3
GENES, ENVIRONMENT, AND DEVELOPMENT

LEARNING OBJECTIVES

After reading and studying the material in this chapter, the student should be able to understand the following ideas/concepts.

3.1 EVOLUTION AND SPECIES HEREDITY

- Summarize the basic argument of Darwin's theory of evolution and the significance of the theory for the study of development.
- Compare and contrast biological evolution and cultural evolution.

3.2 INDIVIDUAL HEREDITY

- Describe the basics of the genetic code and what we inherit from our parents.
- Distinguish and give examples of the major mechanisms of inheritance (single gene-pair, sex-linked, and polygenic inheritance), mutations, copy number variations, and chromosome abnormalities.
- Summarize what we know about the nature, inheritance, diagnosis, and treatment of selected genetic diseases such as sickle-cell disease, Huntington's disease, and phenylketonuria [PKU]), and compare the major techniques of prenatal diagnosis of diseases and disorders.

3.3 STUDYING GENETIC AND ENVIRONMENTAL INFLUENCES

- Define the main goal and research methods of behavioral genetics and the meaning of *heritability*.
- Distinguish among the effects of genes, shared environmental influences, and nonshared environmental influences, and explain how a study of identical and fraternal twin pairs raised together versus raised apart can shed light on the importance of each of these influences.
- Explain what molecular genetics studies tell us that behavioral genetics studies cannot.

3.4 SELECTED BEHAVIORAL GENETICS FINDINGS

- Summarize the main messages of behavioral genetics research on intelligence, personality, and psychological disorder about the roles of genes, shared environment, and nonshared environment.
- Compare the average heritabilities of physical traits, intelligence, personality, psychological disorder, and attitudes and interests.

3.5 GENE-ENVIRONMENT INTERPLAY

- Distinguish between gene-environment interaction (and the diathesis-stress and differential susceptibility concepts) and gene-environment correlation (and passive, evocative, and active types of gene-environment correlations).
- Explain how genetic makeup can affect measures of environment and how genetically-informed studies can help determine whether parenting and other environmental influences on development really matter.
- Explain what epigenetic effects are and what they say about the relationship between genes and environment.
- Explain why genetic research and behavioral genetic research are controversial.

CHAPTER OUTLINE

I Evolution and Species Heredity

A. Main Points of Evolution and Species Heredity
   1. Virtually everyone develops in similar ways at similar ages
      a. Species heredity – genetic endowment members of a species have in common
         i. Birds can fly and humans can feel guilty (but not vice versa)
         ii. Species heredity is one reason that certain patterns of development and aging are universal
         iii. Tied to Darwin's evolutionary theory
   2. Main arguments of Darwin's theory
      a. There is genetic variation in a species (members of a species do not share all of the same genes)
      b. Some genes aid in adaptation more than others do (e.g., how to find food)
      c. Genes that aid in adaptation to the environment will be passed on more often than genes that do not—the principle of natural selection
   3. Kettlewell's study of moths in England demonstrates natural selection principles
      a. Study of pollution and moth color
      b. Light-colored moths survived in rural areas with light-colored trees
      c. Changes in pollution led to changes in moth color
      d. Evolution not just about genes; rather, development is driven by interaction between genes and environment
   4. Cultural evolution – we "inherit" from previous generations a characteristically human environment and tried and true ways of adapting to it, learning to adjust to it, and passing on what we know to the next generation
   5. Most significant biological evolutionary legacy is powerful and flexible brain that assists in learning

Checking Mastery

1. Biological evolution will not necessarily make humans better and better over time, but it *will* make them _____.

- **Answer:** Biological evolution will make humans better adapted to the particular environment in which they live. (However, genes that are selected by natural selection because they enhance survival in one environment may prove maladaptive in another.)

2. For natural selection to work and for a species to evolve, what must be true of the

genetic makeup of a species?

- **Answer:** For evolution to work, there must be genetic variation (some members of the species must have different genes than others) and some genes must aid more in adaptation, and therefore be more likely to be passed on to future generations, than others.

3. What does evolutionary psychology try to explain?

- **Answer:** Evolutionary psychology tries to explain why humans think and behave as they do by asking how cognition and behavior might have contributed to adaptation over the course of evolution.

