3.1 Human Genetics

Learning Objectives

By the end of this section, you will be able to:

- Explain the basic principles of the theory of evolution by natural selection
- Describe the differences between genotype and phenotype
- Discuss how gene-environment interactions are critical for expression of physical and psychological characteristics

Psychological researchers study genetics in order to better understand the biological basis that contributes to certain behaviors. While all humans share certain biological mechanisms, we are each unique. And while our bodies have many of the same parts—brains and hormones and cells with genetic codes—these are expressed in a wide variety of behaviors, thoughts, and reactions.

Why do two people infected by the same disease have different outcomes: one surviving and one succumbing to the ailment? How are genetic diseases passed through family lines? Are there genetic components to psychological disorders, such as depression or schizophrenia? To what extent might there be a psychological basis to health conditions such as childhood obesity?

To explore these questions, let's start by focusing on a specific disease, sickle-cell anemia, and how it might affect two infected sisters. Sickle-cell anemia is a genetic condition in which red blood cells, which are normally round, take on a crescent-like shape (**Figure 3.2**). The changed shape of these cells affects how they function: sickle-shaped cells can clog blood vessels and block blood flow, leading to high fever, severe pain, swelling, and tissue damage.

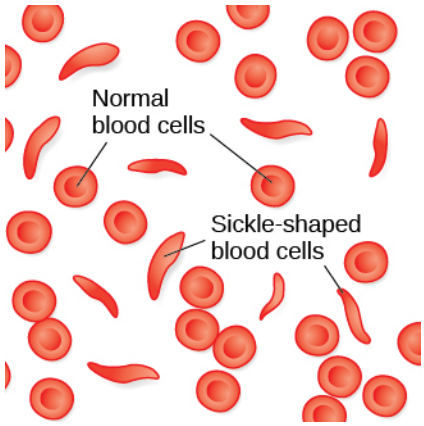


Figure 3.2 Normal blood cells travel freely through the blood vessels, while sickle-shaped cells form blockages preventing blood flow.

Many people with sickle-cell anemia—and the particular genetic mutation that causes it—die at an early age. While the notion of "survival of the fittest" may suggest that people suffering from this disease have a low survival rate and therefore the disease will become less common, this is not the case. Despite the negative evolutionary effects associated with this genetic mutation, the sickle-cell gene remains relatively common among people of African descent. Why is this? The explanation is illustrated with the following scenario.

Imagine two young women—Luwi and Sena—sisters in rural Zambia, Africa. Luwi carries the gene for sickle-cell anemia; Sena does not carry the gene. Sickle-cell carriers have one copy of the sickle-cell gene but do not have full-blown sickle-cell anemia. They experience symptoms only if they are severely dehydrated or are deprived of oxygen (as in mountain climbing). Carriers are thought to be immune from malaria

(an often deadly disease that is widespread in tropical climates) because changes in their blood chemistry and immune functioning prevent the malaria parasite from having its effects (Gong, Parikh, Rosenthal, & Greenhouse, 2013). However, full-blown sickle-cell anemia, with two copies of the sickle-cell gene, does not provide immunity to malaria.

While walking home from school, both sisters are bitten by mosquitos carrying the malaria parasite. Luwi does not get malaria because she carries the sickle-cell mutation. Sena, on the other hand, develops malaria and dies just two weeks later. Luwi survives and eventually has children, to whom she may pass on the sickle-cell mutation.

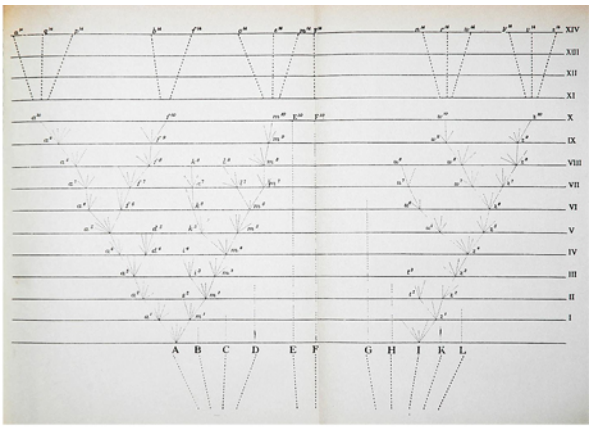
LINK TO LEARNING

Visit this **website (http://openstaxcollege.org/l/sickle1)** to learn more about how a mutation in DNA leads to sickle-cell anemia.

