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Chapter 2: Conception, Heredity, and Environment

WHAT'S TO COME

Conception and Infertility
Learning Objective: Summarize the process of conception and alternative paths to parenthood.

- How does fertilization take place?
- What are some causes of infertility?
- How is infertility treated?
- What are alternative paths to parenthood?

Mechanisms of Heredity
Learning Objective: Describe what genes are and how they influence human development.

- How are genes inherited?
- What determines sexual differentiation?
- How are traits transmitted?

Genetic and Chromosomal Abnormalities
Learning Objective: Identify types of genetic and chromosomal abnormalities and available screening options.

- What is dominant and recessive inheritance?
- What are sex-linked genetic defects?
- What are some common genetic abnormalities?
- How do we test for genetic abnormalities?

Studying the Influence of Heredity and Environment
Learning Objective: Explain how heredity and environment interact in human development.

- How do we measure the relative influences of genes and environment?
- How do genes and environments interact?

Characteristics Influenced by Heredity and Environment
Learning Objective: Identify individual characteristics influenced by heredity and environment.

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- What individual characteristics are influenced by heredity/environment interactions?

TOTAL TEACHING PACKAGE OUTLINE

Chapter 2: Conception, Heredity, and Environment

Heading	Resources & Selected Connect Activities
Conception and Infertility	**Learning Objective:** Summarize the process of conception and alternative paths to parenthood. **Lecture Opener 2.1** **Discussion Topic 2.1 and 2.2** **Knowledge Construction Activity 2.1, 2.2, 2.3, and 2.4**
Mechanisms of Heredity	**Learning Objective:** Describe what genes are and how they influence human development. **Discussion Topic 2.3** **Knowledge Construction Activity 2.1 and 2.5** **Connect:** *Author Narrated Tutorial:* Genetic Code; *Author Narrated Tutorial:* Genotype and Phenotype
Genetic and Chromosomal Abnormalities	**Learning Objective:** Identify types of genetic and chromosomal abnormalities and available screening options. **Lecture Opener 2.2 and 2.4** **Discussion Topic 2.3** **Independent Study 2.1** **Knowledge Construction Activity 2.1 and 2.5**
Studying the Influence of Heredity and Environment	**Learning Objective:** Explain how heredity and environment interact in human development. **Knowledge Construction Activity 2.1 and 2.6** **Lecture Opener 2.3** **Connect:** *Author Narrated Tutorial:* Genotype-Environment Correlations;

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	Concept Clip: Nature/Nurture Debate
Characteristics Influenced by Heredity and Environment	**Learning Objective:** Identify individual characteristics influenced by heredity and environment. **Discussion Topic 2.4** **Knowledge Construction Activity 2.1**
Applied Activities	**Applied Activity 2.1 and 2.2**

EXPANDED OUTLINE

I. Conception and Infertility

A. Fertilization

- Fertilization, or conception, is the process by which sperm and ovum—the male and female gametes, or sex cells—combine to create a single cell called a zygote, which then duplicates itself again and again by cell division to produce all the cells that make up a baby.
- At birth, a female is believed to have about 2 million immature ova in her two ovaries, each ovum in its own small sac, or follicle.
- In a sexually mature woman, ovulation occurs about once every 28 days until menopause.
- After being expelled from the ovary, the ovum is swept along through one of the fallopian tubes by tiny hair cells, called cilia, toward the uterus, or womb.
- Sperm are produced in the testicles (testes), or reproductive glands, of a mature male at a rate of several hundred million a day and are ejaculated in the semen at sexual climax.
  - Deposited in the vagina, they try to swim through the cervix (the opening of the uterus) and into the fallopian tubes.
- Fertilization typically occurs while the ovum is passing through the fallopian tube.
- If fertilization does not occur, the sperm are absorbed by the woman's white blood cells, and the ovum passes through the uterus and exits through the vagina.

B. Infertility

- Infertility is the inability to conceive a baby of after 12 months of intercourse with the absence of birth control methods.
- An estimated 6 percent of US women aged 15-44 experience infertility.
  - Worldwide about 1 in 5 couples have difficulty getting pregnant or maintaining a

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pregnancy to term.

- Women's fertility begins to decline in their late 20s, with a substantial decrease during their 30s.
- By their 40s many women are not able to become pregnant without the use of assistive reproductive technology.
- Men's fertility is less affected by age but begins to decline in the late 30s.
- The most common cause of infertility in men is a low sperm count or insufficiently motile (capable of motion) sperm.
  - A sperm count lower than 60 million per ejaculation makes conception unlikely.
- In a woman, common causes of infertility include:
  - The failure to produce eggs, or ova, or to the failure to produce normal ova
  - Mucus in the cervix, which prevents sperm from penetrating it
  - A disease of the uterine lining, which prevents implantation of the fertilized ovum
- However, the most common cause is blockage of the fallopian tubes, which prevents ova from reaching the uterus.
- In both men and women, modifiable environmental factors are related to infertility.
  - Overweight men and women are more likely to have issues with fertility.
  - Smoking appears to have a negative effect on fertility.

C. Assisted Reproductive Technologies

- **Assisted reproductive technology (ART)**, or conception through artificial means, provides couples having difficulty conceiving naturally with a means to augment their fertility.
- The simplest form of ART is *artificial insemination* in which sperm is injected into a woman's vagina, cervix, or uterus.
  - This procedure can facilitate conception if a man has a low sperm count.
- In another common method, *in vitro fertilization* (IVF), a woman first receives fertility drugs to stimulate the production of multiple ova.
  - Then the ova are surgically removed, fertilized in a laboratory dish, and implanted in the woman's uterus.
- IVF also addresses severe male infertility.
  - A single sperm can be injected into the ovum—a technique called intracytoplasmic sperm injection (ICSI).
- A woman who is producing poor-quality ova or who has had her ovaries removed may try ovum transfer.
  - In this procedure, a donor egg from a fertile younger woman is fertilized in the laboratory and implanted in the prospective mother's uterus.
  - Alternatively, the ovum can be fertilized in the donor's body by artificial insemination. The embryo is retrieved from the donor and inserted into the

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recipient's uterus.