II Individual Heredity

A. The Genetic Code

1. Early genetic materials
   a. Zygote – cell created at conception
   b. Chromosomes – 46 threadlike bodies (23 pairs, one from father and one from mother) containing the genes
   c. Meiosis – reproductive cell division in which one 46-chromosome sperm or ova splits into two 46-chromosome cells, and these split into two more cells (each with 23 chromosomes), resulting in one viable egg (and three nonfunctional in females) or four viable sperm in males
   d. Mitosis – cell division producing two identical cells (e.g., 46-chromosome cell splits into two 46-chromosome cells); continues throughout life
      i. Mitosis creates new cells that replace old cells
   e. Deoxyribonucleic acid (DNA) – double helix molecule that comprises each chromosome
      i. Four types of molecules: A-adenine, C-cytosine, G-guanine, T-thymine
      ii. Gene – functional unit sequence of DNA
      iii. Humans likely have no more than 20,000-25,000 genes
      iv. Each gene has several variants called alleles
      v. Genes lead to production proteins that are the building block of bodily tissues and substances like hormones, neurotransmitters, and enzymes
2. The Human Genome Project
   a. Federally-funded attempt to map out entire DNA sequence of all human chromosomes using supercomputers; completed in 2003
      i. 3.1 billion A, C, G, T molecules
      ii. Only about 3% of genome consists of traditionally defined genes (those that are transcribed into RNA and serve as templates for the production of certain proteins)
      iii. Remaining stretches of DNA consist of "junk genes" that regulate activity of genes
      iv. More emphasis being placed on that 97% of DNA
   b. Humans share majority of genes with primates
      i. Some gene alleles have evolved in recent centuries (e.g., variation that makes humans tolerate lactose in milk driven by rapid spread of dairy farming in Europe)

3. Genetic uniqueness and relatedness
    a. Each parent can produce more than 8 million genetically different sperm or ova, and any couple could produce 64 trillion babies without having two with identical genes
    b. Crossing over – exchanges in pairs of chromosomes before separating
    c. Identical twins (monozygotic) – one fertilized ovum splits to make two genetically identical individuals (1 in 250 births)
    d. Child shares average of about 50% of genes with each parent
    e. Non-identical twin siblings share about 50% of their genes
    f. Fraternal twins (dizygotic) – two eggs released and each fertilized by different sperm (1 in 125 births)
        i. Same genetic relationship as with any other sibling
        ii. Tend to run in families
        iii. More common today due to increased use of fertility drugs and in vitro fertilization
    g. Individuals share some genes with all kin members
4. Determination of sex
    a. 22 of 23 chromosomes (autosomes) are similar in males and females
    b. 23rd pair are the sex chromosomes
    c. Male has one X and one Y chromosome
        i. X is stubbier and has fewer genes than the Y chromosome
    d. XX is typical genetic code for female
    e. Karyotype – photograph of the arrangement of chromosomes
5. X vs. Y chromosome
    a. X has almost 1,100 genes
    b. Y has about 80 (many of which are involved in sperm production)
    c. Most of one X chromosome is normally inactive in females during early prenatal period, but the 15% that is active may contribute to sex differences
    d. Father's Y chromosome determines child's gender
    e. Throughout history, women have been unfairly criticized for not bearing a male heir

B. From Genotype to Phenotype
1. Genotype – genetic makeup one inherits
2. Phenotype – actual characteristics based on genetics and environment
3. Genes responsible for production of chemical substances (e.g., melanin, which impacts iris color)
4. Genetically-coded proteins guide formation of neurons, influencing potential intelligence and personality
5. Genes influenced by biochemical environment surrounding genes and behavior of individual genetic "blueprint" written in erasable pencil (not indelible ink)
    a. Genetic expression – activation of particular genes in particular cells at particular times in the lifespan
        i. A gene is influential only if it is "turned on"
        ii. Genetic expression can be affected by environmental factors like diet, stress, toxins, and parenting

6. Fraga and colleagues analyzed expression of genes in identical twins
    a. Older twin pair more genetically different from younger pairs
        i. Less time spent together was predictive of more genetic variation
        ii. Additional environmental factors (e.g., rat pup grooming by mothers) have been found to impact genetic expression (Exploration Box on early experience and gene expression)
7. No one completely understands epigenetic process (transformation of a single cell into a living, behaving human)

