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1 INTRODUCTION TO CHILD DEVELOPMENT: THEMES, THEORIES, AND RESEARCH

LEARNING OBJECTIVES

- **1.1** Describe developmental periods, developmental domains, and the contexts in which development takes place.
- **1.2** Explain the nature-nurture debate, how children are active in their development, and how development reflects continuous and discontinuous change.
- **1.3** Summarize five categories of theories about child development.
- **1.4** Examine the methods and research designs used to study child development.
- **1.5** Discuss the field of applied developmental science, scientists' obligation to conduct ethical research, and the role of intersectionality in development.

It was a sunny day. I looked up at the bright sky as I leaned back in my stroller and used two hands to pull my hat down onto my head. The simplest of events, but it is one of my first memories. How old was I? Probably on the brink of early childhood.

What is your first memory? Is it similarly vague? What were you doing? Where were you? Who was nearby? How have you changed in the time since that early memory? Are there ways in which you remain the same? How is your experience similar to and different from other children's experiences? What contributes to these differences?

Why do some children thrive and others struggle? How do the people children interact with and the places they live influence them? How can parents, teachers, and other adults help children? These are some of the questions we consider in this book as we examine the nature of child development, its importance, how it is studied, and how scientific findings can be applied to help children and their families.

UNDERSTANDING DEVELOPMENT

1.1 Describe developmental periods, developmental domains, and the contexts in which development takes place.

People undergo innumerable changes as they grow from infants to children and from children to adolescents. **Development** refers to the processes of growth and change, as well as the ways in which we stay the same over time. **Developmental science** is the study of human development at all points in life, from conception to death. In this book, we examine child development. However, individuals undergo complex changes at every period in life, beginning before birth and continuing throughout adulthood. We therefore begin our study of development by considering the question: Why study children?

Why Study Children?

Perhaps the most obvious reason to study children is to promote their development. Parents and caregivers, teachers, researchers, and policymakers approach this goal with different concerns. Parents and caregivers may seek information about physical development, such as the process of pregnancy, patterns of growth, and how children learn to crawl and walk. They may also wonder when children learn language. How do they think? Do caregivers and infants form strong emotional bonds, and how does that help children develop? What is effective discipline? How can caregivers direct children's behavior?

Teachers rely on an understanding of child development to create classroom plans and assignments that match children's abilities. How can educators balance challenging children with supporting their emotional development? School administrators, including principals and school boards, ask questions such as: Should schools focus on physical and emotional development? Should recess and unstructured play be part of the school day?

Through scientific studies, researchers work to answer these questions. They examine developmental processes that influence all aspects of children's functioning. Most researchers narrow their study to specific areas of development, such as thinking or emotional development. Some researchers work in laboratory settings. Others study children in their homes, schools, and communities. Some study children's adjustment. How does adversity, such as living in homes and communities in poverty, exposure to violence, and experiencing discrimination, affect development? Researchers often apply their findings to help children by creating interventions and making recommendations to parents, teachers, and policymakers.

Policymakers are individuals who create and shape **social policy**, local, state, or federal governments' plans and actions to support or improve the residents' welfare. Policymakers turn to researchers for accurate scientific information about child development. What nutritional and health behaviors promote healthy birthweight? How is poverty related to children's brain development? How are race and socioeconomic status related to children's exposure to developmental risks, such as poverty and toxins? How is health care access related to children and families' health and well-being? How can policies address these risks, anticipate other risks, and promote children's development?

Studying children can also help us understand ourselves. What abilities are inborn? How do our childhood experiences influence us? How have factors such as race, socioeconomic status, gender, language, and religion influenced our development? Throughout this book we examine interactions among demographic factors, including race, socioeconomic status, and gender, because they shape our experiences and who we become.

Periods of Development

One of the challenges of studying infants and children is that they develop and change so quickly. A great many changes occur over just a few years. Researchers divide the time between conception and adulthood into a series of periods. Each developmental period is characterized by a predictable pattern of physical, cognitive, and social abilities.

Prenatal period (conception to birth)

After conception, a single cell is formed. It multiplies repeatedly, and all the structures and organs in the body at birth originate from this single cell.

Infancy and toddlerhood (Birth to about 2 years)

Newborns' senses and early learning abilities enable them to adapt to the world. Dramatic changes occur in physical growth as well as motor, perceptual, and intellectual abilities. Infants begin to use language, and emotional bonds form with caregivers. Infancy comprises the first year of life; toddlerhood spans the second.

Early childhood (about 2 to about 6 years)

Children's muscles strengthen and they become more coordinated as they move out of toddlerhood. As thinking, language, and self-regulation improve, children establish ties with peers and engage in make-believe play.

Middle childhood (about 6 to about 11 years)

As children enter school, their memory and reasoning improve and they learn academic skills, such as reading, writing, and arithmetic. As children advance cognitively and gain social experience, their self-understanding and self-control improves; friendships develop and deepen, and peer group memberships become more important.

Adolescence (about 11 to about 18 years)

With puberty, adolescents become physically and sexually mature. Their thinking becomes more complex and abstract. Adolescents spend more time with peers, and friendships become more important. They are driven to learn about themselves, become independent from their parents, and define their values and goals.

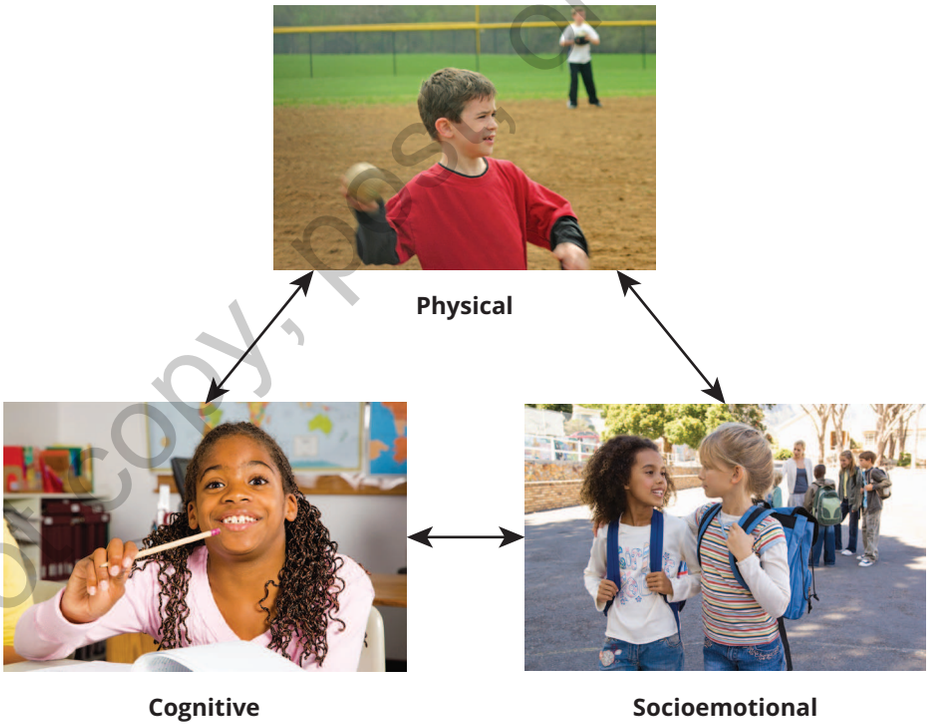
Developmental Domains

Children grow and change in many ways. These changes are grouped into three **developmental domains** or types of development. *Physical development* includes the most visible set of changes: body maturation and growth, such as body size, proportion, appearance, health, and perceptual abilities. *Cognitive development* refers to the maturation of thought processes and how we become aware of the world around us, learn, and solve problems. *Socioemotional development* includes changes in emotions, social abilities, self-understanding, and interpersonal relationships with family and friends.

Developmental domains overlap and interact. For example, the onset of walking precedes advances in language development in infants in the United States and China (He et al., 2015; Lüke et al., 2019). Babies who walk tend to spend more time interacting with caregivers; they can initiate interactions with caregivers, such as by bringing objects to them (West & Iverson, 2021). They also evoke more verbal responses and warnings from caregivers as they interact with items and explore their environment. Therefore, walking, physical development, influences language and social development (Kobaş et al., 2023). Figure 1.1 illustrates how the three domains of development interact, a central principle of development.

FIGURE 1.1 ■ Developmental Domains

Physical development influences learning, which influences children's interactions with others. Relationships with others help children learn and offer opportunities for growth and physical development through play.



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Context

Where did you grow up? Describe your childhood neighborhood. Did you play in a park or playground? Ride your bike outside? What was your elementary school like? Did you have access to technology such as tablets and computers? Did you learn to touch type in school? How large is your family? What were some of your family traditions? What holidays did you celebrate? Did you share family meals often? Your responses to these questions reveal aspects of your context.

Generally, **context** refers to where and when a person develops. Context includes all aspects of the physical and social environments in which we are immersed. Our context also includes intangible characteristics that are not visible to the naked eye, such as values, customs, ideals, and culture. Were you encouraged to be assertive and actively question the adults around you, or were you expected to be quiet and avoid confrontation? What values shaped your parents' childrearing practices and your own values? How did your family's economic status affect your development? These questions examine a critical context for our development, namely home and family. However, we are embedded in many more contexts that influence us, and that we influence, such as our peer group, school, neighborhood or community, and culture (Osher et al., 2021).

Sociohistorical Context

Our development is not just influenced by our surroundings, but also the time period in which we live and its unique historical circumstances, known as **sociohistorical context**. Historical events and trends, including wars, epidemics, advances in science and technology, and economic shifts such as periods of recession or prosperity influence our development (Baltes, 1987). Contextual influences tied to specific historical eras explain why a generation of people born at the same time, called a **cohort**, is similar in ways that people born at other times are different. Adults who were children during the Great Depression and World War II are similar in some ways that make them different from later cohorts; they tend to have particularly strong views on the importance of the family, civic mindedness, and social connection (Bühler & Nikitin, 2020; Rogler, 2002). The same is true for children of the 1960s who grew up during the Vietnam War, children of the 1990s who experienced rapid changes in technology, and so on. How might today's historical circumstance influence children?

The COVID-19 pandemic, which began in 2020, illustrates the influence of sociohistorical context. Children, adolescents, and adults donned face coverings and avoided close contact with other people, often including extended family and friends. School closures during the pandemic posed risks to children's and adolescents' academic and social development as well as their mental health (Mazrekaj & De Witte, 2023; R. S. Mistry et al., 2022). Even relatively temporary changes, such as these, are contextual influences that shape our world and our development. The effect of historical events on development depends in part on when they occur in a person's life—and experience can leave indelible marks on children's and adolescents' development (Bühler & Nikitin, 2020; Elder et al., 2015).

Sociohistorical influences, such as the COVID-19 pandemic, contribute to cohort, or generational, differences in development.

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Cultural Context

Culture, the set of customs, knowledge, attitudes, and values shared by members of a group, is learned early in life through interactions with group members, such as family (Markus & Kitayama, 1991). The culture in which we are immersed influences all our contexts and includes the processes we use to understand and interact with group members (Jones & Mistry, 2019).

Developmental scientists have only recently recognized the importance of culture. Most classic theories and research on development are based on Western samples because researchers once believed that the processes of human development were universal. Yet these studies often yielded narrow views of human development that did not consider the variety of cultural settings in which people live. In some cases, developmental differences in children of other cultural groups were considered abnormal rather than the result of different contextual circumstances (Packer & Cole, 2020).

We now know that development varies dramatically with cultural context—and that these differences are not deficiencies or abnormalities (McCoy, 2022). The cultural context in which individuals live influences the timing and expression of many aspects of development, even physical developments,

such as walking, long thought to be a matter of biological maturation (Amir & McAuliffe, 2020). In Uganda, infants begin to walk at about 10 months of age, in France at about 15 months, and in the United States at about 12 months. These differences are influenced by parenting practices that vary by culture. African parents tend to handle infants in ways that stimulate walking, by playing games that allow infants to practice jumping and walking skills (Hopkins & Westra, 1989; Super, 1981). Applying principles of development derived from Western samples to children of other cultures can yield misleading conclusions about children's abilities (Keller, 2017; J. G. Miller et al., 2020). Culture is inherent in all domains of development and is a contributor to the context in which we are embedded, transmitting values, attitudes, and ideas that shape our thoughts, beliefs, and behaviors.