Malaria is rare in the United States, so the sickle-cell gene benefits nobody: the gene manifests primarily in health problems—minor in carriers, severe in the full-blown disease—with no health benefits for carriers. However, the situation is quite different in other parts of the world. In parts of Africa where malaria is prevalent, having the sickle-cell mutation does provide health benefits for carriers (protection from malaria).

This is precisely the situation that Charles Darwin describes in the **theory of evolution by natural selection** (**Figure 3.3**). In simple terms, the theory states that organisms that are better suited for their environment will survive and reproduce, while those that are poorly suited for their environment will die off. In our example, we can see that as a carrier, Luwi's mutation is highly adaptive in her African homeland; however, if she resided in the United States (where malaria is much less common), her mutation could prove costly—with a high probability of the disease in her descendants and minor health problems of her own.

(a)



(b)

Figure 3.3 (a) In 1859, Charles Darwin proposed his theory of evolution by natural selection in his book, *On the Origin of Species*. (b) The book contains just one illustration: this diagram that shows how species evolve over time through natural selection.

DIG DEEPER

Two Perspectives on Genetics and Behavior

It's easy to get confused about two fields that study the interaction of genes and the environment, such as the fields of evolutionary psychology and behavioral genetics. How can we tell them apart?

In both fields, it is understood that genes not only code for particular traits, but also contribute to certain patterns of cognition and behavior. Evolutionary psychology focuses on how universal patterns of behavior and cognitive processes have evolved over time. Therefore, variations in cognition and behavior would make individuals more or less successful in reproducing and passing those genes to their offspring. Evolutionary psychologists study a variety of psychological phenomena that may have evolved as adaptations, including fear response, food preferences, mate selection, and cooperative behaviors (Confer et al., 2010).

Whereas evolutionary psychologists focus on universal patterns that evolved over millions of years, behavioral geneticists study how individual differences arise, in the present, through the interaction of genes and the environment. When studying human behavior, behavioral geneticists often employ twin and adoption studies to research questions of interest. Twin studies compare the rates that a given behavioral trait is shared among identical and fraternal twins; adoption studies compare those rates among biologically related relatives and adopted relatives. Both approaches provide some insight into the relative importance of genes and environment for the expression of a given trait.

LINK TO LEARNING

Watch this **interview (http://openstaxcollege.org/l/buss)** with renowned evolutionary psychologist Davis Buss for an explanation of how a psychologist approaches evolution and how this approach fits within the field of social science.

GENETIC VARIATION

Genetic variation, the genetic difference between individuals, is what contributes to a species' adaptation to its environment. In humans, genetic variation begins with an egg, about 100 million sperm, and fertilization. Fertile women ovulate roughly once per month, releasing an egg from follicles in the ovary. The egg travels, via the fallopian tube, from the ovary to the uterus, where it may be fertilized by a sperm.

The egg and the sperm each contain 23 chromosomes. **Chromosomes** are long strings of genetic material known as **deoxyribonucleic acid (DNA)**. DNA is a helix-shaped molecule made up of nucleotide base pairs. In each chromosome, sequences of DNA make up **genes** that control or partially control a number of visible characteristics, known as traits, such as eye color, hair color, and so on. A single gene may have multiple possible variations, or alleles. An **allele** is a specific version of a gene. So, a given gene may code for the trait of hair color, and the different alleles of that gene affect which hair color an individual has.

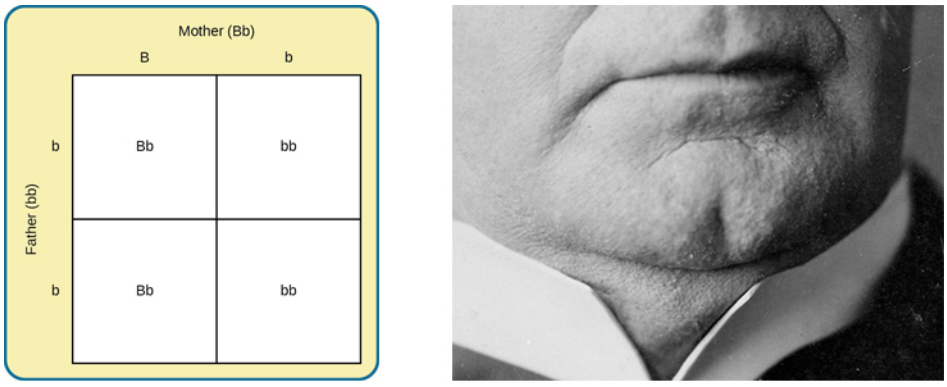
When a sperm and egg fuse, their 23 chromosomes pair up and create a zygote with 23 pairs of chromosomes. Therefore, each parent contributes half the genetic information carried by the offspring; the resulting physical characteristics of the offspring (called the phenotype) are determined by the interaction of genetic material supplied by the parents (called the genotype). A person's **genotype** is the genetic makeup of that individual. **Phenotype**, on the other hand, refers to the individual's inherited physical characteristics (**Figure 3.4**).