C. Mechanisms of Inheritance
1. Single gene-pair inheritance – characteristic influenced by only one pair of genes (one from mom and one from dad)
    a. Gregor Mendel – nineteenth-century monk and pioneer in inheritance research
        i. Noticed patterns in cross-bred strains of peas
        ii. Called one dominant, as it was likely to show up in later generations
    b. Dominant genes – if even only one gene inherited, will produce the effect
    c. Recessive genes – need one gene from both parents to produce effect
        i. Tongue curling dominant
        ii. Two tongue-curling parents could have a no-curling child if both pass on recessive gene (chances of this are 25%)
    d. Incomplete dominance – individual expresses a blend of dominant and recessive traits
        i. Child of one parent with dark skin and the other parent with light skin who has light brown skin
    e. Co-dominance – neither gene in pair is dominant or recessive
        i. AB blood type is mix of A and B blood types
2. Sex-linked inheritance – trait influenced by gene on sex chromosomes
    a. Most are X-linked (rather than sex-linked) as most attributes are associated with genes on only the X chromosome
    b. Color blindness (more common in males) is sex-linked
        i. Boy who inherits defective X chromosome from mom and no color vision gene on Y will be color blind
        ii. Girl who inherits defective X chromosome may inherit normal color vision gene on other X chromosome and have normal color vision
    c. Hemophilia – genetic disorder resulting in deficiency in blood's ability to clot; sex-linked disorder
        i. More common in males as it is associated with a recessive gene on X chromosome
3. Polygenic inheritance – most human characteristics determined by multiple genes
4. Polygenic traits – characteristic influence by multiple pairs of genes
    a. The characteristic impacted by polygenetic traits (e.g., weight, intelligence, depression) tends to be distributed in the population in a bell-shaped or normal curve

D. Mutations
1. Change in structure or arrangement of one or more genes that produce new phenotype

a. Hemophilia may have been introduced to royal families of Europe by Queen Victoria
b. Environmental hazards (e.g., radiation) can increase odds of mutations

2. Some mutations beneficial
   a. Sickle-cell disease – sickle-shaped white blood cells protects from effects of malaria
   b. Does more harm than good in individuals living in non-malaria environments

E. Copy Number Variations
   1. Instances in which part of the genome is either deleted or duplicated
   2. More extensive than a mutation
   3. Can extend over a large stretch of DNA
   4. Can either be inherited or arise spontaneously
   5. Significantly increase the risks of a number of polygenic disorders involving the nervous system

F. Chromosome Abnormalities
   1. Child receives too many or too few chromosomes (about 1 in 160 born with more or less than 46 chromosomes)
      a. Down syndrome
         i. Trisomy 21 (three 21st chromosomes)
         ii. Physical (e.g., distinctive eye folds, short, stubby limbs) and mental (some degree of intellectual disability) impact
         iii. In some parts of the world, over half of these infants die due to heart defects, but in United States and other wealthy nations, many with Down syndrome are living into middle age (many show premature signs of aging including Alzheimer's disease)
         iv. Both mother and fathers can contribute to odds of having child with Down syndrome
         v. Odds 1 in 733 (but increase with parents' age, especially maternal age of 35 or higher)
         vi. As the result of more exposure to environmental hazards, aging ova and sperm more likely to be abnormal
         vii. Delaying parenthood until 30s or 40s increases risk of chromosomal abnormalities
   2. Sex chromosome abnormalities
      a. Turner syndrome (about 1 in 3,000 females)
         i. Female with a single X chromosome (XO)
         ii. Physically small, cannot reproduce, stubby fingers, lower than average spatial and math skills
      b. Klinefelter's syndrome (about 1 in 200 males)
         i. Male with an extra X chromosome (XXY)
         ii. Tend to have long limbs and, at puberty, they may show feminine characteristics such as enlarged breasts
      c. Fragile X syndrome
         i. Most common hereditary cause of intellectual disability
         ii. One arm of X chromosome nearly detached (thus the term fragile)

iii. Results in intellectual disability, some form of cognitive impairment, and autism in some
iv. More common in males
v. Too many repeated gene sequences lead to problem in formation of connections between neurons in brain
vi. Those who carry the gene but do not have enough repeating sequences to have full-blown fragile X, may develop tremors or have problems with infertility or early menopause in middle age