Our development plays out within the contexts in which we live, a theme that we return to throughout this book.

THINKING IN CONTEXT 1.1

1. Identify personal examples of physical, cognitive, and socioemotional development. What changes have you experienced in each of these areas over your childhood? How have these abilities influenced one another?
2. Describe the multiple contexts in which you were raised. Consider your home, school, and neighborhood. Did you spend time at a friend's or relative's home? How might have your experiences in these places influenced your physical, cognitive, and socioemotional development? Provide examples.
3. In what ways have your abilities—physical, cognitive, or socioemotional—influenced aspects of your context, the people and places around you?

CORE CONCEPTS IN DEVELOPMENTAL SCIENCE

1.2 Explain the nature-nurture debate, how children are active in their development, and how development reflects continuous and discontinuous change.

What causes development? What path does development take? What role do children play in their development? Developmental scientists hold different views about these basic questions about child development. The following sections examine each of these questions.

Nature and Nurture: How do biology and environment influence development?

Perhaps the oldest question about development concerns its origin. Often referred to as the **nature-nurture debate**, researchers once asked whether development is most influenced by biological factors (*nature*) or environmental factors (*nurture*). Explanations that rely on biology point to inborn genetic traits and maturational processes as causes of developmental change. Most infants crawl at roughly the same age, suggesting a maturational trend supporting the role of biology in development (Payne & Isaacs, 2020). In contrast, proponents of environmental explanations view children as molded by the physical and social environment in which they are raised. From this perspective, children tend to walk at about the same time because they experience similar environmental circumstances and parenting practices.

While the nature-nurture debate seems to present biology and environment as alternative explanations for development, most scientists generally agree that *both* biology and environment contribute to development. The question is *how* do biology and environment work together to influence child development (Bjorklund, 2018; Lickliter & Witherington, 2017)? For example, walking is heavily influenced by physical maturation, but experiences and environmental conditions can speed up or slow down the process. Although most infants begin to walk at about the same time, infants

who experience malnutrition may walk later than well-nourished infants, and those who are given practice making stepping or jumping movements may walk earlier (Cavagnari et al., 2023; Siekerman et al., 2015).

The Active Child: How do children influence their own development?

Children are influenced by the physical and social contexts in which they live, but they also play a role in influencing their development by interacting with and changing those contexts (Elder et al., 2015). Baby Mickey smiles at each adult he passes by as his mother pushes his stroller in the park. Adults often respond with smiles, use baby talk, and make faces. Baby Mickey's actions, even simple smiles, influence adults, bringing them into close contact and one-on-one interactions that create opportunities for him to learn. Infants and children contribute to their own development by engaging the world around them, thinking, being curious, and interacting with people, objects, and their environment (Lerner et al., 2014). Even without awareness, children interact with and influence the people and things around them, creating experiences that influence their physical, cognitive, and emotional development. That is, they play an active role in influencing their own development.

Infants influence their own development by smiling at adults, making adults more likely to smile, use "baby talk," and play with them in response.

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Infants and children actively influence others and their environment through their behavior and also through their characteristics, such as temperament and appearance. For instance, infants born prematurely often have unique characteristics and needs, such as environmental sensitivity and physical disabilities, that can influence their relationships with caregivers and the care they receive (Green et al., 2021).

Continuities and Discontinuities: In what ways is development continuous and discontinuous?

Some aspects of development unfold slowly and gradually over time, demonstrating **continuous change**. Children slowly gain experience and learn strategies to become quicker at problem solving (Siegler, 2016). Others are best described as **discontinuous change**, characterized by abrupt change. Infants' vocabulary shows a *burst* of growth, and puberty quickly transforms children's bodies into more adult-like adolescent bodies (Manotas et al., 2022; Samuelson, 2021). As shown in Figure 1.2, a discontinuous view of development emphasizes sudden transformation, whereas a continuous view emphasizes gradual and steady changes.

It was once believed that development was either continuous or discontinuous, but not both. Today, scientists agree that development includes both continuity and discontinuity (Bornstein et al., 2017). Whether a particular developmental change appears continuous or discontinuous depends in part on our point of view. Consider physical growth. We often think of increases in height as involving a slow and steady process; each month, an infant is taller than the prior month, illustrating continuous change. However, as shown in Figure 1.3, when researchers measured infants' height every day, they discovered that infants have growth days and nongrowth days, days in which they show rapid change in height interspersed with days in which there is no change in height, illustrating discontinuous change (Lampl et al., 2001). In this example, monthly measurements of infant height suggest gradual increases, but daily measurements show spurts of growth, each lasting 24 hours or less. Thus, whether a given phenomenon, such as height, is described as continuous or discontinuous can vary depending on perspective. Most developmental scientists agree that some aspects of development are best described as continuous and others as discontinuous (P. H. Miller, 2016).

FIGURE 1.2 ■ Continuous and Discontinuous Change

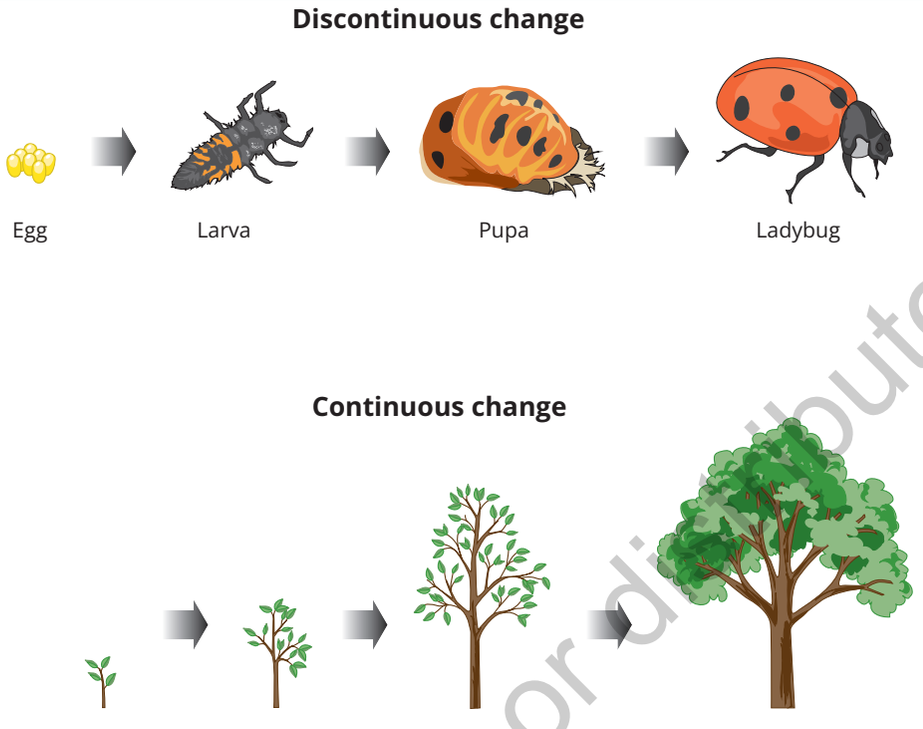
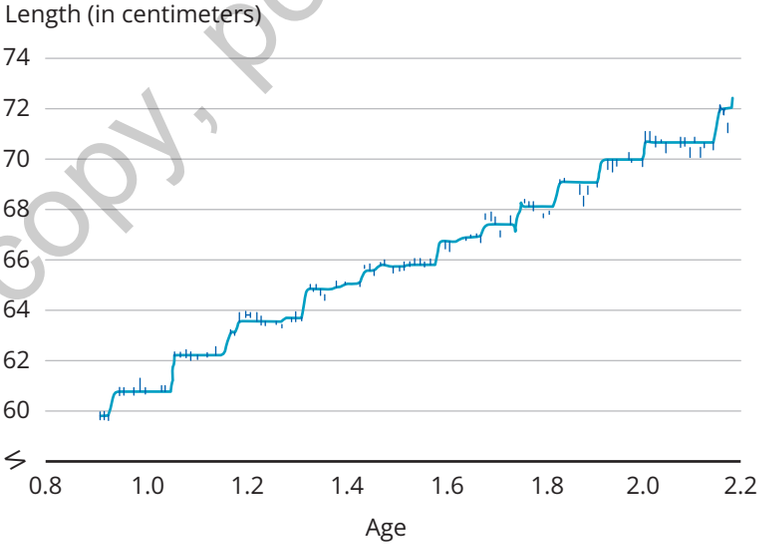


FIGURE 1.3 ■ Infant Growth: A Continuous or Discontinuous Process

Infant's growth occurs in a random series of roughly 1-centimeter spurts in height that occur in 24 hours or less. The overall pattern of growth entails increases in height, but whether the growth appears to be continuous or discontinuous depends on our point of view.



Adapted from Lampl, M., Veldhuis, J. D., & Johnson, M. L. (1992). Saltation and statis: A model of human growth. *Science, 258*, 801–803.

THINKING IN CONTEXT 1.2

1. Consider your own traits and abilities. Which might be influenced by nature, biology? Nurture, environment? Give an example of a trait or ability that might be influenced by both nature and nurture.

2. Can you identify ways in your physical, cognitive, or socioemotional abilities have changed very gradually over the years? Were there other times in which you showed abrupt change, such as physical growth, strength and coordination, thinking abilities, or social skills? In other words, in what ways is your development characterized by continuity? Discontinuity?
3. Give an example of how you played an active role in your own development. Identify how your childhood traits and actions may have influenced others and your environment and, in turn, how they influenced you.

THEORIES OF CHILD DEVELOPMENT

1.3 Summarize five categories of theories about child development.

How do children grow and change? Why do children act the way they do? What developmental changes are most important? To answer these questions developmental scientists observe children's behavior and construct theories to explain what they see. A **theory** is a way of organizing a set of observations or facts into a comprehensive explanation of how something works. Theories are important tools for compiling and interpreting the growing body of research in developmental science as well as determining gaps in our knowledge and making predictions about what is not yet known.

An effective theory generates a specific **hypothesis**, or proposed explanation for a given phenomenon, that can be tested by research, as described later in this chapter. A good theory is *falsifiable* or capable of generating hypotheses that can be tested. As scientists conduct research and learn more about a topic, they modify their theories, then test new hypotheses derived from those theories, and so on. Next, we examine several prominent theories of child development, which are summarized at the end of this section, in Table 1.3.

Psychoanalytic Theories

An early, now classic, set of theories poses that children's development is driven by powerful inner forces. **Psychoanalytic theories** explain development as the result of the interplay of inner drives, memories, and conflicts we are unaware of and cannot control. These inner forces influence our behavior throughout our lives. Psychoanalytic theories emerged and were most popular during the early to mid-1900s.

Freud's Psychosexual Theory

The *father* of psychoanalytic theory, Sigmund Freud (1856–1939), believed that unconscious sexual and aggressive impulses drive our behavior. He described development as the progression through a series of *psychosexual stages*, periods in which unconscious sexual impulses focus on different parts of the body, making stimulation to those parts a source of pleasure (summarized in Table 1.1). Freud believed that the resolution of each stage and, ultimately, the adult personality, is based on how parents gratify children's needs.

Perhaps unsurprisingly, psychosexual stage framework's emphasis on childhood sexuality is unpopular and not widely accepted (Westen, 1998). Notably, Freud did not study children; his theory grew from his work with female psychotherapy patients (Crane, 2017). Some of Freud's ideas, such as the notion of unconscious processes of which we are unaware and the importance of early family experience, especially the parent-child relationship, have permeated popular culture (Bargh, 2013). However, Freud's theory, including unconscious drives and psychosexual stages, is not falsifiable because its parts cannot be directly observed and tested (Miller, 2016). How can we study unconscious drives, for instance, when we are not aware of them?

Erikson's Psychosocial Theory

Erik Erikson (1902–1994) was influenced by Freud, but he placed less emphasis on unconscious motivators of development. Erikson instead focused on interactions between the individual and

their social world, including society, and culture. Over their lifetimes, according to Erikson, people progress through eight *psychosocial stages* that include changes in how they understand and interact with others, as well as changes in how they understand themselves and their roles as members of society (Erikson, 1950). Each stage presents a unique developmental task, which Erikson referred to as a crisis or conflict that must be resolved. How well individuals address the crisis determines their ability to deal with the demands made by the next stage of development. The first developmental task or crisis is for infants to develop a sense of trust (versus mistrust) in others. The resolution of this stage influences their progress in the next stage, developing a sense of autonomy, or the ability to be independent and guide their own behavior, and the outcome of each stage influences the following stages.