(a) (b)

Figure 3.4 (a) Genotype refers to the genetic makeup of an individual based on the genetic material (DNA) inherited from one's parents. (b) Phenotype describes an individual's observable characteristics, such as hair color, skin color, height, and build. (credit a: modification of work by Caroline Davis; credit b: modification of work by Cory Zanker)

Most traits are controlled by multiple genes, but some traits are controlled by one gene. A characteristic like cleft chin, for example, is influenced by a single gene from each parent. In this example, we will call the gene for cleft chin "B," and the gene for smooth chin "b." Cleft chin is a dominant trait, which means that having the **dominant allele** either from one parent (Bb) or both parents (BB) will always result in the phenotype associated with the dominant allele. When someone has two copies of the same allele, they are said to be **homozygous** for that allele. When someone has a combination of alleles for a given gene, they are said to be **heterozygous**. For example, smooth chin is a recessive trait, which means that an individual will only display the smooth chin phenotype if they are homozygous for that **recessive allele** (bb).

Imagine that a woman with a cleft chin mates with a man with a smooth chin. What type of chin will their child have? The answer to that depends on which alleles each parent carries. If the woman is homozygous for cleft chin (BB), her offspring will always have cleft chin. It gets a little more complicated, however, if the mother is heterozygous for this gene (Bb). Since the father has a smooth chin—therefore homozygous for the recessive allele (bb)—we can expect the offspring to have a 50% chance of having a cleft chin and a 50% chance of having a smooth chin (**Figure 3.5**).



(a) (b)

Figure 3.5 (a) A Punnett square is a tool used to predict how genes will interact in the production of offspring. The capital B represents the dominant allele, and the lowercase b represents the recessive allele. In the example of the cleft chin, where B is cleft chin (dominant allele), wherever a pair contains the dominant allele, B, you can expect a cleft chin phenotype. You can expect a smooth chin phenotype only when there are two copies of the recessive allele, bb. (b) A cleft chin, shown here, is an inherited trait.

Sickle-cell anemia is just one of many genetic disorders caused by the pairing of two recessive genes. For example, phenylketonuria (PKU) is a condition in which individuals lack an enzyme that normally converts harmful amino acids into harmless byproducts. If someone with this condition goes untreated, he or she will experience significant deficits in cognitive function, seizures, and increased risk of various

psychiatric disorders. Because PKU is a recessive trait, each parent must have at least one copy of the recessive allele in order to produce a child with the condition (**Figure 3.6**).

So far, we have discussed traits that involve just one gene, but few human characteristics are controlled by a single gene. Most traits are **polygenic**: controlled by more than one gene. Height is one example of a polygenic trait, as are skin color and weight.

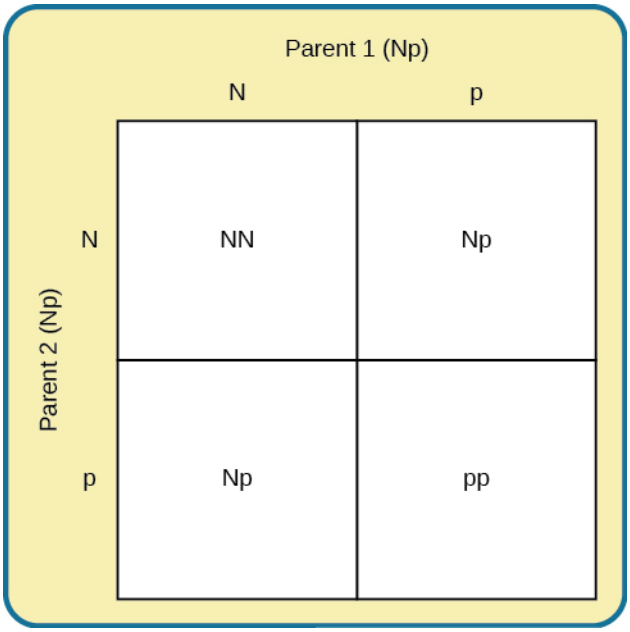


Figure 3.6 In this Punnett square, N represents the normal allele, and p represents the recessive allele that is associated with PKU. If two individuals mate who are both heterozygous for the allele associated with PKU, their offspring have a 25% chance of expressing the PKU phenotype.