G. Genetic Diseases and Their Diagnosis
1. 97% of babies are born without major birth defects/disease/disorder
a. Genetic counseling assesses risk concerning potential for genetic problems
b. Human Genome Project results have increased access to information about genetic defects
2. Examples of disorders that can be identified via genetic counseling: cystic fibrosis, hemophilia, phenylketonuria (PKU), Tay Sachs disease
a. Counselors report percent probability of having a child with a disorder
b. Genetic counseling for sickle-cell disease
i. Disease causes the development of sickle-shaped blood cells that cluster together and result in less oxygen being distributed through the circulatory system
ii. Impacts include breathing difficulty, joint swelling and pain
iii. Life expectancy of children with sickle-cell disease used to be 14 years; they often died of blood clots, or heart or kidney failure
iv. 9% of African Americans have Ss genotype (one dominant gene "S" and one recessive gene "s" for sickle cells)
v. These individuals are called carriers—have a recessive gene that can be transmitted to offspring but due to the presence of a normal dominant gene, they who do not show symptoms
vi. Carriers have two in four (50%) chance of having a child who is a carrier and has both round and sickle-shaped blood cells
3. Common prenatal screening procedures used by counselors include ultrasound, amniocentesis, chorionic villus biopsy, maternal blood sampling, preimplantation genetic diagnosis (Exploration Box on prenatal detection of abnormalities)
a. Ultrasound – visual image of fetus
b. Amniocentesis – sample of amniotic fluid analyzed for genetic material and other problems
c. Chorionic villus sampling – extract hair cells from chorion surrounding fetus and check for genetic defects
d. Maternal blood sampling – check fetal blood cells that entered mom via placenta
e. Preimplantation genetic diagnosis – allow conception via in vitro fertilization, check DNA of first cells
4. Huntington's disease
a. Famous disorder associated with a single dominant gene
b. Typically strikes in middle age and deteriorates nervous system with

numerous symptoms
   i. Slurred speech
   ii. Erratic walking, grimaces, jerking movements
   iii. Increased irritability and moodiness
   iv. Dementia and loss of cognitive ability
c. Gusella discovered location for Huntington's gene on Chromosome 4
d. Can be diagnosed post-birth or with preimplantation genetic diagnosis

Checking Mastery

1. Ted and Ned, fraternal twins, are not very alike at all. Give both a "nature" explanation and a "nurture" explanation of their differences.

- **Answer:** Nature: By the luck of the draw (which parent chromosomes end up in a particular zygote), fraternal twins may inherit far less than 50% of the same genes. Nurture: Their prenatal or postnatal environments could have differed, and these differences in experience could have affected them either directly or through environmental effects on gene expression. Examples: One was positioned more favorable in the womb and got more nourishment, one was favored by parents.

2. Huge nose syndrome (we made it up) is caused by a single dominant gene, *H.* Using diagrams such as those in Figure 3.2, figure out the odds that Herb (who has the genotype *Hh)* and Harriet (who also has the genotype *Hh)* will have a child with huge nose syndrome. Now repeat the exercise, but assume that huge nose syndrome is caused by a recessive gene, *h,* and that both parents again have an *Hh* genotype.

- **Answer:** If the gene is dominant (H), 75% or three of four of the couple's children would be expected to have Huge Nose Syndrome (only the child with an hh genotype will not). If the gene is recessive (h), the couple has only a 25% chance of having a child with the hh genotype and the syndrome.

3. Juan has red-green color blindness. Knowing that he is color blind, what can you infer about his parents?

- **Answer:** Red–green color blindness is sex-linked and the recessive gene for it is on the X chromosome. A boy gets his X from his mother, so Juan's mother must be a carrier of the color-blindness gene (but would be color blind herself only if she has a second color blindness gene). Juan's father may or may not have the gene (and would be color blind like Juan if he did).

III Studying Genetic and Environmental Influences

A. Basics on genetics
   1. Behavioral genetics – study of the extent to which genetic and environmental differences are responsible for a given trait
   2. Impossible to give a specific percentage about how much the environment (or genetics) contributes to a specific trait
   3. Heritability – estimated proportion of trait variability attributable to genes
      a. To say that intelligence is heritable is to say that differences in intelligence between people are to some degree attributable to differences in genetic endowments

B. Experimental Breeding

1. Selective breeding – attempt to breed particular traits into animals
    a. Tyron bright and dull maze rats studies indicate that activity level, emotion, and sex drive may have genetic basis
    b. Due to ethical reasons, selective breeding research can no longer be performed

C. Twin, Adoption, and Family Studies
1. Twins studies
    a. Compare identical twins (share 100% of genes) and fraternal twins (share an average of 50% of genes) raised together and reared apart
        i. Criticisms of this approach include problem of shared prenatal environment and more similar treatment of identical twins vs. fraternal twins
2. Adoption study
    a. Similar environments and different genes
    b. If adopted children like adoptive parents, characteristic said to be due to experience, but if they are not like adoptive parents, characteristics said to be due to genetic factors
    c. Criticisms of the approach:
        i. Maternal prenatal environment could also impact development
        ii. Must correct for tendency of adoption agencies to place children in above-average environments
3. Family studies
    a. Compare various members within family (e.g., half-siblings, unrelated siblings from step families)