Regardless of their success in resolving a crisis of a given stage, children are driven by maturation and social expectations to the next psychosocial stage. No crisis is ever fully resolved, and unresolved crises are revisited throughout life. Although it is never too late, resolving a crisis from a previous stage becomes more challenging given the demands and crises of current psychosocial stages.

Erikson's psychosocial theory views development as life-long, well beyond childhood. Unlike Freud, Erikson studied children, including larger and more diverse samples than Freud, and emphasized the role of the social world, including society and culture. Largely viewed as unfalsifiable, Erikson's theory is criticized as difficult to test. Yet it has nonetheless sparked research on specific stages, such as identity development during adolescence (Crane, 2017). We revisit Erikson's theory throughout this book.

TABLE 1.1 ■ Psychoanalytic Theories of Development

Approximate Age	Freud's Psychosexual Theory		Erikson's Psychosocial Theory	
0 to 18 months	Oral	Basic drives focus on the mouth, tongue, and gums. Feeding and weaning influence personality development. Freud believed that failure to meet oral needs influences adult habits centering on the mouth, such as fingernail biting, overeating, smoking, or excessive drinking.	Trust vs. Mistrust	Infants learn to trust that others will fulfill their basic needs (nourishment, warmth, comfort) or to lack confidence that their needs will be met.
18 months to 3 years	Anal	Basic drives are oriented toward the anus, and toilet training is an important influence on personality development. If caregivers are too demanding, pushing the child before they are ready, or too lax, children may develop control issues such as a need to impose extreme order and cleanliness on their environment or extreme messiness and disorder.	Autonomy vs. Shame and Doubt	Toddlers learn to be self-sufficient and independent through toilet training, feeding, walking, talking, and exploring or to lack confidence in their own abilities and doubt themselves.
3 to 6 years	Phallic	In Freud's most controversial stage, basic drives shift to the genitals. The child develops a romantic desire for the other-sex parent and a sense of hostility and fear of the same-sex parent. The conflict between the child's desires and fears arouses anxiety and discomfort. It is resolved by pushing the desires into the subconscious and spending time with the same-sex parent and adopting their behaviors and roles, adopting societal expectations and values. Failure to resolve this conflict may result in guilt and a lack of conscience.	Initiative vs. Guilt	Young children become inquisitive, ambitious, and eager for responsibility or experience overwhelming guilt for their curiosity and overstepping boundaries.

Approximate Age	Freud's Psychosexual Theory		Erikson's Psychosocial Theory	
6 years to puberty	Latency	This is not a stage but a time of calm between stages when the child develops talents and skills and focuses on school, sports, and friendships.	Industry vs. Inferiority	Children learn to be hardworking, competent, and productive by mastering new skills in school, friendships, and home life or experience difficulty, leading to feelings of inadequacy and incompetence.
Adolescence	Genital	With the physical changes of early adolescence, the basic drives again become oriented toward the genitals. The person becomes concerned with developing mature adult sexual interests and sexual satisfaction in adult relationships throughout life.	Identity vs. Role Confusion	Adolescents search for a sense of self by experimenting with roles. They also look for answers to the question, "Who am I?" regarding career, sexual, and political roles or remain confused about who they are and their place in the world.
Early adulthood			Intimacy vs. Isolation	Young adults seek companionship and a close relationship with another person or experience isolation and self-absorption through difficulty developing intimate relationships and sharing with others.
Middle adulthood			Generativity vs. Stagnation	Adults contribute to, establish, and guide the next generation through work, creative activities, and parenting or stagnate, remaining emotionally impoverished and concerned about themselves.
Late adulthood			Integrity vs. Despair	Older adults look back at life to make sense of it, accept mistakes, and view life as meaningful and productive or feel despair over goals never reached and fear of death.

Behaviorist and Social Learning Theories

In contrast with psychoanalytic theory's emphasis on the unconscious, which cannot be observed or falsified by research, scientists who study **behaviorism** examine only observable behavior—what can be seen. Thoughts and emotion cannot be seen or objectively verified; therefore behaviorists believe they cannot be studied. Central to behaviorism is the belief that all behavior is controlled by the environment. Consider this famous quote from John Watson (1925), a founder of behaviorism:

> Give me a dozen healthy infants, well formed, and my own specified world to bring them up in and I'll guarantee to take any one at random and train him to become any type of specialist I might select—doctor, lawyer, artist, merchant, chief, and yes, even beggar-man and thief, regardless of his talents, penchants, tendencies, abilities, vocations, and race of his ancestors. (p. 82)

By controlling an infant's physical and social environment, Watson believed he could control the child's destiny. Behaviorist theory is also known as *learning theory* because it emphasizes how people and animals learn new behaviors and develop through environmental shaping. Classical and operant conditioning are two forms of behaviorist learning; social cognitive theory integrates behaviorist theory and cognitive theories.

Pavlov's Classical Conditioning

Classical conditioning is a form of learning in which a person or animal comes to associate environmental stimuli with physiological responses. Ivan Pavlov (1849–1936), a Russian physiologist,

Ivan Pavlov (1849–1936) discovered classical conditioning when he noticed that dogs naturally salivate when they taste food, but they also salivate in response to various sights and sounds that they associate with food.

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discovered the principles of classical conditioning when he noticed that dogs naturally salivate when they taste food, but they also salivate in response to various sights and sounds that they encounter before tasting food, such as their bowl clattering or their owner opening the food cupboard. Pavlov tested his observation by pairing the sound of a tone with the dog's' food; the dogs heard the tone, then received their food. Soon the tone itself began to elicit the dogs' salivation.

Through classical conditioning, a neutral stimulus (in this example, the sound of the tone) comes to elicit a response originally produced by another stimulus (food). Many fears, as well as other emotional associations, are the result of classical conditioning. For example, some children may fear a trip to the doctor's office because they associate the doctor's office with the discomfort they felt while receiving a vaccination shot. Classical conditioning applies to involuntary physiological and emotional responses only, yet it is a cornerstone of psychological theory. A second behaviorist theory, operant conditioning, accounts for voluntary, nonphysiological responses.

Skinner's Operant Conditioning

Perhaps it is human nature to notice that the consequences of our behavior influence our future behavior. A child praised for setting the dinner table may be more likely to spontaneously set the table in the future. One scolded for writing on a wall with crayon may be less likely to do so. These two examples illustrate the basic tenet of B. F. Skinner's (1905–1990) theory of **operant conditioning**, which holds that behavior becomes either more or less probable depending on its consequences. According to Skinner, a behavior followed by a rewarding or pleasant outcome, called **reinforcement**, will be more likely to recur. One followed by an aversive or unpleasant outcome, called **punishment**, will be less likely to recur.

Operant conditioning explains much about human behavior, including how children learn skills and habits. Behaviorist ideas about operant conditioning are woven into the fabric of North American culture and are often applied to understand parenting and parent-child interactions (Troutman, 2015). Developmental scientists, however, tend to disagree with operant conditioning's emphasis on only external events (reinforcing and punishing consequences) over internal events (thoughts and emotions) as influences on behavior and development (Crane, 2017). That is, controlling children's environments can influence their development, but recall that children play an active role in influencing their development. Children think and act of their accord. A child can devise new ideas and learn independently, without reinforcement or punishment.

Bandura's Social Cognitive Theory

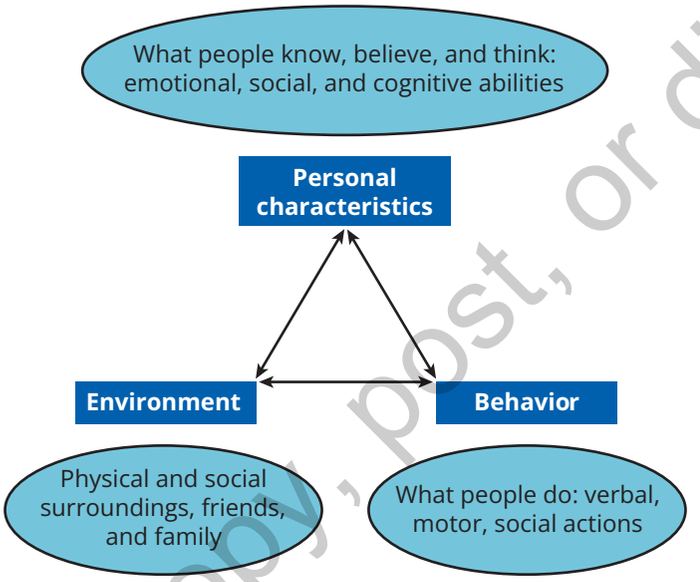
Like B. F. Skinner, Albert Bandura (1925–2021) viewed the environment as an important influence on behavior. Bandura also believed that thoughts and emotions contribute to behavior and development. Children actively process information—they think and feel emotion—and their thoughts and feelings influence their behavior. Moreover, children are active in their development; they are not passively molded by their physical and social environments. Bandura's **social cognitive theory** explains children's development as the result of interactions among their physical and social environment, their cognition and personal characteristics, and behavior, a concept he called **reciprocal determinism** (see Figure 1.4; Bandura, 2011, 2018).

Bandura argues that children's thoughts and characteristics determine their behavior and the environments they seek. Children who are athletically inclined (cognitive/personal characteristic) tend to play sports (behavior) and seek out environments that support their interests, such as athletic teams.

Environments (athletic teams), in turn, influence children's thoughts and personal characteristics (interest in athletics) and behaviors (playing sports). The complex interplay among person, behavior, and physical and social environment underlies much of what we discuss throughout this book.

One of Bandura's most enduring ideas about development is that children learn by observing and imitating others, referred to as **observational learning** (Bandura, 2010). Specifically, children learn by observing the consequences of others' actions. Children who observe violence rewarded, such as a child grabbing another child's toy and getting to play with it, may imitate what they see and use aggressive means to take other children's toys. Alternatively, a child might be less likely to imitate a child who takes another child's toy if the aggressor is scolded by a teacher. Observational learning is one of the most powerful ways in which we learn. We do not need to experience punishment or reinforcement to change our behavior (Bandura, 2012). We can learn by observing and thinking about the potential consequences of our actions. Our thoughts and emotions about the consequences of our behavior influence our future behavior.

FIGURE 1.4 ■ Bandura's Model of Reciprocal Determinism



Cognitive Theories

Thinking changes with development. Developmental scientists agree the infants, children, and adolescents have different cognitive capacities, but they offer varying explanations for these differences. Some view cognition as developing in spurts and others as gradual increases in abilities.

Piaget's Cognitive-Developmental Theory

The first to systematically examine infants' and children's thinking was Swiss scholar Jean Piaget (1896–1980), who believed that cognition is at the center of child development because it influences all behavior. According to Piaget's **cognitive-developmental theory**, children actively explore their world and are driven to learn by interacting with the world around them, organizing what they learn into **cognitive schemas**, or concepts and ways of interacting with the world. Through their exploration, such as grasping, touching, and interacting with objects, children construct and refine their cognitive schemas, thereby contributing to their own cognitive development.

Piaget proposed that children's drive to explore and understand the world—to construct more sophisticated cognitive schemas—propels them through four stages of cognitive development, as shown in Table 1.2.

TABLE 1.2 ■ Piaget's Stages of Cognitive Development

Stage	Approximate Age	Description
Sensorimotor	Birth to 2 years	Infants understand the world and think using only their senses and motor skills, by watching, listening, touching, and tasting.
Preoperations	2 to 6 years	Preschoolers explore the world using their own thoughts as guides and develop the language skills to communicate their thoughts to others. Despite these advances, their thinking is characterized by several errors in logic.
Concrete Operations	7 to 11 years	School-aged children become able to solve everyday, logical problems. Their thinking is not yet fully mature because they can apply it only to tangible problems and tied to specific substances.
Formal Operations	12 years to adulthood	Adolescents and adults can reason logically and abstractly about possibilities, imagined instances and events, and hypothetical concepts.

Piaget's cognitive-developmental theory transformed the field of developmental psychology and remains one of the most widely cited developmental theories. It was the first to consider *how* infants and children think and to view people as active contributors to their development. In addition, Piaget's concept of cognitive stages and the suggestion that children's reasoning is limited by their stage has implications for education—specifically, the idea that effective instruction must match the child's developmental level.