Where do harmful genes that contribute to diseases like PKU come from? Gene mutations provide one source of harmful genes. A **mutation** is a sudden, permanent change in a gene. While many mutations can be harmful or lethal, once in a while, a mutation benefits an individual by giving that person an advantage over those who do not have the mutation. Recall that the theory of evolution asserts that individuals best adapted to their particular environments are more likely to reproduce and pass on their genes to future generations. In order for this process to occur, there must be competition—more technically, there must be variability in genes (and resultant traits) that allow for variation in adaptability to the environment. If a population consisted of identical individuals, then any dramatic changes in the environment would affect everyone in the same way, and there would be no variation in selection. In contrast, diversity in genes and associated traits allows some individuals to perform slightly better than others when faced with environmental change. This creates a distinct advantage for individuals best suited for their environments in terms of successful reproduction and genetic transmission.

GENE-ENVIRONMENT INTERACTIONS

Genes do not exist in a vacuum. Although we are all biological organisms, we also exist in an environment that is incredibly important in determining not only when and how our genes express themselves, but also in what combination. Each of us represents a unique interaction between our genetic makeup and our environment; range of reaction is one way to describe this interaction. **Range of reaction** asserts that our genes set the boundaries within which we can operate, and our environment interacts with the genes to determine where in that range we will fall. For example, if an individual's genetic makeup predisposes her to high levels of intellectual potential and she is reared in a rich, stimulating environment, then she will be more likely to achieve her full potential than if she were raised under conditions of significant deprivation.

According to the concept of range of reaction, genes set definite limits on potential, and environment determines how much of that potential is achieved. Some disagree with this theory and argue that genes do not set a limit on a person's potential.

Another perspective on the interaction between genes and the environment is the concept of **genetic environmental correlation**. Stated simply, our genes influence our environment, and our environment influences the expression of our genes (**Figure 3.7**). Not only do our genes and environment interact, as in range of reaction, but they also influence one another bidirectionally. For example, the child of an NBA player would probably be exposed to basketball from an early age. Such exposure might allow the child to realize his or her full genetic, athletic potential. Thus, the parents' genes, which the child shares, influence the child's environment, and that environment, in turn, is well suited to support the child's genetic potential.

Figure 3.7 Nature and nurture work together like complex pieces of a human puzzle. The interaction of our environment and genes makes us the individuals we are. (credit "puzzle": modification of work by Cory Zanker; credit "houses": modification of work by Ben Salter; credit "DNA": modification of work by NHGRI)

In another approach to gene-environment interactions, the field of **epigenetics** looks beyond the genotype itself and studies how the same genotype can be expressed in different ways. In other words, researchers study how the same genotype can lead to very different phenotypes. As mentioned earlier, gene expression is often influenced by environmental context in ways that are not entirely obvious. For instance, identical twins share the same genetic information (**identical twins** develop from a single fertilized egg that split, so the genetic material is exactly the same in each; in contrast, **fraternal twins** develop from two different eggs fertilized by different sperm, so the genetic material varies as with non-twin siblings). But even with identical genes, there remains an incredible amount of variability in how gene expression can unfold over the course of each twin's life. Sometimes, one twin will develop a disease and the other will not. In one example, Tiffany, an identical twin, died from cancer at age 7, but her twin, now 19 years old, has never had cancer. Although these individuals share an identical genotype, their phenotypes differ as a result of how that genetic information is expressed over time. The epigenetic perspective is very different from range of reaction, because here the genotype is not fixed and limited.

LINK TO LEARNING

Visit this **site (http://openstaxcollege.org/l/twinstudy)** for an engaging video primer on the epigenetics of twin studies.

Genes affect more than our physical characteristics. Indeed, scientists have found genetic linkages to a number of behavioral characteristics, ranging from basic personality traits to sexual orientation to spirituality (for examples, see Mustanski et al., 2005; Comings, Gonzales, Saucier, Johnson, & MacMurray, 2000). Genes are also associated with temperament and a number of psychological disorders, such as depression and schizophrenia. So while it is true that genes provide the biological blueprints for our cells, tissues, organs, and body, they also have significant impact on our experiences and our behaviors.