D. Estimating Influences
1. Concordance rates – percent of pairs in which, if when one has trait, so does the other
    a. Bailey and Pillard, homosexual concordance rate for identical twins 52%, fraternal twins 22% (indicates that genetic makeup contributes to both men and women's sexual orientation, but so do environmental factors)
2. Plomin and colleagues' behavioral geneticists estimated impact of three factors on emotionality
    a. Genes
        i. Some support for heritability of emotionality
    b. Shared environmental influences – common work or home experience
        i. Very weak support for influence on emotionality
    c. Nonshared environmental influences – unique experiences not shared by other family members (e.g., differential treatment by parents, different life crises)
        i. Support for the impact of unique experiences on emotionality
    d. Failure to find a strong shared environmental influence on a behavior does not mean family influences are unimportant

E. Molecular Genetics
1. The Human Genome Project
    a. Analysis of particular genes and their effects
    b. Identify how much multiple genes contribute to polygenetic traits
        i. Many genes contribute to polygenetic effects

ii. Goal is to identify the percent of contribution for each gene; results of this effort have been disappointing, with each gene making only a small contribution to the overall variation
iii. Apolipoprotein E (ApoE4) gene linked to risk of Alzheimer's disease, but many with Alzheimer's do not have the gene
iv. ApoE4 linked with greater memory deterioration but not Alzheimer's disease
v. Having ApoE4 gene and experiencing specific environmental event (e.g., head injury) may increase risk

Checking Mastery

1. What does the following (hypothetical) table of correlations tell you about the contributions of genes, shared environment, and nonshared environment to frequency of use of marijuana?

	Raised together	**Raised apart**
Identical twins	+0.70	+0.40
Fraternal twins	+0.40	+0.10

- **Answer:** In this example, genes are important because identical twins are more similar in frequency of marijuana use than fraternal twins; shared environment is important because both types of twins are more alike when raised together than when raised apart, and nonshared environment is somewhat important too because we see some dissimilarity between identical twins raised together (.70 is less than 1.00).

2. What are two problems with adoption studies of genetic influence?

- **Answer:** Adopted children can be affected not only by their biological parents' genes but also by the prenatal environment their biological mother provided before they were adopted away; they may be placed in homes similar to those they were adopted from; and they are typically placed in above-average environments (so adoption studies may underestimate the full effects of good and bad environments on a trait).

3. If twin studies show that depression is heritable, what good would it do to conduct molecular genetics studies of the disorder?

- **Answer:** Molecular genetics research can help identify which specific genes are responsible for the findings of twin studies (for example, researchers can scan the genomes of people with and without depression to see which specific gene variants the depressed individuals often have and the nondepressed individuals do not have).

VI. Selected Behavioral Genetics Findings

A. Intellectual Abilities
1. Bouchard Jr. and McGue correlated IQ scores of different pairs of relatives
   a. Correlation higher in more closely related individuals
   b. Overall heritability of IQ around .50

2. Evidence for impact by genetics, shared, and nonshared environments
    a. Pairs of family members reared together have more similar IQ than those reared apart
    b. Fraternal twins, especially those with similar family experiences who grew up at the same time, tend to be more alike than siblings born at different times
    c. IQs of adopted children related to those of their adoptive parents
    d. Shared environment influences tend to make people more similar while unique nonshared experiences make them different
3. Influence of genes becomes greater with age until adulthood
    a. With age, IQ's estimated heritability increase for identical twins
    b. With age, IQ's estimated heritability decrease for fraternal twins
    c. Shared environmental influences become less significant with age
    d. IQs of adopted children more strongly correlated with biological and adoptive parents
    e. IQ levels of children (including adopted children) can be improved if they are raised in a stimulating home environment early in life
    f. Genes largely account for intellectual stability from early adulthood to late middle age
    g. Genetic influences on intelligence still strong in old age
    h. Heritability may diminish in old age as the result of disease and nonshared environmental experience