Some critics of cognitive-developmental theory argue that Piaget focused too heavily on cognition and ignored emotional and social factors in development (Crane, 2017). Others believe that Piaget neglected the influence of contextual factors by assuming that cognitive-developmental stages are universal, that all children everywhere progress through the stages in unvarying sequence. Some cognitive theorists believe that cognitive development is not a discontinuous series of stages but instead is a continuous process of gaining skills in manipulating information (Birney & Sternberg, 2011).

Information Processing Theory

In contrast with Piaget's stage theory, cognitive development is viewed as continuous in **information processing theory**. This theory likens the mind to a computer where information is received, processed and organized, stored, recalled, and manipulated to solve problems (Halford & Andrews, 2011; Wickens & Carswell, 2021). Unlike the theories we have discussed so far, information processing theory isn't attributed to a single theorist but is made up of numerous theories, each emphasizing a different aspect of thinking (Conte & Richards, 2021; Eggen, 2020; Winne, 2021). Some theories focus on how people perceive, attend to, and absorb information. Others examine how people store information, create memories, and remember information. Still others examine problem-solving skills, such as how people approach and solve problems in school, the workplace, and in everyday life. For example, a researcher might give a 5-year-old child a toy maze with a dog, cat, and a mouse who must find their way through to reach a bone, a fish, and a piece of cheese (Klahr, 1985). How does the child approach this task? What strategies do they use? How quickly do they respond? How do they explain their thinking? Finally, how does their process and performance differ from those of children older and younger than them?

Information processing theorists believe that children are born with the ability to process information. The mental processes of noticing, taking in, manipulating, storing, and retrieving information change gradually over infancy and childhood (Klahr & Wallace, 2022). Development is continuous, influenced by brain development, and includes improvements in efficiency and speed (Gibb, 2020). Through experience and interaction with others, children learn new ways of managing and manipulating information.

Information processing theory offers a detailed view of how children think, which permits scientists to make specific predictions about behavior and performance that can be tested. Indeed, information processing theory has generated a great many research studies and has garnered much empirical support (Halford & Andrews, 2011; Wickens & Carswell, 2021). Critics of information processing

theory argue that a computer model cannot capture the complexity of the human mind and people's unique cognitive abilities. In addition, findings from laboratory research may not extend to everyday contexts in which people must adapt to changing circumstances and challenges to attention (Miller, 2016).

Vygotsky's Sociocultural Theory

Writing at the same time as Piaget, Russian scholar Lev Vygotsky (1896–1934) emphasized the importance of culture in cognition. Recall that culture refers to the beliefs, values, customs, and skills of a group; it is a product of people's interactions in everyday settings (Markus & Hamedani, 2020). Vygotsky's (1978) **sociocultural theory** examines how culture and its tools (such as language) are transmitted from one generation to the next through social interaction.

Children interact with adults and more experienced peers as they talk, play, and work alongside them. Through these formal and informal social contacts, children learn about their culture and acquire cultural tools, including a culture's language, which transmits ways of thinking. Vygotsky believed that acquiring language is a critical milestone for children because it enables children to participate in culturally valued activities, have more sophisticated dialogues with others, and adopt attitudes and perspectives valued by their community (Daniels, 2017). By participating in cooperative dialogues and receiving guidance from adults and more expert peers, children adopt their culture's perspectives and practices, learning to think and behave as members of their group (Rogoff, 2016). Over time, children apply these ways of thinking to guide their own actions, thus requiring less assistance from adults and peers (Daniels, 2017; Rogoff et al., 2014).

Vygotsky's sociocultural theory holds important implications for understanding cognitive development. Like Piaget, Vygotsky emphasized that children actively participate in their development by engaging with the world around them. However, Vygotsky placed greater emphasis than Piaget on the cultural context in influencing people's development. He viewed cognitive development as a social process that relies on interactions with adults, more mature peers, and other members of their culture. Critics of Vygotsky's theory argue that it overemphasizes context and undervalues the roles of biological factors and children's own influence on their development (Crane, 2017). We revisit Vygotsky's ideas about the roles of culture, language, and thought in Chapter 8.

Systems Theories

Many theories examine a specific aspect of development, such as cognition, the sense of self, and environmental determinants of behavior. Systems theories take a broader approach, considering all parts of the individual and the many contexts in which they are embedded, such as home, school, peer group, and so on. A system is a set of interacting parts that are interconnected and work together as a network. We are composed of multiple interacting systems that make up the physical, cognitive, and socioemotional developments that we have discussed so far. We are also embedded in systems, or contexts. People take an active role in their development by interacting with people, objects, and settings—and they are also influenced by these factors. These interactions take place all throughout our lives, changing over time. The two predominant systems theories are the bioecological systems theory and dynamic systems theory.

Bronfenbrenner's Bioecological Systems Theory

Similar to other developmental theorists, Urie Bronfenbrenner (1917–2005) believed that children influence their own development. He also emphasized the importance of context in development. Bronfenbrenner proposed that all individuals are embedded in, or surrounded by, a series of contexts: home, school, neighborhood, culture, and society. As shown in Figure 1.5, contexts are organized into a series of systems in which individuals are embedded and that interact with one another and the person to influence development. Bronfenbrenner's **bioecological systems theory** explains development as the result of the ongoing interactions among biological, cognitive, and psychological changes in children and their changing context (Bronfenbrenner & Morris, 2006). The bioecological systems theory thus offers a comprehensive perspective on the role of context as an influence on development.

Ontogenetic development. At the center of the bioecological system is the individual. **Ontogenetic development** refers to the changes that take place within the individual over their lifetime, including biological, cognitive, and socioemotional changes, which influence each other. Physical development, such as brain maturation, may influence children's cognitive development, such as reasoning and the ability to consider other people's perspectives. These changes might influence social development, specifically the ability to have more complex and intimate friendships, which can influence cognitive development, as children learn from each other. In this way the various forms of development interact. Ontogenetic development is not only influenced by but also influences the many contexts in which children are embedded (Bronfenbrenner & Morris, 2006).

Microsystem. Perhaps the most visible context of the bioecological system is the **microsystem**, the innermost layer. It includes a child's interactions with the immediate physical and social environment surrounding the child, such as family, peers, and school. Because the microsystem includes the child, it has an immediate and direct influence on their development—and children affect it. Interactions with friends, family, and teachers (all part of the microsystem) can influence (and are influenced by) children's sense of self-esteem, social skills, and emotional development (ontogenetic development).

Mesosystem. Microsystem factors naturally interact. Experiences in the home (one microsystem factor) influence those at school (another microsystem factor). Encouragement and support for reading at home, for instance, can influence the child's experiences in the classroom. These interactions comprise the **mesosystem**, which refers to the relations among microsystems, connections among contexts, such as home, peer group, school, work, and neighborhood. Like the microsystem, the mesosystem has a direct influence on children (and is influenced by children) because they participate in it.

Exosystem. The **exosystem** consists of settings that affect children but in which they do not participate. A parent's experiences at work can influence their children's home environment. Promotions, raises, long work hours, stressful interactions, and lengthy commutes can influence parents' interactions with family members and the emotional climate at home. The availability of funding for schools, another exosystem factor, indirectly affects children by influencing the availability of classroom resources. Exosystem factors trickle down to influence children's interactions in the mesosystem and microsystem.

Macrosystem. The **macrosystem** is the greater sociocultural context in which the microsystem, mesosystem, and exosystem are embedded. It includes cultural values, legal and political practices, and other elements of society at large. The macrosystem indirectly influences children because it affects each of the other contextual levels. Cultural beliefs about the value of education (macrosystem) influence funding decisions made at national and local levels (exosystem), as well as what happens in the classroom and in the home (mesosystem and microsystem).

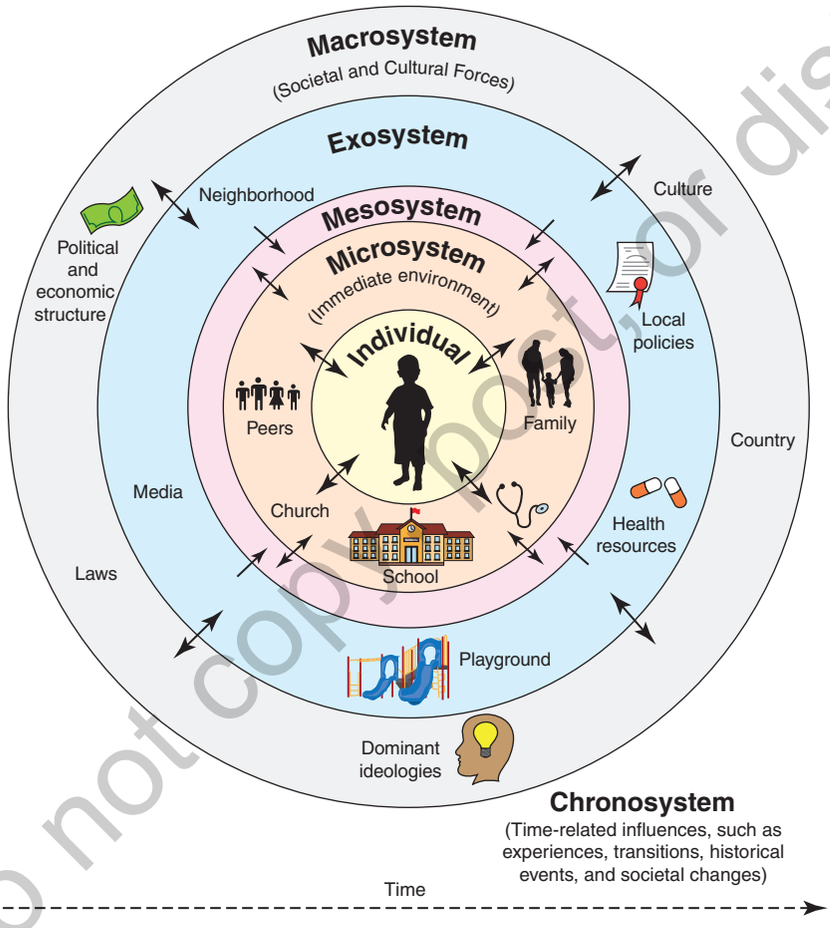
Chronosystem. By its very nature, the bioecological system is always shifting because individuals and their contexts interact dynamically and perpetually, resulting in a constant state of change. The final element of the bioecological system is the **chronosystem**, which refers to the passing of time. The historical time in which children live influences their development. Large scale social changes, such as those that accompany war, natural disasters, and epidemics, can influence each level of the bioecological system. Neighborhood resources may change over time with changes in local policies and funding. Children's relationships with parents, friends, and teachers change over time—and their microsystems and mesosystems change dynamically.

Evaluating Bronfenbrenner's bioecological systems theory. Recently, bioecological systems theory has been criticized for its vague explanation of development, especially the role of culture (Vélez-Agosto et al., 2017). Situated in the macrosystem, culture is said to influence development through the interdependence of the systems. Today's developmental scientists believe that culture is not just a macrosystem factor. Culture refers to *all* the processes used by people as they make meaning

or think through interactions with group members (J. Mistry et al., 2016; Varnum & Grossmann, 2017). Critics argue that since culture is manifested in our daily interactions and activities, it is inherent in each bioecological level, not just the macrosystem as Bronfenbrenner believed (Vélez-Agosto et al., 2017).

A second criticism arises from the sheer complexity of the bioecological system and its attention to patterns and dynamic interactions. We can never measure and account for all the potential individual and contextual influences on development at once, making it difficult to devise research studies to test the validity of the model. In contrast, proponents of bioecological theory argue that rather than conducting large studies to test all the model's components at once, smaller studies can examine each component over time (Jaeger, 2016; Tudge et al., 2016, 2022). In any case, bioecological theory remains an important contribution toward explaining children's development and is a theory that we consider throughout this book.

FIGURE 1.5 ■ Bronfenbrenner's Bioecological Systems Theory



Adapted from Bronfenbrenner, U., & Morris, P. A. (2006). The bioecological model of human development. In R. M. Lerner & W. Damon (Eds.), *Handbook of child psychology: Theoretical models of human development* (Vol. 1, pp. 793–828). John Wiley & Sons.