- ART can result in a tangled web of legal, ethical, and psychological dilemmas.
  - The issues multiply when a *surrogate mother* is involved.
  - The surrogate, a fertile woman, is impregnated by the prospective father, usually by artificial insemination.
  - She agrees to carry the baby to term and give it to the father and his partner.

D. Adoption

- If a woman cannot conceive on her own, and she is either unwilling or unable to conceive with the ART, adoption is an alternative.
- In the United States, adoptions may either be national or international.
- Single adults and married couples may adopt.
- Stepparents can adopt the child of a spouse if the spouse has legal custody.

II. Mechanisms of Heredity

The science of genetics is the study of heredity—the inborn factors from the biological parents that affect development.

A. The Genetic Code

- The fundamental unit of heredity is a chemical called **deoxyribonucleic acid (DNA)**.
- The double-helix structure of DNA resembles a long, spiraling ladder whose steps are made of pairs of chemical units called *bases* (Figure 2.1).
- **Chromosomes** are coils of DNA that consist of smaller segments called **genes** and are found in every cell in the human body.
- Each gene has a specific location on its chromosome and contains thousands of bases.
- The complete sequence of genes in the human body constitutes the **human genome**.
  - The human genome is a reference point that shows the location of all human genes—every human has a unique genome.
- Every cell in the normal human body except the sex cells (sperm and ova) has 23 pairs of chromosomes—46 chromosomes in all.
- Through a type of cell division called *meiosis*, each sex cell ends up with only 23 chromosomes.
  - When sperm and ovum fuse at conception, they produce a zygote with 46 chromosomes: 23 from the father and 23 from the mother (Figure 2.2).
- At the moment of conception, the single-celled zygote receives all the biological information needed to guide its development.
- Through *mitosis*, a process by which the nonsex cells divide in half over and over again,

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the DNA replicates itself, so each newly formed cell is a complete genetic copy with the same hereditary information.
- Genes spring into action when they are turned on or off, either by external environmental factors or by internal factors.

B. Sex Determination

- Twenty-two of the 23 pairs of chromosomes are **autosomes**, chromosomes not related to sexual expression.
- The 23rd pair are **sex chromosomes**—one from the father and one from the mother—that govern the baby's sex.
- Females have two X chromosomes (XX), and males have one of each type (XY).
- Each sperm cell has an equal chance of carrying an X or a Y, and thus it is the father who determines sex.
- Early in development, the embryo's rudimentary reproductive system appears almost identical in both males and females.
- On the Y chromosome, there is a gene called the SRY gene.
  - Once hormones signal the *SRY* gene to turn on, cell differentiation and formation of the testes is triggered.
  - Otherwise, male sexual development will not occur, and the embryo will develop genitals that appear female.
  - At six to eight weeks after conception, the testes start to produce the hormone testosterone.
  - Exposure of a genetically male embryo to steady, high levels of testosterone ordinarily results in the development of a male body with male sexual organs.
  - Without this hormonal influence, a genetically male mouse will develop genitals that appear female rather than male.
- The development of the female reproductive system is equally complex and depends on a number of genetic variants, including the *HOX genes* and a signaling substances molecule called *Wnt-4*, a variant form of which can masculinize a genetically female fetus.

C. Patterns of Genetic Transmission

- During the 1860s, Gregor Mendel, an Austrian monk, laid the foundation for the understanding of patterns of inheritance.
- By crossbreeding strains of peas, he discovered two fundamental principles of genetics:
  - Traits could be either dominant or recessive. *Dominant traits* are always expressed, while *recessive traits* are expressed only if both copies of the gene are recessive.
  - Traits are passed down independently of each other.

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1. Dominant and Recessive Inheritance

- Genes that can produce alternative expressions of a characteristic, such as the presence or absence of dimples, are called **alleles**.
- Alleles are the different version of a particular gene.
- Every person receives one maternal and one paternal allele for any given trait.
- When both alleles are the same, the person is **homozygous** for the characteristic; when they are different, the person is **heterozygous**.
- In **dominant inheritance**, when an offspring receives at least one dominant allele for a trait, it will be expressed.
- **Recessive inheritance**, or the expression of a recessive trait, occurs only when a person receives two recessive alleles, one from each parent.
- Traits may also be affected by **mutations**, permanent alterations in genetic material.
  - Mutations, such as the spontaneous dominant mutation known as achondroplasia which results in dwarfism, are generally due to copying errors and are usually harmful.

2. Multifactorial Transmission

- **Multifactorial transmission** is a combination of genetic and environmental factors to produce certain complex traits.
  - Multifactorial transmission illustrates the action of nature and nurture and how they mutually and reciprocally affects outcomes.
  - Some physical characteristics and most psychological characteristics are products of multifactorial transmission.

D. Epigenesis: Environmental Influence on Gene Expression

- Your **genotype** is what is coded in your genes—the recipe for making you.
- What is expressed—who you actually are—is your **phenotype**.
- Except for monozygotic twins, identical twins who started out as a single fertilized ovum, no two people have the same *genotype*.
- The phenotype is the genotype in action.
- The difference between genotype and phenotype helps explain why a clone, a genetic copy of an individual, or even an identical twin can never be an exact duplicate of another person.
- Mounting evidence suggests that gene expression is controlled by reversible chemical reactions that turn genes on or off as they are needed but that do not change the underlying genetic code.