B. Temperament and Personality
1. Temperament – set of tendencies concerning emotional reactivity, activity, and sociability
    a. Genes contribute to individual differences in temperament in infancy and to both continuity and change in later personality
    b. Average correlation between temperament score of identical twins is between .50 and .60, while the correlation between fraternal twins is around 0
    c. About 40% of variation in adult personality attributable to genetics, 5% from shared environmental experiences, and 55% from nonshared environmental influences
    d. Living in same home does not make children more similar in personality
    e. Family experience leads to more differences than similarities
2. Personality
    a. About 40% of the variation on major personality dimensions is attributable to genetic differences
    b. Shared environmental influences can be important (e.g., children adopt attitudes and interests similar to parents)
        i. Parent conflict can cause multiple children in the same home to develop psychological problems
    c. Nonshared influences significant
        i. Little evidence that parents mold all children's personalities in similar directions
        ii. Parents often develop unique relationships with each of their children
        iii. Siblings grow up at different times and have different experiences

iv. Brothers and sisters try to differentiate themselves and establish their own identities
v. Children have different peer groups and teachers

C. Psychological Disorders
1. Schizophrenia – serious mental disorder involving disturbed thinking, emotions, and social behavior
a. Genes may contribute substantially to development of the disorder
i. Average concordance rate for identical twins 48%, rate for fraternal twins is 17%
ii. Adopted children with biological parent with schizophrenia are at risk for developing the disorder
b. 1% of people in general population have schizophrenia; 10% of children who have a schizophrenic parents will become schizophrenic; 90% of children with a schizophrenic parent do not develop schizophrenia
c. Do not inherit the disorder, but rather the predisposition to develop the disorder
d. Actual development depends on combination of genetics and environmental stress (e.g., dysfunctional family)
i. Genetically at-risk infants who came down with an infectious disease like the flu while mothers were pregnant are at increased risk to develop schizophrenia
ii. Infants deprived of oxygen at birth are at risk to develop schizophrenia
iii. Adopted children with biological parent who is schizophrenic are more likely to develop the disorder if they grow up in a dysfunctional adoptive home

D. The Heritability of Different Traits
1. Some traits more influenced by genes than others
a. Observable physical (e.g., eye color, height) and physiological traits (e.g., reactions to alcohol) strongly influenced by genetics
b. Susceptibility to many diseases related to aging influenced by genes
c. General intelligence moderately influenced by genetics (50% or more of variation attributed to genes)
d. Genetic endowment contributes only modestly to attitudes and interests (e.g., vocational interest)
e. Difficult to find a human characteristic that is not to some degree heritable

E. Influences on Heritability
1. Heritability not fixed
2. Heritability impact differs depending on the age of the individuals being sampled
a. Genes explain more variation in eating disorders in girls during puberty vs. girls at age 11
3. Heritability impact differs depending on environmental background
a. One study found that genes explained IQ differences in children from wealthy families but not from poor families
b. Understimulating environment negatively impacts children regardless of genetics

Checking Mastery

1. Professor Gene Ohm is studying genetic and environmental influences on individual differences in extraversion/introversion. Based on previous behavioral genetics studies, what should he expect?
   - **Answer:** Research suggests that about 40% of the variation among people in major dimensions of personality like extraversion-introversion will be attributable to genetic differences, 55% to nonshared environmental influences, and only 5% to shared environmental influences.
2. Ayaan's biological mother had schizophrenia, so he was placed in an adoptive home when he was only 2 months old. He grew up with his adoptive parents (neither of whom had any psychological disorders) in a stable, loving family. What would you tell Ayaan, now age 18, about his chances of developing schizophrenia if you were a genetic counselor?
   - **Answer:** About 10% of children of a parent who has schizophrenia develop it (compared to 1% of the general population). Growing up a high quality adoptive home may decrease Alan's odds.

V. Gene-Environment Interplay

A. Basic trends in genes
   1. Genes are always turning on or off over the entire life span
   2. Environmental influences also impact from conception to death
   3. Unique genes exert themselves more as we become adults
   4. Shared environmental influences are stronger early in life
   5. Nonshared environmental influences remain important throughout the life span
   6. Don't ask "how much" of genes but rather how heredity and environment work together

B. Gene-Environment Interactions
   1. Genes do not determine anything but rather provide potential
   2. Caspi and colleagues described impact of genes and stressful life events on development of depression in New Zealanders
      i. Predisposition to depression results in somewhat higher probability of having depression
   3. Individuals with two high-risk variants for depression more vulnerable to depression than those with protective variant only if they experience multiple stressful events
   4. Multiple stressful events tend to not result in schizophrenia in those with protective genes
   5. Often takes combination of high-risk genes and a high-risk environment to trigger many psychological problems