Thelen's Dynamic Systems Theory

As we have discussed, developmental scientists generally agree that development is influenced by the interaction of biology and environment—and that children influence their development through their interactions with their context. These important ideas are reflected in Esther Thelen's (1995, 2000) **dynamic systems theory**, which emphasizes interactions between biological maturation, environmental

circumstances and constraints, and individuals' drive to engage the world. Collectively these are an integrated system that is constantly changing, resulting in developmental change and the emergence of new abilities in children.

Dynamic systems theory places children at the center of their development. Children direct and advance their own development because they are motivated to obtain objects, interact with others, understand their experience, and control their environment. Each child's physical characteristics are unique. Their environmental circumstances are also unique, affording specific opportunities and constraints for movement and learning. Therefore, children's behavior and development are the result of their motivation to master their unique environment, capitalizing on opportunities, and adapting to constraints. Infants' desire to reach objects and master their environment drives them to crawl, but how they crawl and the timeframe in which crawling unfolds varies with their physical abilities and their specific environment, such as whether they live in a home with carpeting (which might make crawling easier) or slippery floors (which might make it more difficult).

Thelen described dynamic systems theory with motor development in mind. Theorists are now applying it to understand children's cognitive and emotional development as well as the nature of development itself (Adolph, 2020; Perone et al., 2021; Sosnowska et al., 2020). We explore this theory in Chapter 4.

Ethology and Evolutionary Developmental Theory

What motivates parents of most species to care for their young? Some researchers believe that caregiving behaviors have an evolutionary basis. **Ethology** is the scientific study of the evolutionary basis of behavior (Bateson, 2015). In 1859, Charles Darwin proposed his theory of evolution, explaining that all species adapt and evolve over time. Specifically, traits that enable members of a species to adapt, thrive, and mate tend to be passed to succeeding generations. The traits that helped individuals survive to adulthood and reproduce successfully are passed to their offspring, aiding their survival and that of the species.

Several early theorists applied the concepts of evolution to behavior. Konrad Lorenz and Kiko Tinbergen, two European zoologists, observed animal species in their natural environments and noticed patterns of behavior that appeared to be inborn, emerged early in life, and were necessary for the animals' survival. Shortly after birth, goslings imprint on their mother, meaning that they bond to her and follow her. Imprinting aids the goslings' survival because it ensures that they stay close to their mother, get fed, and remain protected. For imprinting to occur, the mother goose must be present immediately after the goslings hatch; mothers instinctively stay close to the nest so that their young can imprint (Lorenz, 1952).

According to John Bowlby (1969), humans also display biologically preprogrammed behaviors that have survival value and promote development. Caregivers naturally respond to infants' cues. Crying, smiling, and grasping are inborn ways that infants get attention from caregivers, bring caregivers into physical contact, and ensure that they will be safe and cared for. Such behaviors have adaptive significance because they meet infants' needs and promote the formation of bonds with caregivers who then feel a strong desire and obligation to care for them (Bowlby, 1973). In this way innate biological drives and behaviors work together with experience to influence adaptation and ultimately an individual's survival.

Another theory, **evolutionary developmental theory**, also applies principles of evolution to understand development; however, this approach emphasizes the interactive influence of genetic and environmental mechanisms in development (Bjorklund & Hart, 2022; Blasi, 2020). You may have wondered whether you—your abilities, personality, and competencies—result from your genes or from the physical and social environment in which you were raised. Evolutionary developmental scientists explain that this is the wrong question to ask because genes and context interact in an ever-changing way so that it is impossible to isolate the contributions of each to development (Blasi, 2020).

Evolutionary developmental theorists view children as active in their development, influencing their contexts, responding to the demands for adaptation posed by their contexts, and constantly interacting with and adapting to the world around them (see Table 1.3). In this way, children's genetic factors and biological predispositions interact with their physical and social environment to influence development. Ultimately, Darwinian natural selection determines what genes and traits are passed from adults to the next generation (Bjorklund, 2020; Witherington & Lickliter, 2016).

Most developmental scientists appreciate the contributions of evolutionary developmental theory because the relevance of both biological and contextual factors to human development is indisputable (DelGiudice, 2018; Frankenhuis & Tiokhin, 2018; Legare et al., 2018). We examine the interactive effect of genes and environment in Chapter 2.

TABLE 1.3 ■ Comparing Theories of Child Development

Theory	How do biology and environment influence development?	How do children influence their own development?	In what ways is development continuous and discontinuous?
Freud's psychosexual theory	*Greater emphasis on biology*: People are driven by inborn drives, but the extent to which the drives are satisfied influences developmental outcomes.	*Children are passive*: People are driven by inborn instincts and are not active participants in their development.	*Discontinuous*: Stages
Erikson's psychosocial theory	*Both biology and environment*: Biological and social forces propel children through the stages, and social and psychosocial influences determine the outcome of each stage.	*Children are active*: Children interact with their social world to resolve psychosocial tasks.	*Discontinuous:* Stages
Behaviorist theory	*Environment*: Environmental influences shape behavior.	*Children are passive*: Children are shaped and molded by their environment.	*Continuous:* Gradual process of learning new behaviors
Bandura's social learning theory	*Both biology and environment:* Inborn characteristics and the physical and social environment influence behavior.	*Children are active*: Children are influenced by the environment and also play an active role in their development through reciprocal determinism.	*Continuous:* Gradual process of learning new behaviors
Piaget's cognitive-developmental theory	*Both biology and environment*: An inborn ability to learn coupled with brain development leads children to interact with the world. Opportunities provided by the physical and social environment influence development.	*Children are active*: Children actively interact with the world to create their own schemas.	*Discontinuous:* Stages
Information processing theory	*Both biology and environment*: Children are born with processing capacities that develop through maturation and environmental influences.	*Children are active*: Children attend to, process, and store information.	*Continuous:* Gradual increase of skills and capacities
Vygotsky's sociocultural theory	*Both biology and environment*: Children learn through interactions with more skilled members of their culture; capacities are influenced by genes, brain development, and maturation.	*Children are active*: Children actively interact with members of their culture.	*Continuous:* Continuous interactions with others lead to developing new reasoning capacities and skills.
Bronfenbrenner's bioecological systems theory	*Both biology and environment*: Children's inborn and biological characteristics interact with an ever-changing context to influence behavior.	*Children are active*: Children interact with their contexts, being influenced by their contexts but also determining what kinds of physical and social environments are created and how they change.	*Continuous*: People constantly change through their interactions with the contexts in which they are embedded.

(*Continued*)

TABLE 1.3 ■ Comparing Theories of Child Development (*Continued*)

Theory	How do biology and environment influence development?	How do children influence their own development?	In what ways is development continuous and discontinuous?
Dynamic systems theory	*Both biology and environment*: Developmental domains, maturation, and environment form an integrated system.	*Children are active*: Children's goal-oriented behavior influences their development.	*Continuous*: New developmental achievements are the result of systematic skill-building.
Ethology and evolutionary developmental theory	*Both biology and environment*: Genetic programs and biological predispositions interact with the physical and social environment to influence development, and Darwinian natural selection determines what genes and traits are passed on to the next generation.	*Children are active*: Children interact with their physical and social environment.	*Both continuous and discontinuous:* People gradually grow and change throughout life, but there are sensitive periods in which specific experiences and developments must occur.

THINKING IN CONTEXT 1.3

"Babies naturally bond to their caregivers. It's inborn," Chloe explains. "No," Dedra counters, "at birth they don't know who their caregivers are! Bonding comes with experience."

1. Consider the following theoretical perspectives: Erik Erikson's psychosocial theory, behaviorism, Bandura's social learning theory, Piaget's cognitive developmental theory, and evolutionary developmental theory. Which theories align with Chloe's argument? Which fit(s) Dedra's? Explain your choices.
2. Considering bioecological systems theory, what microsystem and mesosystem factors influence the parent-child bond? What role might exosystem and macrosystem factors take?

RESEARCH IN CHILD DEVELOPMENT

1.4 Examine the methods and research designs used to study child development.

Developmental scientists create theories, such as those we have discussed, to organize their observations of how children behave in various settings and circumstances. Theories guide these scientists as they ask and answer questions about how people grow and change over childhood and throughout their lives. Theories suggest new hypotheses to test in research studies. In turn, research findings are used to modify theories.

The Scientific Method

The **scientific method** refers to a process of asking and answering questions through systematic observation to gather and summarize information and draw conclusions. It is an organized way of formulating questions, finding answers, and communicating research discoveries. Its basic steps are as follows:

1. Identify the research question or problem to be studied and formulate the hypothesis, or proposed explanation, to be tested.
2. Gather information to address the research question.

3. Summarize the information gathered and determine whether the hypothesis is refuted or shown to be false.
4. Interpret the summarized information, consider the findings in light of prior research studies, and share findings with the scientific community and world at large.

This 4-step process seems straightforward and linear. In practice, it is often more complicated. Frequently research studies raise as many questions as they answer—and sometimes more. Unexpected findings can prompt new studies. Researchers may repeat an experiment (called a *replication*) to see whether the results are the same as previous ones. Sometimes analyses reveal flaws in data collection methods or research design, prompting a revised study. Experts may also disagree on the interpretation of a study, leading to new hypotheses and studies. For these reasons, scientists often say the scientific method is *messy*.

Methods of Data Collection

All research involves gathering data, information, about the topic of interest—Step 2 in the scientific method. How can we gather data about children? Should we simply talk with them? Watch them as they play? Hook them up to machines that measure physiological activity such as heart rate or brain waves? Developmental scientists use a variety of different methods, summarized in Table 1.4 and discussed next.

Observational Measures

Some developmental scientists collect data by watching and recording children's behavior. Developmental scientists employ two types of observational measures: naturalistic observation and structured observation.

Naturalistic observation. Scientists who use **naturalistic observation** observe and record behavior in natural, real-world settings. For example, Salo et al. (2018) observed 12-month-old infants playing with their parents. They recorded infants' gestures and how often they participated with parents in paying attention to or interacting with an object (such as a toy). One year later, infants who used more gestures and engaged in more joint attention, especially responses to parents' efforts to direct their attention, showed more advanced language development; they understood and produced more words.

Naturalistic observation can reveal patterns of behavior in everyday settings, such as whether a particular event or behavior typically precedes another. Such observations can help researchers determine which behaviors are important to study. A scientist who studies bullying by observing children's play may notice that some victims act aggressively *before* a bullying encounter (Kamper-DeMarco & Ostrov, 2017). The scientist may then decide to examine aggression in victims not only after a bullying incident but also beforehand.

A challenge of using naturalistic observation is that sometimes the presence of an observer causes those being observed to behave unnaturally. This is known as *participant reactivity*. One way of reducing the effect of participant reactivity is to conduct multiple observations so that the children get used to the observer and return to their normal behavior. Another promising method of minimizing participant reactivity is to use an *electronically activated voice recorder* (EAR) (Carey et al., 2020; Mehl, 2017). Participants carry the EAR as they go about their daily lives. The EAR captures segments of audio information over time: hours, days, or even weeks. It records a log of people's activities as they naturally unfold. The EAR minimizes participant reactivity because the participant is unaware of exactly when the EAR is recording. Researchers who study child trauma use EAR to sample conversations between parents and children to understand how parent-child interactions influence children's adjustment and how the family environment can aid children's recovery from trauma (Alisic et al., 2016; Vasileva et al., 2022).

Naturalistic observation is a useful way of studying events and behaviors that are common. Some behaviors and events are difficult to observe or occur infrequently, however, requiring a researcher to observe for very long periods of time to obtain data on the behavior of interest. For this reason, many researchers make structured observations.

This researcher is using a video camera to observe and record the facial expressions a newborn baby makes while it sleeps.

Thierry Berrod, Mona Lisa Production/Science Source

Structured observation. Observing and recording behaviors displayed in a controlled environment, a situation constructed by the experimenter, is known as **structured observation**. Children might be observed in a laboratory setting as they play with another child or complete a puzzle-solving task. The challenges of identifying and categorizing which behaviors to record are similar to those involved in naturalistic observation. However, the laboratory environment permits researchers to exert more control over the situation than is possible in natural settings. In addition to cataloguing observable behaviors, researchers can use technology to measure biological functions such as heart rate, brain waves, and blood pressure. One disadvantage to conducting structured observations, of course, is that people do not always behave in laboratory settings as they do in real life.