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- This phenomenon is called **epigenesis**.

- Epigenesis works via chemical molecules, or "tags," attached to a gene that affect the way a cell "reads" the gene's DNA.
- Because every cell in the body inherits the same DNA sequence, the function of the chemical tags is to differentiate various types of body cells.
- These tags work by switching particular genes on or off during embryonic formation.
- Environmental factors, such as nutrition, smoking, sleep habits, stress, and physical activity can cause epigenetic changes.
  - These epigenetic changes can contribute to such common ailments as cancer, diabetes, and heart disease.
  - In addition, they may explain why one monozygotic twin is susceptible to a disease such as alcoholism, but the other twin is not, and why some twins get the same disease but at different ages.
- Epigenetic changes are more likely to occur in response to environmental triggers during critical or sensitive periods of development such as puberty and pregnancy.
  - Epigenetic changes may be heritable.

III. Genetic and Chromosomal Abnormalities

- Most birth disorders are fairly rare, affecting only about 3 percent of live births. Nevertheless, they are the leading cause of infant death in the United States, accounting for approximately 20 percent of all deaths.
  - Rates of disorders vary with race and ethnicity
- Not all genetic or chromosomal abnormalities are apparent at birth.
- Table 2.1 lists some of the disorders caused by genetic and chromosomal abnormalities.
- It is in genetic defects and diseases that we see most clearly the operation of dominant and recessive transmission, and also of a variation, sex-linked inheritance.

A. Dominant or Recessive Inheritance of Defects

- Most of the time, normal genes are dominant over those carrying abnormal traits, but sometimes the gene for an abnormal trait is dominant.
  - When this is the case, even one copy of the "bad" gene will result in a child expressing the disorder.
- Among the 1,800 disorders known to be transmitted by dominant inheritance are achondroplasia (a type of dwarfism) and Huntington's disease.
- Although they can be serious, defects transmitted by dominant inheritance are less likely to be lethal at an early age than those transmitted by recessive inheritance.
  - This is because if a dominant gene is lethal at an early age, then affected children would be likely to die before reproducing.

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- Recessive defects are expressed only if the child is homozygous for that gene; in other words, a child must inherit a copy of the recessive gene from each parent to be affected.
  - Because recessive genes are not expressed if the parent is heterozygous for that trait, both parents may be carriers without realizing it.
  - Defects transmitted by recessive genes tend to be lethal at an earlier age, in contrast to those transmitted by dominant genes as they can be passed down to the next generation by carriers.
- In **incomplete dominance**, a trait is not fully expressed.

B. Sex-Linked Inheritance of Defects

- Certain recessive disorders are transmitted by **sex-linked inheritance**.
  - They are linked to genes on the sex chromosomes and affect male and female children differently.
- When a mother is a carrier of a sex-linked disorder, she has a 50 percent chance of passing that gene on to her children.
  - A male child has a 50 percent chance of getting the faulty gene and having the disorder because there is no backup copy.
  - A female child, even if she gets a copy of the faulty gene from her mother, will receive another allele from her father.
- Red-green color blindness and hemophilia are examples of sex-linked inheritances.

C. Chromosomal Abnormalities

- Chromosomal abnormalities typically occur because of errors in cell division.
  - Klinefelter syndrome, found only in males, is caused by an extra female sex chromosome (shown by the pattern XXY).
  - Turner syndrome results from a missing sex chromosome (XO) and is found only in females.
  - Triple X syndrome results from an extra X chromosome. Also known as trisomy X, it is associated with delayed language and motor development and affects approximately 1 in 1,000 females.
- The most common genetic disorder in children is **Down syndrome**.
  - It is responsible for about 40 percent of cases of moderate-to-severe intellectual disability as defined by performance on an intelligence test.
  - The condition is also called *trisomy-21* because it is characterized in more than 90 percent of cases by an extra 21st chromosome.
  - The most obvious physical characteristics associated with Down syndrome are distinct facial characteristics including a downward-sloping skin fold at the inner corners of the eyes.

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    - Children with Down syndrome also tend to have slowed growth; poor muscle tone; congenital heart defects; thick hands; ear infections and early hearing loss; and impaired communication, language, memory, and motor skills.
- Slightly under 14 of every 10,000 live births is a child with Down syndrome.
    - Although the risk of having a child with Down syndrome rises with age of the mother, because of the higher birthrates of younger women, there are actually more young mothers with children with Down syndrome.
- Rather than having the three familiar branching lines on their palm, children with Down syndrome are more likely to have one horizontal line across their palms, a characteristic known as the single transverse palmar crease.
    - This trait sometimes occurs in the general population, but it is more likely in children with Down syndrome.
- Children with Down syndrome, like other children with disabilities, tend to benefit cognitively, socially, and emotionally when placed in regular classrooms rather than in special schools and when given regular, intensive therapies to help them achieve important skills.

D. Genetic Counseling and Testing

- **Genetic counseling** can help prospective parents assess their risk of bearing children with genetic or chromosomal defects.
- People who have already had a child with a genetic defect, who have a family history of hereditary illness, who suffer from conditions known or suspected to be inherited, or who come from ethnic groups at higher-than-average risk of passing on genes for certain diseases can get information about their likelihood of producing affected children.
- Screening for disorders can either happen before pregnancy when parents can be screened for the presence of recessive genetic disorders or after conception via genetic assessments such as chorionic villi sampling (CVS) and amniocentesis.
- Geneticists have made great contributions to the prevention of birth defects.

