talbot, 2009).

How about using drugs not to enhance memory but to erase it—especially memories of sorrowful and traumatic events? By altering the biochemistry of the brain in mice or rats, or using a toxin to kill targeted cells, researchers have been able to wipe out the animals' memories of a learned shock, their ability to recall a learned fear, or their memory of an object previously seen, while leaving other memories intact (Cao et al., 2008; Han et al., 2009; Serrano et al., 2008). If these results eventually apply to human beings, what, again, are the implications?

Some victims of sexual or physical abuse, wartime atrocities, or a sudden horrifying disaster might welcome the chance to be rid of their disturbing memories. But could a "delete" button for the brain be used too often, changing the storehouse of memories that make us who we are? Could memory erasure be misused by unscrupulous governments to eliminate dissent, as George Orwell famously predicted it would in his great novel *1984*? Should we wish to erase memories that evoke embarrassment or guilt, emotions that are unpleasant yet enable us to develop and retain a sense of morality and learn from our mistakes? And would we come to regret the obliteration of a part of our lives, as Jim Carrey did in the film *Eternal Sunshine of the Spotless Mind*? Such concerns may be the reason that most people, when asked if they would take a pill to eradicate a painful memory, respond loudly and clearly: No, thanks (Berkowitz et al., 2008).

In contrast, many people might say "Yes, please" to brain-enhancing drugs. But before they do, they will need to think critically—by separating anecdotes from data, real dangers from false alarms, and immediate benefits from long-term risks. What is to be gained from neuroenhancers, and what might be lost?

Cosmetic Brain Surgery

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