Self-Report Measures

Interviews and questionnaires are known as *self-report measures* because participants, such as children and parents under study, answer questions about their experiences, attitudes, opinions, beliefs, and behavior. Interviews are one-on-one conversations that can take place in person, over the phone, or over videoconferencing.

In an **open-ended interview** a trained interviewer uses a conversational style that encourages children to expand their responses. The scientist begins with a question and then follows up with prompts to better understand the child's reasoning (McConaughy & Whitcomb, 2022). Interviewers may vary the order of questions, probe, and ask additional questions based on each child's responses. Cognitive-developmental theorist Jean Piaget adopted this approach to study children's thinking. Consider this dialogue between Piaget (1929) and a 6-year-old child:

> You know what a dream is?
>
> *When you are asleep and you see something.*
>
> Where does it come from?
>
> *The sky.*
>
> Can you see it?
>
> *No! Yes, when you're asleep*
>
> Could I see it if I was there?
>
> *No.*
>
> Why not?
>
> *Because it is in front of us. . . . When you are asleep you dream and you see them, but when you aren't asleep you don't see them.*

In open-ended interviews children can explain their thoughts thoroughly and in their own words, but the flexibility of these interviews also poses challenges. When questions are phrased differently for each child, responses may not capture real differences in how children think about a given topic and instead may reflect differences in how the questions were posed and followed up by the interviewer.

In contrast, a **structured interview** poses the same set of questions in the same order to each child. Structured interviews are less flexible than open-ended interviews. All participants receive the same set

of questions so differences in responses are more likely to reflect true differences among participants and not merely differences in the manner of interviewing. Evans et al. (2002) used a structured interview to examine North American children's beliefs about magic. Children between the ages of 3 and 8 were asked the following set of questions:

> What is magic? Who can do magic?
>
> Is it possible to have special powers? Who has special powers?
>
> Does someone have to learn to do magic? Where have you seen magic? (p. 49).

After compiling and analyzing the children's responses, as well as administering several cognitive tasks, the researchers concluded that even older children who can think logically and perform concrete operations may display magical beliefs.

To collect data from large samples of people, scientists may develop and use **questionnaires**, also called surveys, made up of sets of questions, typically multiple choice. Questionnaires can be administered in person, online, or by telephone, email, or postal mail. Questionnaires are popular data collection methods because they are easy to use and enable scientists to collect information from many people quickly, inexpensively, and anonymously (people can respond without sharing their name). The Monitoring the Future Study, for instance, is an annual survey of 50,000 8th-, 10th-, and 12th-grade students that collects information about their behaviors, attitudes, and values concerning drug and alcohol use (Miech et al., 2024). This anonymous survey permits scientists to gather an enormous amount of data while protecting the adolescent participants from the consequences of sharing personal information that they might not otherwise reveal.

Despite these benefits, questionnaires rely on children's ability to read and understand questions and provide responses. It is not until late childhood, and more often adolescence, that questionnaires become feasible sources of data.

A challenge of self-report measures, both survey and interview, is that sometimes people give socially desirable answers rather than sharing their true feelings. They respond in ways that reflect how they would like themselves to be perceived or give answers they believe researchers want to hear. A fifth-grade student might sometimes peek at other students' tests but might not report this behavior when completing a survey about cheating. Their survey responses might instead match the person they aspire to be or the behaviors they believe a teacher expects—that is, someone who does not cheat on exams. Self-report data, then, may not always reflect children's true understanding, attitudes, or behavior. Also, people are not always fully aware of their feelings and may not provide useful insight into their thoughts and behavior through self-report measures (Newell & Shanks, 2014).

Physiological Measures

Physiological measures are increasingly used in developmental research because cognition, emotion, and behavior have physiological indicators. When speaking in public, such as when you give a class presentation, do you feel your heart beat more rapidly or your palms grow sweaty? Increases in heart rate and perspiration are physiological measures of anxiety that might be measured by researchers. Other researchers might measure cortisol, a hormone triggered by the experience of stress (Simons et al., 2017).

Eye movements and pupil dilation can indicate attention and interest. Researchers studying children's acquisition of a second language might measure children's eye movements to track their attention and determine whether a child connects a new word with an object or concept (Dussias & Miller, 2022). Pupil dilation can be used as a measure of infants' interest and of attention and processing in older children (Köster & Hepach, 2024; Selezneva & Wetzel, 2022).

Physiological measures of brain activity are a particularly promising source of data. Several tools are used to study the brain. **Electroencephalography (EEG)** measures electrical activity patterns produced by the brain via electrodes placed on the scalp. Researchers study fluctuations in activity that occur when participants are presented with stimuli or when they sleep. EEG simply measures electrical activity but cannot provide information about the location of that activity or the brain structures that are the source of brain activity.

Computerized tomography (CT) compiles multiple x-ray images to create a 3-D picture of a person's brain, including brain structures, bone, brain vasculature, and tissue (Withers et al., 2021). CT scans can provide researchers with information about the density of brain structures to illustrate how the thickness of the cortex changes with development. Recording multiple x-ray images, however, exposes research participants to higher levels of radiation than a single x-ray (Rehani & Nacouzi, 2020).

Positron emission tomography (PET) involves injecting a small dose of radioactive material into the participant's blood stream to monitor the flow of blood (Gellman, 2020). Because blood flows more readily to active areas of the brain, PET scans allow researchers to identify what parts of the brain are active as participants view stimuli and solve problems.

Functional magnetic resonance imaging (fMRI) uses a powerful magnet and radio waves to measure blood oxygen level (Moriguchi, 2020). Active areas of the brain require more oxygen-rich blood, which fMRI can detect, enabling researchers to determine what parts of the brain are active as individuals complete cognitive tasks. fMRI images are much more detailed than PET scans and do not rely on radioactive molecules that can only be administered a few times before becoming unsafe.

Diffusion tensor imaging (DTI) uses an MRI machine to track how water molecules move in and around the fibers connecting different parts of the brain (Lope-Piedrafita, 2018). DTI gauges the thickness and density of the brain's connections, permitting researchers to measure the brain's white matter and determine changes that occur with development.

An advantage of physiological measures is they do not rely on verbal reports and generally cannot be faked. On the other hand, although physiological responses can be recorded, they may be difficult to interpret. Excitement and anger may both cause an increase in heart rate.

TABLE 1.4 ■ Data Collection Methods

	Advantage	Disadvantage
Observational Measures		
Naturalistic observation	Gathers data on everyday behavior in a natural environment as behaviors occur.	The observer's presence may influence the children's behavior. No control over the observational environment.
Structured observation	Observation in a controlled setting.	May not reflect real-life reactions and behavior.
Self-Report Measures		
Open-ended interview	Gather a large amount of information quickly and inexpensively.	Nonstandardized questions. Characteristics of the interviewer may influence participant responses.
Structured interview	Gather a large amount of information quickly and inexpensively.	Characteristics of the interviewer may influence children's responses.
Questionnaire	Gather data from a large sample more quickly and inexpensively than by interview methods.	Some participants may respond in socially desirable or inaccurate ways.
Physiological Measures		
Electroencephalography (EEG)	Measures electrical activity patterns produced by the brain.	Does not provide information about the brain structures that are the source of brain activity.
Computerized tomography (CT scan)	Provides images of brain structures, bone, brain vasculature, and tissue.	Exposes participants to low levels of radiation.
Positron emission tomography (PET)	Illustrates activity in specific parts of the brain as participants complete cognitive tasks.	Exposes participants to low levels of radiation
Functional magnetic resonance imaging (fMRI)	Illustrates activity in specific parts of the brain as participants complete cognitive tasks. More detailed images than PET scans and do not rely on radiation.	Expensive and requires participants to be completely still during the scan.
Diffusion tensor imaging (DTI)	Measures the thickness and density of brain connections. Less expensive than fMRI.	Requires participants to be completely still during the scan.

Research Designs

Conducting research entails determining a question, deciding what information to collect, and choosing a research design—a technique for conducting the research study. Developmental scientists employ several types of designs, summarized in Table 1.5.

Case Study

A child with unique experiences, abilities, or disorders might prompt a developmental scientist to conduct a **case study**, which is an in-depth examination of a single person (or small group of individuals). Intended to provide a rich description of a person's life and influences on their development, a case study is conducted by gathering information from many sources, including observations, interviews, and conversations with family, friends, and others who know the individual. It may include samples or interpretations of a person's writing, such as poetry or journal entries, artwork, and other creations. Conclusions drawn from a case study may shed light on a specific person's development but may not be generalized or applied to others. Case studies can be a source of hypotheses to examine in large scale research.

Correlational Research

Are children with high self-esteem more likely to excel at school? Do infants who walk early relative to their peers also have a larger vocabulary than other infants? Is screen time related to adolescents' social skills? All these questions can be studied with **correlational research**, which examines relationships among measured characteristics, behaviors, and events.

For example, scientists examined the relationship between physical fitness and cognitive performance in children and found that children with a higher aerobic capacity scored higher on tests of attention and concentration achievement tests than did those with poorer aerobic capacity (González-Fernández et al., 2023). Notice, however, that this correlation does not tell us *why* physical fitness was associated with cognitive performance. Correlational research cannot answer this question because it simply describes relationships that exist among variables; it does not enable us to reach conclusions about the causes of those relationships. It is likely that other variables influence both the child's physical fitness and cognitive performance, such as general health. Correlational studies do not yield information about the causes of behavior—for that we need an experiment.

Experimental Research

Scientists who seek to test hypotheses about *causal* relationships, such as whether media exposure influences behavior or whether hearing particular types of music influences mood, conduct an **experiment**. An experiment is a procedure that uses control to determine causal relationships among variables. Specifically, one or more variables thought to influence a behavior of interest are changed, or manipulated, while other variables are held constant. Researchers can then examine how the changing variable influences the behavior under study. If the behavior changes as the variable changes, this suggests that the variable caused the change in the behavior.

Gentile et al. (2017) examined the effect of playing violent videogames on children's physiological stress and aggressive thoughts. Children were randomly assigned to play a violent videogame (*Superman*) or a nonviolent videogame (*Finding Nemo*) for 25 minutes in the researchers' lab. The researchers measured physiological stress as indicated by heart rate and cortisol levels before and after the children played the videogame. Children also filled out a word completion task that the researchers used to measure the frequency of aggressive thoughts. The researchers found that children who played violent videogames showed higher levels of physiological stress and aggressive thoughts than did the children who played nonviolent videogames. They concluded that the type of videogame changed children's stress reactions and aggressive thoughts.

Let's take a closer look at the components of this experiment. Conducting an experiment requires choosing at least one **dependent variable**, the behavior under study (in this case two behaviors: physiological stress, indicated by heart rate and cortisol, and aggressive thoughts) and at least one **independent variable**, the factor proposed to change the behavior under study (type of videogame). The

independent variable is manipulated or varied systematically by the researcher during the experiment (a child plays with a violent or a nonviolent videogame). Specifically, this manipulation is administered to one or more *experimental groups*, or test groups (children who are asked to play a violent videogame). The *control group* is treated just like the experimental group except that it is not exposed to the independent variable (children who play a nonviolent videogame). After the independent variable is manipulated, if the experimental and control groups differ on the dependent variables (levels of physiological stress and aggressive thoughts are different in the two groups), it is concluded that the independent variable *caused* the change in the dependent variables. That is, a cause-and-effect relationship has been demonstrated.

A procedure called **random assignment** is critical to drawing conclusions from experiments. When participants are randomly assigned to groups, each participant has an equal chance of being assigned to the experimental group and the control group. Random assignment ensures that the groups are as equal as possible in all preexisting characteristics (e.g., age, ethnicity, and gender). Random assignment makes it less likely that preexisting differences between the groups are the cause of any observed differences in the outcomes of the experimental and control groups.

The type of experiment described here is good for identifying the impact of various interventions in the short term, but experimental research relies on experimenters' exerting control over variables. Developmental scientists frequently study problems, such as influences on academic achievement, that cannot be controlled. In these instances correlational research can shed light on relationships among variables. In addition, developmental scientists are interested in how people change over time. For this kind of study, researchers must carefully consider age and use specialized research designs.

Developmental Research Designs

Do children outgrow shyness? Are infants' bonds with their parents associated with their peer relationships in adolescence? These challenging questions require developmental scientists to examine relationships among variables over time. There are several approaches to examining developmental change.