Let's look at the following findings regarding schizophrenia in light of our three views of gene-environment interactions. Which view do you think best explains this evidence?

In a study of people who were given up for adoption, adoptees whose biological mothers had schizophrenia *and* who had been raised in a disturbed family environment were much more likely to develop schizophrenia or another psychotic disorder than were any of the other groups in the study:

- Of adoptees whose biological mothers had schizophrenia (high genetic risk) and who were raised in disturbed family environments, 36.8% were likely to develop schizophrenia.
- Of adoptees whose biological mothers had schizophrenia (high genetic risk) and who were raised in healthy family environments, 5.8% were likely to develop schizophrenia.
- Of adoptees with a low genetic risk (whose mothers did not have schizophrenia) and who were raised in disturbed family environments, 5.3% were likely to develop schizophrenia.
- Of adoptees with a low genetic risk (whose mothers did not have schizophrenia) and who were raised in healthy family environments, 4.8% were likely to develop schizophrenia (Tienari et al., 2004).

The study shows that adoptees with high genetic risk were especially likely to develop schizophrenia only if they were raised in disturbed home environments. This research lends credibility to the notion that both genetic vulnerability and environmental stress are necessary for schizophrenia to develop, and that genes alone do not tell the full tale.

Key Terms

action potential electrical signal that moves down the neuron's axon

adrenal gland sits atop our kidneys and secretes hormones involved in the stress response

agonist drug that mimics or strengthens the effects of a neurotransmitter

all-or-none phenomenon that incoming signal from another neuron is either sufficient or insufficient to reach the threshold of excitation

allele specific version of a gene

amygdala structure in the limbic system involved in our experience of emotion and tying emotional meaning to our memories

antagonist drug that blocks or impedes the normal activity of a given neurotransmitter

auditory cortex strip of cortex in the temporal lobe that is responsible for processing auditory information

autonomic nervous system controls our internal organs and glands

axon major extension of the soma

biological perspective view that psychological disorders like depression and schizophrenia are associated with imbalances in one or more neurotransmitter systems

Broca's area region in the left hemisphere that is essential for language production

central nervous system (CNS) brain and spinal cord

cerebellum hindbrain structure that controls our balance, coordination, movement, and motor skills, and it is thought to be important in processing some types of memory

cerebral cortex surface of the brain that is associated with our highest mental capabilities

chromosome long strand of genetic information

computerized tomography (CT) scan imaging technique in which a computer coordinates and integrates multiple x-rays of a given area

corpus callosum thick band of neural fibers connecting the brain's two hemispheres

dendrite branch-like extension of the soma that receives incoming signals from other neurons

deoxyribonucleic acid (DNA) helix-shaped molecule made of nucleotide base pairs

diabetes disease related to insufficient insulin production

dominant allele allele whose phenotype will be expressed in an individual that possesses that allele

electroencephalography (EEG) recording the electrical activity of the brain via electrodes on the scalp

endocrine system series of glands that produce chemical substances known as hormones

epigenetics study of gene-environment interactions, such as how the same genotype leads to different phenotypes

fight or flight response activation of the sympathetic division of the autonomic nervous system, allowing access to energy reserves and heightened sensory capacity so that we might fight off a given threat or run away to safety

forebrain largest part of the brain, containing the cerebral cortex, the thalamus, and the limbic system, among other structures

fraternal twins twins who develop from two different eggs fertilized by different sperm, so their genetic material varies the same as in non-twin siblings

frontal lobe part of the cerebral cortex involved in reasoning, motor control, emotion, and language; contains motor cortex

functional magnetic resonance imaging (fMRI) MRI that shows changes in metabolic activity over time

gene sequence of DNA that controls or partially controls physical characteristics

genetic environmental correlation view of gene-environment interaction that asserts our genes affect our environment, and our environment influences the expression of our genes

genotype genetic makeup of an individual

glial cell nervous system cell that provides physical and metabolic support to neurons, including neuronal insulation and communication, and nutrient and waste transport

gonad secretes sexual hormones, which are important for successful reproduction, and mediate both sexual motivation and behavior