IV. Studying the Influence of Heredity and Environment

A. Measuring Heritability

- **Heritability** is a statistical estimate of how much heredity contributes to variations in a specific trait at a certain time within a given population.
- It does not refer to the relative influence of heredity and environment in a particular individual.
- It merely indicates the statistical extent to which genes contribute to a trait among a

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group of people.

- Heritability is expressed as a percentage ranging from 0.0 to 1.0; the higher the number, the greater the heritability of a trait.
- A heritability estimate of 1.0 indicates that genes are 100 percent responsible for variances in the trait within the population.
- Heritability cannot be measured directly, researchers in behavioral genetics have developed indirect methods for assessing the relationship between the expression of traits and the genetic environmental factors influencing them.
- Our phenotype results from the joint action of genetic and environmental influences. We can estimate the shared genetic influences between two people relatively easily.
  - If two people are unrelated, we know they are not likely to share any genes. If two people are identical twins, we know they share all their genes. If two people are fraternal twins, siblings, or parents, they share roughly 50 percent of their genes with each other.
  - If we know, on average, how many genes people share, then we can measure how similar they are on traits (their concordance rate) and work backward to determine the relative environmental influences.
  - If heredity has a large influence on a particular trait, identical twins should be more alike on that trait than fraternal twins and adopted children should be more like their biological parents than their adoptive parents.
  - If the environment exerts a large influence on a trait, people who live together should be more similar than those that live apart, and shared genes should matter less.
- In *family studies*, researchers measure the degree to which biological relatives share certain traits and determine whether or not the closeness of the familial relationship is associated with the degree of similarity.
  - The more closely two people are related, the more likely they will be similar on a trait if that trait is genetically influenced.
  - Therefore, researchers use concordance rates on traits to infer genetic influences.
- *Adoption studies* look at similarities between adopted children and their adoptive families and also between adopted children and their biological families.
  - When adopted children are more like their biological parents and siblings in a particular trait, we see the influence of heredity.
  - When they resemble their adoptive families more, we see the influence of environment.
- *Twin studies* compare pairs of monozygotic twins, or identical, with same-sex dizygotic, or fraternal, twins.
  - Monozygotic twins should be twice as genetically similar, on average, as dizygotic twins.
  - When monozygotic twins are more alike, or more *concordant*, on a trait than dizygotic twins, we see the likely effects of heredity.

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B. How Heredity and Environment Work Together

- The effects of genetic influences, especially on behavioral traits, are rarely inevitable.
- Even in a trait strongly influenced by heredity, the environment can have a substantial impact.
- From conception, a combination of constitutional (biological and psychological), social, economic, and cultural factors help shape development.
  - The more advantageous these circumstances and the experiences to which they give rise, the greater the likelihood of optimum development.

1. Reaction Range and Canalization

- **Reaction range** is the conventional term for a range of potential expressions of a heredity trait.
  - Body size, for example, depends largely on biological processes, which are genetically regulated. Even so, a range of sizes is possible. In societies in which nutrition has dramatically improved an entire generation has grown up to tower over the generation before.
- Heredity can influence whether a reaction range is wide or narrow.
  - The genotype places limits on the range of possible phenotypes.
- The metaphor of **canalization** illustrates how heredity restricts the range of development for some traits.
  - Highly canalized traits, such as eye color, are analogous to the deep canals. They are so strongly programmed by genes, and there is little opportunity for variance in their expression. It would take an extreme change in environment to alter their course.
- Because they are so important, natural selection has designed highly canalized traits to develop in a predictable and reliable way within a variety of environments and multitude of influences.
  - For example, normal babies follow a predictable sequence of motor development: rolling, sitting, standing, walking, and running, in that order, at certain approximate ages.
  - The sequence is said to be canalized, in that children will follow this same blueprint irrespective of many variations in the environment.
- Cognition and personality, however, are night highly canalized. They are more subject to variations in experience.
  - Example: The environment plays a large part in reading skills development.
  - Children who are not taught to read do not learn to do so spontaneously.

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2. Genotype–Environment Interaction

- **Genotype–environment interaction** usually refers to the effects of similar environmental conditions on genetically different individuals.
  - For example, many children are exposed to pollen and dust, but those with a genetic predisposition are more likely to develop allergic reactions.
  - Interactions can work the other way as well: Genetically similar children often develop differently depending on their home environments.
  - It is the interaction of hereditary and environmental factors, not just one or the other, which produces certain outcomes.

3. Genotype–Environment Correlation

- The environment often reflects or reinforces genetic disorders. This tendency is called **genotype–environment correlation**, and it works in three ways to strengthen the phenotypic expression of a genotypic tendency:
  - *Active correlations*: Children actively select experiences that are consistent with their genetic tendencies. For example, a shy child is more likely than an outgoing child to spend time in solitary pursuits. This tendency to seek out environments compatible with one's genotype is called *niche-picking*.
  - *Passive correlations*: Children not only inherit genes from their parents, they also inherit environments. For example, a musical parent is likely to create a home environment in which music is heard regularly, to give a child music lessons, and to take the child to musical events. If the child inherited the parent's musical talent, the child's musicality would reflect a combination of genetic and environmental influences. This type of correlation is called passive because the child does not control it.
  - *Reactive, or evocative, correlations*: Children with differing genetic makeup evoke different responses from adults. If a child shows interest and ability in music, parents who are not musically inclined may react by making a special effort to provide that child with musical experiences. This response, in turn, strengthens the child's genetic inclination toward music.