Cross-Sectional Research

A **cross-sectional research study** compares groups of children of different ages at a single point in time. To examine how vocabulary improves in elementary school, a researcher might measure the vocabulary size of children in first, third, and fifth grade. The resulting comparison describes how the vocabulary of first-grade children differs from older children in Grades 3 and 5. But are these changes in vocabulary age-related or developmental change? In a cross-sectional research study, we will not know how the first graders' vocabulary changes over the next few years because this type of study does not follow children over time; it compares the current first graders to current third and fifth graders.

The conclusions researchers can draw about development are limited in a cross-sectional study because participants differ in both age and cohort. A cohort is a group of people of the same age who are exposed to similar historical events and cultural and societal influences. In this example, although the first- and fifth-grade children may attend the same school, they are different ages and different cohorts with potentially different experiences. Suppose the elementary school adopted a new language curriculum, leading the first-grade children to be taught by a new, improved curriculum, whereas the fifth graders received the old curriculum. Any differences in vocabulary may be not only due to age but also to different experiences.

Longitudinal Research

In contrast with a cross-sectional study, which examines children just once, a **longitudinal research study** follows the same group of children over time. By repeatedly examining a set of children, we can describe how they change and the circumstances that surround their development. We can witness development unfolding. Returning to the previous example, a developmental scientist using

longitudinal research would measure children's vocabulary size in first grade, then follow up 2 years later in third grade, and then 2 years later in fifth grade. This longitudinal study would take 4 years to complete.

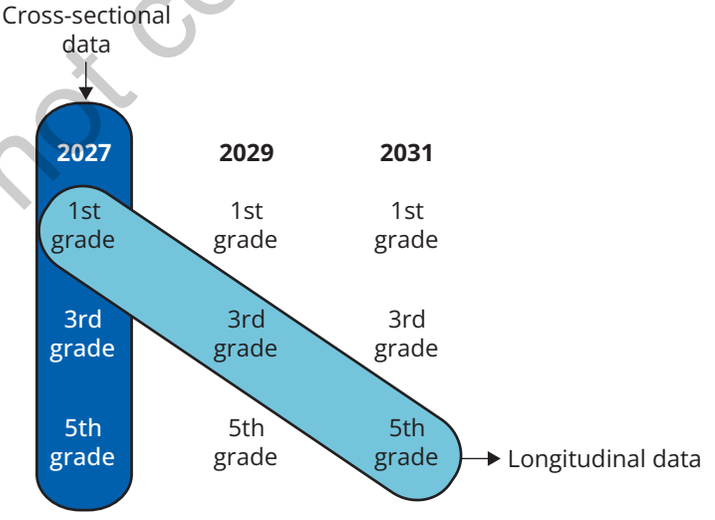
Because longitudinal research follows children over time, scientists can study the first graders' vocabulary progression throughout elementary school. However, longitudinal research studies only one cohort or age group over time. Are the observed findings due to developmental change or are they specific to the children studied? Because only one cohort is assessed, it is not possible to determine whether the observed changes are developmental age-related changes or those that are unique to the cohort examined.

Sequential Research

Sequential research combines the best features of cross-sectional and longitudinal research by assessing multiple cohorts over time, enabling scientists to disentangle the effects of cohort and age (see Figure 1.6). Consider the vocabulary study of children in Grades 1, 3, and 5 once more. A sequential design would begin by measuring vocabulary in first-, third-, and fifth-grade children. Two years later, the first graders are in third grade; the third graders are now in fifth grade; and the fifth graders, now in seventh grade, have presumably graduated from the elementary school and are no longer under study. Next, a new group of first-grade children are introduced to the study. Unique to the sequential design is the addition of new participants at various points throughout the study. The pattern continues. Two years later, that new set of first graders are now in third grade; the original first graders are in fifth grade; the original third graders are in seventh and have aged out of the study; and a new group of first-grade children are introduced to the study, and so on.

The sequential design combines cross-sectional and longitudinal designs to provide information about age, cohort, and age-related change. The cross-sectional data (comparisons of first, third, and fifth graders from a given year) provide information about age differences, meaning how the age groups differ from one another. The longitudinal data captures age-related change, meaning how the group of first graders develop throughout elementary school, because the participants are followed biannually. Because several cohorts are examined at once, the effect of cohort can be studied and conclusions about age-related developmental changes can be drawn. The sequential design is complex, but it permits human development researchers to disentangle the effects of age and cohort and answer questions about developmental change.

FIGURE 1.6 ■ Developmental Designs



Adapted from Kim, J.-S., & Böckenholt, U. (2000). Modeling stage-sequential change in ordered categorical responses. *Psychological Methods, 5*(3), 380–400.

TABLE 1.5 ■ Comparing Research Designs

Design	Strengths	Limitations
Research Designs		
Case study	Provides a rich description of an individual.	Conclusions may not be generalized to other individuals.
Correlational	Permits the analysis of relationships among variables as they exist in the real world.	Cannot determine cause-and-effect relations.
Experimental	Permits a determination of cause-and-effect relationships.	Data collected in artificial environments may not represent behavior in real-world environments.
Developmental Research Designs		
Cross-sectional	More efficient and less costly than the longitudinal design. Permits the determination of age differences.	Does not permit inferences regarding age change. Confounds age and cohort.
Longitudinal	Permits the determination of age-related changes in a sample of participants assessed for a period of time.	Time consuming and expensive. Participant attrition may limit conclusions. Cohort-related changes may limit the generalizability of conclusions.
Sequential	Permits thorough analyses of developmental change. Simultaneous longitudinal and cross-sectional comparisons reveal age differences and age change, as well as cohort effects.	Time consuming, expensive, and complicated data collection and analysis.

THINKING IN CONTEXT 1.4

Paulo is interested in determining whether screen time is related to children's physical activity.

1. How might Paulo gather information to address this hypothesis? How might Paulo measure children's physical fitness? Screen time?
2. What are some of the challenges of measuring behaviors such as these?
3. What kind of research design should Paulo use? What are the advantages and disadvantages of this design?
4. Suppose Paulo wanted to know how children's use of screens changes over elementary school. What kind of study might Paulo choose?

APPLIED DEVELOPMENTAL SCIENCE, ETHICS, AND INTERSECTIONALITY

1.5 Discuss the field of applied developmental science, scientists' obligation to conduct ethical research, and the role of intersectionality in development.

Throughout this book our discussions of child development exemplify **applied developmental science**. Applied developmental science is a field of study that examines the lifelong developmental interactions among individuals and their contexts and applies these findings to prevent and intervene in problems and promote positive development (Barbot et al., 2020; Fisher et al., 2013; Lerner, 2012). Applied developmental scientists study pressing social issues, such as ways to promote the development of preterm infants, the impact of children's and adolescents' use of screens and social media, the juvenile justice system, and ways to help children and families manage the stress that accompanied the COVID-19 pandemic (C. Brown et al., 2023; Fernández de Gamarra-Oca et al., 2021; Hassinger-Das et al., 2020; Odgers et al., 2020; Shorer & Leibovich, 2022). Working to enhance the life chances of diverse groups of individuals, families, and communities requires a multidisciplinary approach that combines the expertise of scientists from many fields, such as human development, psychology, medicine, biology, anthropology, and more. This work poses unique ethical challenges.

Research Ethics

Suppose a researcher wanted to determine the effects of malnutrition on development or the effects of bullying on emotional development. Would it be possible to design a study in which some kindergarteners are deprived of food or some children are exposed to bullying? Of course not. These studies violate the basic ethical principles that guide developmental scientists' work. Developmental scientists must balance conducting scientifically sound research with protecting their participants' rights and welfare. Specifically, developmental scientists must (1) help and not harm participants, (2) be responsible to participants and society, (3) be honest and fair, and (4) respect participants' autonomy (American Psychological Association, 2010).

Help and Not Harm Participants

Researchers are obligated to protect and help the children, families, and communities in their work. They must maximize the benefits for participants and minimize the potential harms of their research. Participating in research must never pose threats to children and families beyond those they might encounter in everyday life. Researchers also have the responsibility to aid individuals for example, by directing a distressed adolescent toward helpful resources.

Responsibility to Participants and Society

Responsible scientists adhere to professional standards of conduct, clarify their obligations and roles to others, and avoid conflicts of interest. Psychologists who conduct research with children and parents must explain their role as scientists and that they are not counselors. They must help participants understand they are simply gathering information from them rather than conducting therapy.

Researchers' responsibility extends beyond their participants to society at large. Research findings often gain media attention. Scientists must work to ensure that their findings are accurately portrayed. This is admittedly difficult, but scientists must attempt to foresee ways in which their results may be misinterpreted and correct any misinterpretations that occur (Lilienfeld, 2002; Society for Research in Child Development, 2021).

Be Honest and Fair to Participants

Developmental scientists must be honest with participants. They must be mindful and attempt to keep the promises they make to children and families. Honesty can take the form of **debriefing** or informing participants about the purpose and results of their research after the study is completed. Researchers are also obligated to treat their participants fairly. **Justice** requires ensuring that the risks and benefits of research participation are spread equitably across individuals and groups. Every participant should have access to the contributions and benefits of research. When a treatment or intervention under study is found to be successful, all participants must be allowed to benefit from it.

Respect Participant Autonomy

Perhaps the most important principle of research ethics is respect for autonomy. Scientists have a special obligation to respect participants' **autonomy**, their ability to make and implement decisions. Ethical codes of conduct require that researchers protect adult participants' autonomy by obtaining **informed consent**—adults' informed, rational, and voluntary agreement to participate. Soliciting informed consent requires providing the individuals under study with information about the research study, answering questions, and ensuring that they understand that they are free to decide not to participate in the research study.

Respecting children's autonomy is more complicated because they are not capable of making judgments and asserting themselves. Parents provide parental permission for their minor children to participate in research because researchers (and lawmakers) assume that minors cannot meet the rational criteria of informed consent (Remien & Kanchan, 2022). Although children cannot provide informed consent, researchers respect their growing capacities for decision making in ways appropriate to their age by seeking **child assent**, children's agreement to participate (Tait & Geisser, 2017; Weisleder, 2020).

Parents provide informed consent for a child to participate in research. Researchers respect children's developing autonomy by seeking assent, the children's willingness to participate.

Phynart Studio/ Getty Images

For toddlers and young children, obtaining assent may involve simply asking if they want to play with the researcher (H. R. Brown et al., 2017). As children age, and their cognitive and social development increases, they can better understand the nature of science and engage meaningfully in decisions about research participation. Discussions about research participation should be tailored to children's development, including offering more detailed information and seeking more comprehensive assent as children grow older (Gaches, 2021). Moreover, seeking assent has the benefit of helping children learn how to make decisions and participate in decision making within safe contexts (Weisleder, 2020).

Intersectionality and Development

Children's opportunities and outcomes vary with their personal characteristics and contexts—and the opportunities that accompany each. **Intersectionality** refers to the dynamic interrelations of social categories with which people identify, such as gender, race and ethnicity, sexual orientation, socioeconomic status, immigration status, and ability, as well as the interwoven systems of power and privilege that accompany social category membership (Crenshaw, 1989). Inequities in power, opportunity, privilege, and disadvantage accompany some social categories and are experienced as racism, sexism, classism, heterosexism, and more, to shape individuals' lived experiences (Azmitia et al., 2023; Iruka et al., 2022; Santos & Toomey, 2018).

All people are members of multiple intertwined social categories, including gender, race, and sexual orientation. Individuals' understanding and experience of each category is influenced by their membership in other categories. Children and adolescents' experience of gender may be filtered through the lens of their membership in another social category, such as ethnicity. Latina girls' views of themselves and their worlds may be quite different from those of Latino boys as well as those of girls of other ethnicities, such as Black and white girls. In this example the intersection of ethnicity and gender combine to influence girls' self-understanding and experience. Power and opportunity are enmeshed with social categories, such as ethnicity and gender. Latina girls' views of themselves reflect not simply their gender and ethnicity, but the relative power ascribed girls and persons of color in U.S. society.