gyrus (plural: gyri) bump or ridge on the cerebral cortex

hemisphere left or right half of the brain

heterozygous consisting of two different alleles

hindbrain division of the brain containing the medulla, pons, and cerebellum

hippocampus structure in the temporal lobe associated with learning and memory

homeostasis state of equilibrium—biological conditions, such as body temperature, are maintained at optimal levels

homozygous consisting of two identical alleles

hormone chemical messenger released by endocrine glands

hypothalamus forebrain structure that regulates sexual motivation and behavior and a number of homeostatic processes; serves as an interface between the nervous system and the endocrine system

identical twins twins that develop from the same sperm and egg

lateralization concept that each hemisphere of the brain is associated with specialized functions

limbic system collection of structures involved in processing emotion and memory

longitudinal fissure deep groove in the brain's cortex

magnetic resonance imaging (MRI) magnetic fields used to produce a picture of the tissue being imaged

medulla hindbrain structure that controls automated processes like breathing, blood pressure, and heart rate

membrane potential difference in charge across the neuronal membrane

midbrain division of the brain located between the forebrain and the hindbrain; contains the reticular formation

motor cortex strip of cortex involved in planning and coordinating movement

mutation sudden, permanent change in a gene

myelin sheath fatty substance that insulates axons

neuron cells in the nervous system that act as interconnected information processors, which are essential for all of the tasks of the nervous system

neurotransmitter chemical messenger of the nervous system

occipital lobe part of the cerebral cortex associated with visual processing; contains the primary visual cortex

pancreas secretes hormones that regulate blood sugar

parasympathetic nervous system associated with routine, day-to-day operations of the body

parietal lobe part of the cerebral cortex involved in processing various sensory and perceptual information; contains the primary somatosensory cortex

peripheral nervous system (PNS) connects the brain and spinal cord to the muscles, organs and senses in the periphery of the body

phenotype individual's inheritable physical characteristics

pituitary gland secretes a number of key hormones, which regulate fluid levels in the body, and a number of messenger hormones, which direct the activity of other glands in the endocrine system

polygenic multiple genes affecting a given trait

pons hindbrain structure that connects the brain and spinal cord; involved in regulating brain activity during sleep

positron emission tomography (PET) scan involves injecting individuals with a mildly radioactive substance and monitoring changes in blood flow to different regions of the brain

prefrontal cortex area in the frontal lobe responsible for higher-level cognitive functioning

psychotropic medication drugs that treat psychiatric symptoms by restoring neurotransmitter balance

range of reaction asserts our genes set the boundaries within which we can operate, and our environment interacts with the genes to determine where in that range we will fall

receptor protein on the cell surface where neurotransmitters attach

recessive allele allele whose phenotype will be expressed only if an individual is homozygous for that allele

resting potential the state of readiness of a neuron membrane's potential between signals

reticular formation midbrain structure important in regulating the sleep/wake cycle, arousal, alertness, and motor activity

reuptake neurotransmitter is pumped back into the neuron that released it

semipermeable membrane cell membrane that allows smaller molecules or molecules without an electrical charge to pass through it, while stopping larger or highly charged molecules

soma cell body

somatic nervous system relays sensory and motor information to and from the CNS

somatosensory cortex essential for processing sensory information from across the body, such as touch, temperature, and pain

substantia nigra midbrain structure where dopamine is produced; involved in control of movement

sulcus (plural: sulci) depressions or grooves in the cerebral cortex

sympathetic nervous system involved in stress-related activities and functions

synapse small gap between two neurons where communication occurs

synaptic vesicle storage site for neurotransmitters

temporal lobe part of cerebral cortex associated with hearing, memory, emotion, and some aspects of language; contains primary auditory cortex

terminal button axon terminal containing synaptic vesicles

thalamus sensory relay for the brain

theory of evolution by natural selection states that organisms that are better suited for their environments will survive and reproduce compared to those that are poorly suited for their environments

threshold of excitation level of charge in the membrane that causes the neuron to become active

thyroid secretes hormones that regulate growth, metabolism, and appetite

ventral tegmental area (VTA) midbrain structure where dopamine is produced: associated with mood, reward, and addiction

Wernicke's area important for speech comprehension

Summary

3.1 Human Genetics

Genes are sequences of DNA that code for a particular trait. Different versions of a gene are called alleles—sometimes alleles can be classified as dominant or recessive. A dominant allele always results in the dominant phenotype. In order to exhibit a recessive phenotype, an individual must be homozygous for the recessive allele. Genes affect both physical and psychological characteristics. Ultimately, how and when a gene is expressed, and what the outcome will be—in terms of both physical and psychological characteristics—is a function of the interaction between our genes and our environments.