4. What Makes Siblings So Different?

- You might assume that siblings, as they share approximately 50 percent of their genes, might be very similar to each other.
  - However, siblings can differ greatly in intellect and especially in personality, and this difference increases with age.
- One reason may be genetic differences, which lead children to need different kinds of

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stimulation or to respond differently to a similar home environment, and thus develop along increasingly divergent paths.
    - For example, twin studies have identified that genetic differences between siblings in part drive how family conflict is experienced.
- In addition, there are also **nonshared environmental effects** that result from the unique environment in which each child in a family grows up.
    - For example, parents and siblings may treat each child differently; a firstborn gets undivided attention, but laterborns must compete for it.
    - Certain events, such as illnesses and accidents, and experiences outside the home affect one child and not another.
- Genotype-environment correlations can explain some of the effects of the nonshared environment on siblings' experiences.
    - One child may be shy and elicit more gentle behavior from parents, another may be bold and given greater freedom and encouragement to explore.

V. Characteristics Influenced by Heredity and Environment

A. Physical and Physiological Traits

- Not only do monozygotic twins generally look alike, but they also are more concordant than dizygotic twins in their risk for medical disorders such as high blood pressure, heart disease, stroke, rheumatoid arthritis, peptic ulcers, and epilepsy.
- **Obesity** is measured by body mass index, or BMI (comparison of weight to height).
    - The risk of obesity is two to three times higher for a child with a family history of obesity. Therefore, we might reasonably conclude obesity involves genetic contributions.
    - Research shows that obesity is indeed affected by genetics. There is a not "a" gene for obesity, rather it is a multifactorial condition
    - However, this increased risk is not solely genetic. The kind and amount of food eaten in a particular home and the amount of exercise that is encouraged can increase or decrease the likelihood that a child will become overweight.

B. Intelligence

- Heredity exerts a strong influence on general intelligence, as measured by intelligence tests, and a moderate effect on specific abilities such as memory, verbal ability, and spatial ability.
- While specific genes might contribute to intelligence, intelligence is influenced by the effects of large numbers of genes working together.
- Indirect evidence of the role of heredity in intelligence comes from adoption and twin

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studies.
  - Adopted children's scores on standardized intelligence tests are consistently closer to the scores of their biological mothers than to those of their adoptive parents and siblings; monozygotic twins are more alike in intelligence than dizygotic twins.
- Intelligence also depends in part on brain size and structure, which are under strong genetic control.
  - Experience counts, too; an enriched or impoverished environment can substantially affect the development and expression of innate ability.

C. Temperament and Personality

- **Temperament** is a characteristic disposition, or style of approaching and reacting to situations, that is apparent from early infancy and is a precursor to personality.
  - Temperament is largely inborn and is relatively consistent over the years, though it may respond to special experiences or parental handling.
  - Siblings tend to be similar in temperament on such traits as positive affect, activity level, and behavioral regulation.
- Temperament is believed to underlie adult personality.
  - Scientists have identified genes directly linked with specific aspects of personality, such as neuroticism and extraversion.
  - Heritability of personality traits appears to be around 40%, and there is little evidence of shared environmental influence.

D. Psychopathology

- There is evidence for a strong hereditary influence on such mental disorders as schizophrenia, autism, alcoholism, and depression.
  - All tend to run in families and to show greater concordance between monozygotic twins than between dizygotic twins.
- Schizophrenia is an example of heredity-environment interaction.
  - It is a neurological disorder that affects about 1 percent of the U.S. population each year.
  - It is characterized by loss of contact with reality; hallucinations and delusions; loss of coherent, logical thought; and inappropriate emotionality.
  - Estimates of heritability range from 60 to 80 percent.
  - A wide array of rare gene mutations may increase susceptibility to schizophrenia.

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TEACHING AND LEARNING ACTIVITIES

LECTURE OPENERS

2.1 Current Issues in Conception

Objective: To explore ethical issues about reproductive technologies and to clarify terminology.

Time necessary: 15–30 minutes, depending on whether the exercise is shared in small groups or in a larger discussion

Directions: Introduce the following concepts:

Artificial insemination: When a woman receives injections of her partner's or a donor's sperm directly into her cervix.

In vitro fertilization: Conception outside the body that involves the extraction of an egg from the mother or egg donor which is then washed and placed in a dish to mature in an incubator. Sperm is prepared and placed in the dish to combine with the egg. After the zygote contains at least four cells the embryo is implanted into the mother's uterus.

Surrogate motherhood: The surrogate mother is impregnated by the potential father, most often artificially.

If you are comfortable with controversy and like to add some critical thinking to your class bring in how these options have provided parenthood options to gay and transgendered couples.

Questions for discussion:

1. In situations where more embryos are created than desired by a couple, who should decide what happens to the unused embryos? What should happen if the couple divorces?
2. In cases of surrogate motherhood, should the surrogate mother have visitation rights to see the child later?
3. Given the expense entailed with the procedures for many of these reproductive technologies, who should pay the bill for couples who have been unable to conceive a child on their own?
4. Should the same rights and rules apply for same-sex couples as for heterosexual couples wishing to have children?

Wrap-Up: Due to the controversial nature and ethical issues that surround many reproductive technologies, these questions usually engage students in lively

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discussion and debate. Occasionally it may be necessary to remind students to be respectful of opinions different from their own. Challenge them to examine the origin of their ideas and opinions.

2.2 Abnormal Sex Chromosome Patterns

Objective: To educate students about several abnormal chromosomal patterns and how they affect development.

Time necessary: 15–30 minutes, depending on the amount of class participation

Directions: Present the following conditions to illustrate chromosomal patterns.

Kleinfelter's syndrome: Some males have an XXY pattern, or an additional X chromosome. Physical characteristics of these individuals include above average height and long arms and legs. Other physical characteristics include possible breast development during puberty, a high-pitched voice, and light beard growth. Sometimes intellectual functioning is impaired, and Kleinfelter males are sterile.