C. Gene-Environment Correlations
   1. Gene-environment interactions tell us that people with different genes react differently to the experiences they have
   2. Gene-environment correlations say that people with different genes experience different environments

a. Passive gene-environment correlations – parents' genes influence the environment they provide for children, as well as the genes the child receives
    i. Parents with "sociable genes" create a social home environment (combination of genes for sociability and social environment may make child more sociable than he or she would otherwise be)
    ii. Shy parents may receive genes for shyness and provide less social stimulation
b. Evocative gene-environment correlation – child's genotype evokes certain reactions
    i. Sociable babies elicit more social reactions from others and provide more opportunities to build social skills
    ii. Sociable adolescents invited to more parties
c. Active gene-environment correlation – child's genotype influences the environment that she or he seeks
    i. Extravert likely to go to every party in sight and build a "niche" that is highly socially simulating and strengthens social skills
d. Scarr and McCartney suggest that the balance between the three types of genotype-environment correlations shifts with development
    i. Passive influences large in infancy
    ii. Evocative influences operate throughout life
    iii. Active become more important as we age

D. Genetic Influences on the Environment
1. Measures of environment are heritable
2. Genes affect similarity of environments we experience and perceptions of those environments
    a. Identical twins who are irritable could help create conflict-ridden families
3. Must constantly question assumptions about nature and nurture
    a. Aggression in children may be influenced by environment provided by parent and the parent's genes (possible that inherited gene that predisposed them to aggression also made parent hostile toward them)
4. Authors of book *The Relationship Code* argue that family processes are the mechanism through which the genetic code is expressed
    a. Genes and environment (especially unique experiences) conspire to shape development
5. Sorting Out Genetic Influences on the Environment
    a. Objective and perceived aspects of parenting
    b. Time spent watching television
    c. Number of stressful life events
    d. Genetically influenced personality traits

E. Epigenetic Effects on Gene Expression
1. Epigenesis
2. Epigenetic effects
3. Epigenetic research

F. Controversies Surrounding Genetic Research
1. Early experience and gene expression

2. Gene Therapy

Checking Mastery

Label each example below as an example of (a) gene–environment interaction, (b) passive gene–environment correlation, (c) evocative gene–environment correlation, (d) active gene–environment correlation, or (e) epigenetic effects.

1. Roger inherited genes for artistic creativity from his parents and grew up watching them sketch and paint.
   - **Answer:** passive gene—environment correlation
2. Tamara was abused as a child and this seems to have made her stress response system overly reactive.
   - **Answer:** epigenetic effects
3. Kayla inherited genes for mathematical ability and has been taking extra math and science courses in college.
   - **Answer:** active gene—environment correlation
4. Sydney inherited a gene that can cause intellectual disability but only in children who do not receive enough folic acid in their diet.
   - **Answer:** gene—environment interaction
5. Jorge got genes for anxiety, and his anxious behavior makes his parents overprotective of him.
   - **Answer:** evocative gene—environment correlation

SUGGESTIONS FOR CLASS DISCUSSIONS OR PROJECTS: To develop critical thinking skills and enhance student learning with exercises that support the course learning objectives.

1. ***Sibling Trait Comparisons:*** Ask students to consider how they are similar to and different from their siblings. Have them speculate about the source of these similarities and differences (genetic factors or environmental factors). Point out that researchers argue that a shared family environment may actually contribute more to differences than similarities among siblings.

To make this concrete for students, have them write down, or share with another student in class, an episode within their family that was interpreted one way by them and a different way by their sibling. For students who don't have a sibling, ask them to think of something that has happened within a group of friends that was interpreted differently by each person present. Then ask students to speculate on how these different interpretations might lead to different developmental outcomes.

An alternative (or additional) project would be to have students present evidence (including personal experiences) that suggests that shared environments actually result in increased similarity among siblings and others.

2. ***Social Events and Multi-Influence Perspective:*** Ask students to provide examples of some behavioral traits that they believe are primarily genetically or primarily environmentally determined. What evidence do they have for their positions? Chances are that many will refer to media examples (e.g., talk shows, television shows, movies) as part of their "evidence." This could spark an interesting discussion of the role of the media in perpetuating beliefs concerning

the "cause" of a behavior. Have students select controversial social events and compare and contrast genetic, environmental, and personality influences that may explain behavior.