3.2 Cells of the Nervous System

Glia and neurons are the two cell types that make up the nervous system. While glia generally play supporting roles, the communication between neurons is fundamental to all of the functions associated with the nervous system. Neuronal communication is made possible by the neuron's specialized structures. The soma contains the cell nucleus, and the dendrites extend from the soma in tree-like branches. The axon is another major extension of the cell body; axons are often covered by a myelin sheath, which increases the speed of transmission of neural impulses. At the end of the axon are terminal buttons that contain synaptic vesicles filled with neurotransmitters.

Neuronal communication is an electrochemical event. The dendrites contain receptors for neurotransmitters released by nearby neurons. If the signals received from other neurons are sufficiently strong, an action potential will travel down the length of the axon to the terminal buttons, resulting in the release of neurotransmitters into the synapse. Action potentials operate on the all-or-none principle and involve the movement of Na^+ and K^+ across the neuronal membrane.

Different neurotransmitters are associated with different functions. Often, psychological disorders involve imbalances in a given neurotransmitter system. Therefore, psychotropic drugs are prescribed in an attempt to bring the neurotransmitters back into balance. Drugs can act either as agonists or as antagonists for a given neurotransmitter system.

3.3 Parts of the Nervous System

The brain and spinal cord make up the central nervous system. The peripheral nervous system is comprised of the somatic and autonomic nervous systems. The somatic nervous system transmits sensory and motor signals to and from the central nervous system. The autonomic nervous system controls the function of our organs and glands, and can be divided into the sympathetic and parasympathetic divisions. Sympathetic activation prepares us for fight or flight, while parasympathetic activation is associated with normal functioning under relaxed conditions.

3.4 The Brain and Spinal Cord

The brain consists of two hemispheres, each controlling the opposite side of the body. Each hemisphere can be subdivided into different lobes: frontal, parietal, temporal, and occipital. In addition to the lobes of the cerebral cortex, the forebrain includes the thalamus (sensory relay) and limbic system (emotion and memory circuit). The midbrain contains the reticular formation, which is important for sleep and arousal, as well as the substantia nigra and ventral tegmental area. These structures are important for movement, reward, and addictive processes. The hindbrain contains the structures of the brainstem (medulla, pons, and midbrain), which control automatic functions like breathing and blood pressure. The hindbrain also contains the cerebellum, which helps coordinate movement and certain types of memories.

Individuals with brain damage have been studied extensively to provide information about the role of different areas of the brain, and recent advances in technology allow us to glean similar information by imaging brain structure and function. These techniques include CT, PET, MRI, fMRI, and EEG.

3.5 The Endocrine System

The glands of the endocrine system secrete hormones to regulate normal body functions. The hypothalamus serves as the interface between the nervous system and the endocrine system, and it controls the secretions of the pituitary. The pituitary serves as the master gland, controlling the secretions of all other glands. The thyroid secretes thyroxine, which is important for basic metabolic processes and growth; the adrenal glands secrete hormones involved in the stress response; the pancreas secretes hormones that regulate blood sugar levels; and the ovaries and testes produce sex hormones that regulate sexual motivation and behavior.

Review Questions

1. A(n) _____ is a sudden, permanent change in a sequence of DNA.
a. allele
b. chromosome
c. epigenetic
d. mutation

2. _____ refers to a person's genetic makeup, while _____ refers to a person's physical characteristics.
a. Phenotype; genotype
b. Genotype; phenotype
c. DNA; gene
d. Gene; DNA

3. _____ is the field of study that focuses on genes and their expression.
a. Social psychology
b. Evolutionary psychology
c. Epigenetics
d. Behavioral neuroscience

4. Humans have _____ pairs of chromosomes.
a. 15
b. 23
c. 46
d. 78

5. The _____ receive(s) incoming signals from other neurons.
a. soma
b. terminal buttons
c. myelin sheath
d. dendrites

6. A(n) _____ facilitates or mimics the activity of a given neurotransmitter system.
a. axon
b. SSRI
c. agonist
d. antagonist

7. Multiple sclerosis involves a breakdown of the _____.
a. soma
b. myelin sheath
c. synaptic vesicles
d. dendrites

8. An action potential involves Na^+ moving _____ the cell and K^+ moving _____ the cell.
a. inside; outside
b. outside; inside
c. inside; inside
d. outside; outside