Turner's syndrome: Some females are missing an X chromosome and, thus, have an XO pattern. Physical characteristics of such women include a short and immature appearance, webbed neck, eyelid fold, receding chin, and a broad chest. Supplemental estrogen therapy during adolescence does stimulate breast development and other secondary sex characteristics, though Turner females are sterile. There is little or no impairment in intellectual ability, and some show above average IQ.

The double Y syndrome: About one out of every 1,000 males has an extra Y chromosome, or an XYY pattern. This phenomenon first attracted attention when it was reported that a disproportionate segment of the prison population were XYY men, and it was rumored that this syndrome led to increased violence. Evidence indicates that the rate of violent crimes for the double Y syndrome men is lower than that for other prison inmates. The syndrome is, however, associated with intellectual impairment and height that exceeds even that of Kleinfelter's syndrome.

Wrap-Up: Berch and Bender suggest that children with chromosomal abnormalities do not have the serious behavioral difficulties that were initially predicted. An editorial by Barbara Biesecker outlines the need for parents to have accurate information about the long-term effects of the diagnoses. Both articles emphasize the interplay between genetics and environment, and thus this material provides excellent

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opportunity to revisit this issue.

References:

Berch, D., & Bender, B. (1987, December). Margins of sexuality. *Psychology Today*, pp. 54–57.

Biesecker, B. (2001, February). Prenatal diagnoses of sex chromosome conditions: parents need more than just accurate information. *British Medical Journal*, pp. 441–442.

2.3 The Pillsbury Doughboy: Nature Versus Nurture

Objective: To provide a visual metaphor for the interaction between nature and nurture or heredity and environment.

Time necessary: 20–30 minutes on average.

Directions: David B. Miller describes a useful metaphor to illustrate the complexities of biology and environmental influences on development. Miller uses four different food items to represent developmental outcomes. All four food items use flour as a base ingredient; flour represents genetic factors. Other ingredients interact with the flour in different ways, as does the cooking process. For example, flour plus salt plus water fried in shortening "develops" into a flour tortilla. The same ingredients, when baked, yield a matzo. Add yeast to these ingredients, and it is bread. By adding butter, cocoa, and sugar, it transforms into a brownie.

Miller describes using two methods to present this analogy. He has used a slide or picture version that he reports is less dramatic and messy. A more theatrical approach would be an actual "cooking demonstration," in which you bring the ingredients to class, mix them on paper plates before the students, and pull out the final products to illustrate the developmental process.

Miller highlights four developmental processes with this demonstration:

1. Developmental constraints—range of possible outcomes is narrowed by the selected ingredients.
2. Flour does not "code" for any specific outcome, nor do genes code for developmental results.
3. As development proceeds, the organism achieves a form that more and more closely approximates the developmental outcome.
4. Once the developmental endpoint or outcome is reached, it is difficult to separately identify the earlier elements that contributed to the final "product."

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Wrap-Up: This cooking metaphor can be useful to set up later references to the heredity vs. environment discussion.

Reference:

Miller, D. B. (1996). The nature-nurture issue: Lessons from the Pillsbury Doughboy. In Ware, M. E., & Johnson, D. E. (Eds.). *Handbook of demonstrations and activities in the teaching of psychology* (Vol. II). Hillsdale, NJ: Erlbaum.

2.4 Thinking about Genetic Testing

Objective: To expose students to socially constructed beliefs about genetic testing and potential consequences.

Time necessary: 15–30 minutes, depending on the amount of class discussion

Directions: Write each of these 10 statements on a separate 3 × 5 index card:

- Your baby is likely to grow up to be very neurotic.
- Your baby is likely to be very extroverted.
- Your baby is likely to be autistic.
- Your baby is likely to be a genius.
- Your baby is likely to be a genius and neurotic.
- Your baby is likely to be musically very talented but also likely to be poor at verbal tasks.
- Your baby is likely to be a homosexual.
- Your baby is likely to be just average.
- Your baby is likely to be dyslexic.
- Your baby is likely to grow up to be just like you.

Begin by asking students whether they would like to know in advance the sex of their baby and what impact this information might have on them. Then distribute the cards randomly in the class. Students should be asked to read the diagnosis aloud (some explanation may be necessary for conditions or concepts students do not understand). Ask students if their child-rearing practices would change, knowing this information in advance. Would they try to alter some outcomes more than others? Why or why not?

This exercise provides opportunity to discuss "genetic predisposition" as a concept, and a link to discussions of heredity and environment.

Wrap-Up: The discussion can be concluded by asking students to address what the risks and benefits of wide-scale prenatal or genetic screening might be, and/or whether they think the

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government should fund or mandate such screening.

Reference:

Ely, R. (1999). Bringing genetic screening home. In Benjamin, L. R., Nodine, B. F., Ernst, R. M., & Broeker, C. B. (Eds.), *Activities handbook for the teaching of psychology* (Vol. 4). Washington, DC: APA.

DISCUSSION TOPICS

Discussion Topic 2.1: Infertility on the Rise?

The first section of the chapter examines issues related to infertility and the technologies developed to manage it. Investigate with your class reasons for the rise in infertility in our present society. Has the declining birthrate and the rise in the number of couples who actively choose not to have children simply made us more sensitive to those couples with fertility problems? Were the estimates of infertility in the past inaccurately low because there were no services or advanced technology to help individuals and, therefore, no one spoke of their difficulties? Are there social and psychological factors that lead to infertility in addition to the physical ones mentioned in the text? Is our society more stressful, and is fertility a result of this stress? Is there any relationship between shifting gender roles for men and women and the rate of infertility?
Additional statistics and information on infertility are available from the Centers for Disease Control and Prevention: https://www.cdc.gov/reproductivehealth/infertility/index.htm.