3. ***Sex-Linked Inheritance:*** Have students (possibly working in small groups) solve problems involving single gene-pair and sex-linked inheritance by drawing tables like those in the text (see Figure 3.3 in the text). For example, what are the odds that Arlo Guthrie will develop Huntington's disease (caused by a dominant gene) as his father Woody did? If a man and a woman are carriers of the gene for sickle-cell disease, what are their odds of having a child with sickle-cell disease? If a girl has hemophilia (sex-linked), what can we infer about her parents? If a boy has hemophilia, what can we infer about his parents?

4. ***Genetic Research:*** In the movie *Spiderman*, a character states, "With great power, comes great responsibility." In Chapter 3, students are introduced to the Human Genome Project, a scientific endeavor that is destined to change the world as we know it (i.e., great power). Advances made by Human Genome Project researchers have also raised a variety of ethical concerns. For example, the development of tests to identify carriers of diseases and for prenatal detection of diseases such as cystic fibrosis and Huntington's disease has been met with mixed responses. Some applaud these tests as they could prevent many infants from being born with damaging or deadly illnesses. Others believe that the test has more drawbacks than benefits as they may lead to a world in which only "perfect" people will be allowed to be born. There is also growing concern over who should have access to the results of genetic tests.

The goal of this assignment is to help students consider what responsibility we have to protect individuals from advancements made by the Human Genome Project and other studies of genetic influences on behavior. Have students consider the following issues as part of a class discussion on ethics and testing: 1) what is the value of genetic testing for someone who is not going to consider an abortion? 2) Should partners be obligated to inform each other of any genetic defects in their family? 3) Does a child or adolescent have the right to request (or refuse) to have genetic testing done to them? 4) Should insurance companies have the right to access the results of genetic tests so they can adjust the rates for an individual? 5) Should employers be able to screen potential employees based on genetic tests? 6) Should the government have the right to require genetic testing if it leads to healthier infants? 7) Should people have the right to purchase genetic tests for themselves?

SUGGESTED FILMS AND VIDEOS

Heredity and the Environment: Beginnings of a Baby (2005, Insight Media, DVD 29 minutes): This DVD discusses how both environmental and genetic factors combine to influence development. It also presents information on gene therapy.

Prenatal Development: A Life in the Making (2005, Insight Media, DVD 26 Minutes). Tracing the transformation of a one-celled zygote into a fully functional human being, this program explores the stages of prenatal development.

Nature and Nurture: Heredity and Environment (2003, Insight Media, DVD 30 minutes): A top-

selling video on factors shaping human development.

Personality: All about me (2004, Films for the Humanities and Sciences, DVD-R or VHS 60 minutes): Program from *The Human Mind: From Neurons to Knowledge* series exploring factors that shape personality across the lifespan.

The Biological Mind: Deeply Depressed (2006, Insight Media, DVD 46 minutes): This video provides a nice introduction to factors that influence vulnerability to depression.

SUGGESTED WEBSITES

March of Dimes: Working Together for Stronger Healthier Babies
Provides informative information on chromosomal conditions, the causes, detection, and prevalence rates.

Center for Evolutionary Psychology
Provides a primer, a look at evolutionary psychology past and present, and the principles of evolutionary psychology.

Gene Therapy
Brings the latest research into genetic and cell-based technologies to treat disease.

Human Genome Project
Completed in 2003, the Human Genome Project (HGP) was a 13-year project coordinated by the U.S. Department of Energy (DOE) and the National Institutes of Health. During the early years of the HGP, the Wellcome Trust (U.K.) became a major partner; additional contributions came from Japan, France, Germany, China, and others.

MedlinePlus: Genetic Counseling
Offers information on genetic counseling and some guidelines as to when to pursue this service.

Chapter 3

SUGGESTED READINGS

Hess, P.G. (2009). Diagnostic genetic testing for a fatal illness: The experience of patients with movements. *New Genetics & Society*, 28(1), 3-18.

Knafo, A., and Plomin, R. (2006). Prosocial behavior from early to middle childhood: Genetic and environmental influences on stability and change. *Developmental Psychology,* 42(5), 771-786.

Moffitt, T.E. (2005). The new look of behavioral genetics in developmental psychopathology: Gene-Environment interplay in antisocial behaviors. *Psychological Bulletin,* 131(4), 533-554.

Plomin, R. (2010). Genetics of learning abilities and disabilities: Recent developments from the UK and possible directions for research in China. *Behavioral Genetics*, 40(3), 297-305.

Rolland, J.S. (2006). Genetics, family systems, and multicultural influences. *Families, Systems, & Health*, 24(4), 425-441.