9. Our ability to make our legs move as we walk across the room is controlled by the _____ nervous system.
a. autonomic
b. somatic
c. sympathetic
d. parasympathetic

10. If your _____ is activated, you will feel relatively at ease.
a. somatic nervous system
b. sympathetic nervous system
c. parasympathetic nervous system
d. spinal cord

11. The central nervous system is comprised of _____.
a. sympathetic and parasympathetic nervous systems
b. organs and glands
c. somatic and autonomic nervous systems
d. brain and spinal cord

12. Sympathetic activation is associated with _____.
a. pupil dilation
b. storage of glucose in the liver
c. increased heart rate
d. both A and C

13. The _____ is a sensory relay station where all sensory information, except for smell, goes before being sent to other areas of the brain for further processing.
a. amygdala
b. hippocampus
c. hypothalamus
d. thalamus

14. Damage to the _____ disrupts one's ability to comprehend language, but it leaves one's ability to produce words intact.
a. amygdala

b. Broca's Area
c. Wernicke's Area
d. occipital lobe

15. A(n) _____ uses magnetic fields to create pictures of a given tissue.
a. EEG
b. MRI
c. PET scan
d. CT scan

16. Which of the following is not a structure of the forebrain?
a. thalamus
b. hippocampus
c. amygdala
d. substantia nigra

17. The two major hormones secreted from the pancreas are:
a. estrogen and progesterone
b. norepinephrine and epinephrine
c. thyroxine and oxytocin
d. glucagon and insulin

18. The _____ secretes messenger hormones that direct the function of the rest of the endocrine glands.
a. ovary
b. thyroid
c. pituitary
d. pancreas

19. The _____ gland secretes epinephrine.
a. adrenal
b. thyroid
c. pituitary
d. master

20. The _____ secretes hormones that regulate the body's fluid levels.
a. adrenal
b. pituitary
c. testis
d. thyroid

Critical Thinking Questions

21. The theory of evolution by natural selection requires variability of a given trait. Why is variability necessary and where does it come from?

22. Cocaine has two effects on synaptic transmission: it impairs reuptake of dopamine and it causes more dopamine to be released into the synapse. Would cocaine be classified as an agonist or antagonist? Why?

23. Drugs such as lidocaine and novocaine act as Na^+ channel blockers. In other words, they prevent sodium from moving across the neuronal membrane. Why would this particular effect make these drugs such effective local anesthetics?

24. What are the implications of compromised immune function as a result of exposure to chronic stress?

25. Examine **Figure 3.14**, illustrating the effects of sympathetic nervous system activation. How would all of these things play into the fight or flight response?

26. Before the advent of modern imaging techniques, scientists and clinicians relied on autopsies of people who suffered brain injury with resultant change in behavior to determine how different areas of the brain were affected. What are some of the limitations associated with this kind of approach?

27. Which of the techniques discussed would be viable options for you to determine how activity in the reticular formation is related to sleep and wakefulness? Why?

28. Hormone secretion is often regulated through a negative feedback mechanism, which means that once a hormone is secreted it will cause the hypothalamus and pituitary to shut down the production of signals

necessary to secrete the hormone in the first place. Most oral contraceptives are made of small doses of estrogen and/or progesterone. Why would this be an effective means of contraception?

29. Chemical messengers are used in both the nervous system and the endocrine system. What properties do these two systems share? What properties are different? Which one would be faster? Which one would result in long-lasting changes?

Personal Application Questions

30. You share half of your genetic makeup with each of your parents, but you are no doubt very different from both of them. Spend a few minutes jotting down the similarities and differences between you and your parents. How do you think your unique environment and experiences have contributed to some of the differences you see?

31. Have you or someone you know ever been prescribed a psychotropic medication? If so, what side effects were associated with the treatment?

32. Hopefully, you do not face real physical threats from potential predators on a daily basis. However, you probably have your fair share of stress. What situations are your most common sources of stress? What can you do to try to minimize the negative consequences of these particular stressors in your life?

33. You read about H. M.'s memory deficits following the bilateral removal of his hippocampus and amygdala. Have you encountered a character in a book, television program, or movie that suffered memory deficits? How was that character similar to and different from H. M.?

34. Given the negative health consequences associated with the use of anabolic steroids, what kinds of considerations might be involved in a person's decision to use them?