Discussion Topic 2.2: The Availability of Artificial Reproductive Technologies

Explore with your students the ethical and socioeconomic concerns surrounding artificial reproductive technologies. The procedures are expensive. Should they be made available only to those with the ability to pay for them? How much coverage should be provided by medical insurance? Should access be limited only to childless offspring? Should single individuals be allowed to use the modern technologies to sire or bear offspring? Who is liable if the baby conceived by way of modern technology has a birth defect?

Discussion Topic 2.3: Prenatal Tests and Down Syndrome

The development of first trimester screening tests for extra chromosomes has expanded the use of these screening tests to more women. (Until 2007, only pregnant women 35 and older were routinely tested to see if their fetuses had the extra chromosome that causes Down syndrome.) Ask your students to visit the following link and read through the article:

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https://www.nytimes.com/2007/05/09/us/09down.html
Students can also read more about prenatal screening for extra chromosomes from the American College of Obstetricians and Gynecologists: https://www.acog.org/Patients/FAQs/Cell-free-DNA-Prenatal-Screening-Test-Infographic

Discuss with your students the pros and cons of these early screening procedures. Do you believe the parents should be given the choice to continue or terminate the pregnancy? Should more efforts be undertaken to educate people about the value of accepting children with Down syndrome?

Discussion Topic 2.4: Obesity

Science shows that genetics plays a role in obesity. Genes can directly cause obesity in disorders such as Bardet-Biedl syndrome and Prader-Willi syndrome. Ask your students to review relevant background information:
http://obesity.ulaval.ca/obesity/generalities/genetic.php
https://www.cdc.gov/genomics/resources/diseases/obesity/index.htm
https://blogs.cdc.gov/genomics/2018/01/29/genomics-and-obesity/
https://medlineplus.gov/ency/patientinstructions/000383.htm

Discuss with your students the steps would-be parents can take to protect their children from obesity.

INDEPENDENT STUDIES

Independent Study 2.1

Select three of the genetic and chromosomal abnormalities mentioned in this chapter. Try to include one or more abnormalities with both cognitive and physical, effects. Then explore the Internet to identify support groups or organizations for parents whose children have these abnormalities. Based on the information you find in the websites for these organizations, compare the psychosocial impacts of the three abnormalities you have chosen. Are similar or different issues highlighted for each?

KNOWLEDGE CONSTRUCTION ACTIVITIES

Knowledge Construction Activity 2.1: Application of Terms

This activity will use the principles of generative learning to assist students in gaining a better

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understanding of terms. Divide the class into groups of four or five. Assign each group the task of generating an example for a generative term from this chapter. The example that each group creates cannot be one used in class or in the book. They must think of a new application for the term they are given. Groups may use their books and notes. By creating their own example of the term, they demonstrate an understanding of the term to the level of application. Several approaches can be used in this exercise. Students may be given the entire list at once. Another strategy is to give all of the groups the same term to create an example and then go around the room to discuss outcomes. A third approach is to give each group a different term and see what examples they can generate.

Some generative terms for Chapter 2

Homozygous
Heterozygous
Dominant inheritance
Recessive inheritance
Epigenesis
Phenotype
Genotype
Sex-linked inheritance
Reaction range

Knowledge Construction Activity 2.2: Choosing Parenthood

The decision to have a child is one of the most important decisions a person or couple can make. Consider some of the following questions in terms of the impact childbearing can have.

- Do I like doing the things parents generally do?
- Would I expect my child to take care of me in my old age?
- Could I find happiness in teaching and guiding a child, a teenager, or a young adult?
- Am I financially able to support a child?
- Would a child interfere with my freedom or educational plans?
- Would I be willing to devote a large part of my life to being a parent?
- Could I accept and love a child who was physically or intellectually disabled?

Knowledge Construction Activity 2.3: Infertility Options—Adoption

Some couples choose not to have children because of the risk of genetic abnormalities. Other couples are infertile and cannot have children. Still, others feel called to help children in need. Have students investigate the option of adoption. In your state, what are the legal requirements for adoption? Who can adopt a child? Are there standards for age, weight, health, sexual orientation, marital status, income and so on, of the parents? Can single persons adopt? Must there be a racial match between parent and child? What is the availability of infants, older children, minority-group children, and handicapped children?

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Knowledge Construction Activity 2.4: Infertility Options and Embryo Rights

A recent divorce case involved legal questions about frozen embryos. While married, the couple had attempted to have children. They finally availed themselves of modern reproductive techniques in which conception was achieved outside the womb. Several of the resulting embryos were frozen, awaiting the future needs of the couple. The legal questions focused on who had rights to the embryos when the marriage was dissolved. Assign students to research the topic and elicit responses as to which side they are on, and then make them argue for the opposite side.

Knowledge Construction Activity 2.5: Thinking About Genetic Testing

If you were going to have a baby, would you want to know the sex of the child in advance? Genetic testing allows people to discover a great deal of information about their children before they are even born, but not everyone wants to know everything!

Assign three to four students to a group. Construct a set of situation cards for each group (3 x 5 index cards), place them face down, and have each member choose one card.

Situation cards:
Your baby is likely to grow up to be very shy and anxious.
Your baby is likely to be very extroverted and hyperactive.
Your baby is likely to be autistic.
Your baby is likely to be a genius in math.
Your baby is like to be a genius and neurotic (anxious).
Your baby is likely to be musically very talented but also likely to be poor at verbal tasks.
Your baby is likely to be just average.
Your baby is likely to be dyslexic.
Your baby is likely to grow up to be just like you.

Instruct participants to read the situation card aloud to their group and then comment on whether their child-rearing practices would change knowing this information in advance. Would they try to alter some outcomes more than others?

Further questions for discussion:

- What do you think people believe about genetic predisposition and the effect of the environment?
- What do you think about the value of prenatal diagnosis for the kinds of situations described in the cards?

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Knowledge Construction Activity 2.6: Gene-Environment Interaction

The following exercise is to demonstrate the connection between passive, evocative, and active gene-environment correlation. First, assign students to three groups of four or five and have each person write down an example of a positive environmental factor that played a major role in the direction that his/her life took. Group One might look at the passive gene-environment correlation: association between the genotype a child inherits from her parents and the environment in which the child is raised. Group Two looks at evocative gene-environment correlations. This happens when an individual's (heritable) behavior evokes an environmental response. Group Three can look at the active gene-environment correlation. This occurs when an individual possesses a heritable propensity to select environmental exposure.

Applied Activity 2.1: Gene-Environment Correlations (Class Discussion)

"As you reflect upon your life to this point, it is possible to look back and see what factors have been influential in bringing you to where you are today. For each of the following terms, give an example of an environmental influence that may have been linked by your genetics. An issue to consider might be what has led you to choose the career path that you have selected (Nursing, Education, etc.)."

1. Passive Genotype-Environmental Correlation.
2. Reactive or Evocative Genotype-Environmental Correlation.
3. Active Genotype-Environmental Correlation.

Applied Activity 2.2: Genetics (Class Discussion)

Do an Internet search on the term "genetics." Visit several websites to answer the following questions:

- What constitutes the study of genetics?
- Who might benefit from genetic counseling?
- What kind of information do you find on the Internet?
- Are there agencies, universities, or medical centers studying human genetics?
- Are there certification requirements for genetic counselors?
- What are some findings of genetics research?

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The Ten-Minute Test

Name: _____

Answer the questions below utilizing the following terms:

clone	heritability	zygote
reaction range	chromosomes	genes
heterozygous	dominant	recessive
phenotype	monozygotic	genotype
sex-linked inheritance	behavioral genetics	fertilization
dizygotic	homozygous	epigenesis

1. A one-celled organism resulting from fertilization is called a _____.

2. Twins conceived by the union of two different ova with two different sperm are called _____ twins.

3. Small segments of DNA located in definite positions on particular chromosomes are called _____.

4. _____ means that an organism possesses two identical alleles for a trait.

5. _____ inheritance is when a child receives contradictory alleles, and only one is expressed.

6. _____ is the observable characteristics of a person.

7. A pattern of inheritance in which certain characteristics carried on the X chromosome inherited from the mother are transmitted differently to her male and female offspring is called _____.

8. _____ is the quantitative study of relative heredity and environmental influences.

9. _____ is a statistical estimate of the contribution of heredity to individual differences in a specific trait within a given population.

10. _____ is the potential variability in the expression of a hereditary trait.

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Answers to the Ten-Minute Test

1. zygote
2. dizygotic
3. genes
4. homozygous
5. dominant
6. phenotype
7. sex-linked inheritance
8. behavioral genetics
9. heritability
10. reaction range

Resources for Instructors

Books and Journal Articles

Am I Parent Material? National Organization for Non-ParentsETR, 100 Enterprise Way, Suite G300, Scotts Valley, CA 95066 3 North Liberty Street, Baltimore, MD 21201

Hetherington, E.M., Reiss, D., & Plomin, R. (Eds.). (2013). *Separate social worlds of siblings: The impact of nonshared environment on development.* New York: Routledge.

Huxley, A. (1946). *Brave new world*. New York: Harper and Row.

Knopik, V.S., Neiderhiser, J.M., DeFries, J.C., & Plomin, R. (2016). *Behavioral genetics* (7th ed.). New York: Worth.

Moldin, S.O. & Rubenstein, R.R.L. (2006). *Understanding autism: From basic neuroscience to treatment.* Boca Raton, FL: Taylor & Francis.

Nussbaum, R.L., McInnes, R.R., & Willard, H.F. (2015). *Thompson & Thompson genetics in medicine* (8th ed.). Philadelphia: PA: Saunders-Elsevier.

Pennington, Moon, Edgin, Stredron, & Nadel. (2003). The neuropsychology of Down syndrome. *Child Development, 74,* 75-93.

Plomin, R. (2004). *Nature and nurture: An introduction to human behavioral genetics.* Belmont, CA: Wadsworth.

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Web Resources

Learn.Genetics
learn.genetics.utah.edu

This site provides downloadable teaching tips and classroom resources covering topics such as basic genetics, genetic disorders, and genetic testing.

Human Genome Project
www.ornl.gov/hgmis

This site provides the latest and archival information on uncovering the genes in the human cell.

In vitro fertilization program
http://www.ihr.com/ucsfivf/indx.html

This site can be used as an example of programs for in vitro fertilization available to people choosing this option for pregnancy.

The Multidimensional Human Embryo
http://embryo.soad.umich.edu/

A collaboration funded by the National Institute of Child Health and Human Development (NICHD) to produce and provide over the Internet a three- dimensional image reference of the human embryo based on magnetic resonance imaging. The collection of images is intended to serve students, researchers, clinicians, and the general public interested in studying and teaching human development.

National Down Syndrome Society
www.ndss.org

This site provides information and support.

University of Kansas Medical Center, Genetics Education Center
www.kumc.edu/gec.

This site is an excellent companion resource to the Human Genome project with exhibits, links, and articles.

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