The effects of social category membership are not experienced universally, but vary with context (Ghavami et al., 2016; Stein et al., 2023). Intersectionality is inherently tied to context. Social categories such as gender, race, and sexual orientation may be more salient and meaningful in some contexts and at some times than others, creating distinct experiences for subgroup members with implications for development (Crenshaw, 1989; Mathews et al., 2020). For instance, intersecting expectations about race and gender may uniquely shape the experience of Black boys in classroom settings, how they are perceived and treated, that is unique from those experienced by boys of other races and ethnicities and the experiences of Black girls—with implications for their academic performance, development, and long-term outcomes (Cooper et al., 2022; Iruka et al., 2022). Likewise, Black boys' classroom experiences might vary with context, whether rural, suburban, or urban, and part of the United States, such as the North, South, Midwest, and coasts.

Applied developmental scientists study systemic inequities in children's and families' opportunities (Alegría et al., 2023; Elenbaas et al., 2020). They seek to promote equity and social justice, the basic human right of children to have access to experiences and resources that maximize their potential for growth, health, and happiness (Killen et al., 2021; Smith & Smith Lee, 2019). Equity and social justice involve recognizing and addressing these disparities and the complex factors that contribute to them.

Intersectionality is an emerging approach in developmental science with a small but rapidly growing body of research that recognizes the many ways that gender, ethnicity and race, sexual orientation, socioeconomic status, and disability interact to influence development (Godfrey & Burson, 2018; Grzanka, 2020). Throughout this book we examine development through an intersectional lens whenever possible.

THINKING IN CONTEXT 1.5

1. Suppose, as part of your research, you wanted to interview children in first and seventh grade. What ethical principles are most relevant to your work in studying school children? What challenges do you anticipate in conducting this work? How might your considerations vary with children's age?
2. Consider the social categories of which you are a member. What is your race and ethnicity? Gender? Sexual orientation? Skin color? Socioeconomic status? Did your parents attend college? Do you speak more than one language? What is your first language? Where do you live—city, suburb, rural area? Are you able-bodied? These are just a few categories on which people vary.
   a. Consider the differences in status that might accompany each of these categories. Are some responses "dominant" or representative of the majority culture, or most people?
   b. Can you identify other social categories?
   c. How do the categories to which you belong intersect or interact? To what extent are these important to you? To what extent have they influenced your experience?

APPLY YOUR KNOWLEDGE

In school, at recess, 9-year-old Christiano taunts his classmate, Josh, "Chicken! What are you afraid of? Everything!" He shoves Josh, who quietly walks away, head down and sniffling. This happens several times each week. Christiano and Josh's classmates usually notice and most watch. Some laugh at the funny things Christiano says or when Josh trips as he slinks away and hopes that Christiano will leave him alone.

After school Christiano walks home alone. He usually takes the long way, walking around the block to avoid the older kids who hang out outside the convenience store on the corner. The older kids are friends with Christiano's brother, and they often tease Christiano—especially when his brother his there. Sometimes the kids take Christiano's hat and laugh when he tries to retrieve it. No one in the neighborhood seems to notice. Christiano thinks it's because no one cares.

Christiano returns to an empty home. After entering he quickly and quietly walks through his home to be sure that it's empty. His mother always reminds him to be sure that it's safe before settling in. He feels silly but also a little bit nervous as he looks around. You can't be too careful, he thinks to himself. Afterward Christiano locks the door and makes a snack.

Christiano's mother usually doesn't get home from work until 7 p.m. Christiano knows he should do his homework like his mother says, but what's the point when he keeps getting Ds and Fs? Instead Christiano plays video games. He likes to pretend that he's in the game, running, leaping, and shooting at the bad guys. Christiano wants to be strong and tough so that nobody messes with him. "Not like that weakling Josh," he thinks.

1. Describe Christiano's behavior and interactions at school, in his neighborhood, and at home.
2. How might behaviorist and social learning theorists explain Christiano's behavior at school? In his neighborhood? At home?
3. How might Erikson explain Christiano's development and behavior?

4. Consider Christiano's development and behavior from the perspective of Bronfenbrenner's bioecological theory. Specifically:
5. Identify macrosystem influences on Christiano's behavior.
6. Discuss the interactions among mesosystem factors that might influence Christiano.
7. Give examples of exosystem factors and discuss how might they influence Christiano's behavior and development.
8. How might the macrosystem affect Christiano?

CHAPTER SUMMARY

1.1 Describe developmental periods, developmental domains, and the contexts in which development takes place.

Development begins at conception and progresses from the prenatal period through infancy, early childhood, middle childhood, adolescence, and into adulthood. Each period is characterized by a predictable pattern of functioning across three developmental domains (physical, cognitive, and socioemotional development) that unfold across a variety of contexts in which the developing person interacts, such as home, school, and peer group.

1.2 Explain the nature-nurture debate, how children are active in their development, and how development reflects continuous and discontinuous change.

Developmental scientists examine three fundamental questions about how development proceeds and its influences. First, how do biology (nature) and environment (nurture) influence development? Second, how do children play an active role in their own development, interacting with and influencing the world around them? Finally, in what ways is developmental change continuous, characterized by slow and gradual change, or discontinuous, characterized by sudden and abrupt change? Most developmental scientists agree that development reflects the interactions of nature and nurture, children influence their own development, and some aspects of development appear continuous and others discontinuous.

1.3 Summarize five categories of theories about child development.

Psychoanalytic theories include Freud's psychosexual theory, which explains personality development as progressing through a series of psychosexual stages during childhood, and Erikson's psychosocial theory, in which people move through eight stages of psychosocial development across the lifespan. Behaviorist and social cognitive theories emphasize environmental influences on behavior, specifically, classical conditioning and operant conditioning, as well as observational learning. Cognitive theories include Piaget's cognitive-developmental theory, information processing theory, and Vygotsky's sociocultural theory. Piaget describes cognitive development as an active process proceeding through four stages. Information processing theorists study the steps involved in cognition: perceiving and attending, representing, encoding, retrieving, and problem solving. Vygotsky's sociocultural theory examines the importance of culture and context in cognition. Systems theories include both Bronfenbrenner's bioecological model and Thelen's dynamic systems theory. Bronfenbrenner's bioecological model explains development as a function of the ongoing reciprocal interaction among biological and psychological changes in the person and their changing context. Dynamic systems theory views children's developmental capacities, goals, and context as an integrated system that influences the development of new abilities. Finally, ethology and evolutionary developmental psychology integrate Darwinian principles of evolution and scientific knowledge about the interactive influence of genetic and environmental mechanisms.

1.4 Examine the methods and research designs used to study child development.

A case study is an in-depth examination of an individual. Interviews and questionnaires are called self-report measures because they ask the persons under study questions about their own experiences, attitudes, opinions, beliefs, and behavior. Observational measures are methods that scientists use to collect and organize information based on watching and monitoring people's behavior. Physiological measures gather the body's physiological responses as data. Scientists use correlational research to describe relations among measured characteristics, behaviors, and events. To test hypotheses about causal relationships among variables, scientists employ experimental research. Developmental designs include cross-sectional research, which compares groups of people at different ages simultaneously, and longitudinal research, which studies one group of participants at many points in time. Cross-sequential research combines the best features of cross-sectional and longitudinal designs by assessing multiple cohorts over time.

1.5 Discuss the field of applied developmental science, scientists' obligation to conduct ethical research, and the role of intersectionality in development.

Applied developmental science examines the lifelong interactions among individuals and their contexts and applies these findings to prevent and intervene in problems and promote positive development in people of all ages. Developmental scientists conduct ethical research by working to help and not harm their participants and taking responsibility to ensure that others understand their role and the scope of their research findings. Developmental scientists must be honest and fair to their participants, debriefing them and ensuring that risks and benefits are justly distributed. They must respect participants' autonomy by seeking informed consent and child assent. Children's experiences and access to support and opportunity vary dramatically with intersectionality, the dynamic interrelations of social categories, such as gender, race and ethnicity, sexual orientation, socioeconomic status, immigration status, and disabilities. These experiences are shaped by context and systemic inequities. By recognizing the diverse ways in which children's experiences vary due to their membership in multiple social categories, applied developmental scientists are better equipped to identify and address disparities in power, privilege, and opportunity. This, in turn, can help promote equity and social justice for all children.

KEY TERMS

applied developmental science
autonomy
behaviorism
bioecological systems theory
case study
child assent
chronosystem
classical conditioning
cognitive schemas
cognitive-developmental theory
cohort
Computerized tomography (CT scan)
context
continuous change
correlational research
cross-sectional research
culture
debriefing
dependent variable
development
developmental domains
developmental science
Diffusion tensor imaging (DTI)
discontinuous change
dynamic systems theory
Electroencephalography (EEG)
ethology
evolutionary developmental theory
exosystem
experiment
Functional magnetic resonance imaging (fMRI)
hypothesis
independent variable
information processing theory
informed consent
intersectionality

justice
longitudinal research
macrosystem
mesosystem
microsystem
naturalistic observation
nature-nurture debate
observational learning
ontogenetic development
open-ended interview
operant conditioning
Positron emission tomography (PET)
psychoanalytic theory
punishment
random assignment
reciprocal determinism
reinforcement
scientific method
sequential research
social cognitive theory
social policy
sociocultural theory
sociohistorical context
structured interview
structured observation
theory
questionnaires

CAREERS IN CHILD DEVELOPMENT: FOUNDATIONS OF DEVELOPMENT

Developmental science is a multidisciplinary field, integrating findings from many disciplines and settings. In this feature that appears at the end of each major part of this book, we explore some of the diverse career opportunities for students interested in child development. Students with interest in child development select many college majors, such as human development and family studies, psychology, social work, education, nursing, and more. Besides a grounding in developmental science, these fields hold in common training in transferable skills that are valuable in a range of employment settings.

Transferrable Skills

Just as it sounds, transferable skills are those that can *transfer* to and be applied in a variety of settings. Employers value transferable skills because they can be adapted and used in many contexts. In fact, the top five attributes that employers look for in potential employees are not tied to any one major (Table 1.6). Instead, they all involve transferable skills, including problem solving, analytical/quantitative abilities, teamwork, and a strong work ethic. These are skills that students of all disciplines who study child development have the opportunity to hone. Let's take a closer look at some of these transferable skills.

TABLE 1.6 ■ Top 5 Key Attributes Employers Prefer in Applicants

Desired Attribute	Percentage of Employers Endorsing
Problem-solving skills	86
Analytical/quantitative skills	78
Ability to work in a team	76
Communication skills (written)	73
Strong work ethic	71

Source: National Association of College and Employers. (2022). *The attributes employers want to see on college students' resumes*. https://www.naceweb.org/about-us/press/the-attributes-employers-want-to-see-on-college-students-resumes/

Perhaps not surprisingly, the skill employers view as more valuable is *problem solving*. Individuals who are successful at problem solving can gather and synthesize information from various sources. They learn to weigh multiple sources of information, determine the degree of support for each position, and generate solutions based on the information at hand. Effective problem solving relies on *analytical skills*. Exposure to diverse perspectives and ideas about human development trains students to think flexibly and to accept some ambiguity because solutions to complex problems are often not clear-cut.

Students in child development fields learn *teamwork skills* in coursework and placements. For example, nursing, psychology, and human development and family studies students may work together as lab members. Education students may collaborate on group projects, such as designing curricula, and social work students may get hands-on experience working with others in field placements. These valuable experiences foster the ability to effectively work with teams, a skill coveted by employers of all fields.

Students in child development and family studies, psychology, social work, education, and nursing take coursework relevant to their discipline, but success in each of these fields requires a *strong work ethic* and good *communication skills*. Succeeding in challenging courses like anatomy and physiology, research methods, and statistics require dedication and consistent work. Oral and written communication skills are developed not only in coursework but also in field and practicum experiences when students learn to communicate with children, adolescents, adults, and supervisors.

Each transferrable skill contributes to an individual's ability to be versatile, adaptable, and collaborative in the workplace. Skilled problem solvers, communicators, and team workers foster a productive work environment, enabling employees to tackle complex tasks and efficiently work together.

Child Development Career Fields

As we consider career opportunities in child development, we organize them into several areas: education; health care and nursing; counseling, psychology, and social work; and research and advocacy.

Education

Perhaps the most obvious career for students passionate about child development is that of an educator or teacher. Educators who work with young children include *early childhood educators* and *preschool teachers*. For older children and adolescents there are *elementary* and *high school teachers*. Some educators specialize in working with children with specific developmental needs (*special education teachers*). Others focus on teaching English as a Second Language (*ESL teachers*) and work with children, adolescents, and adults. Becoming a teacher requires a bachelor's degree and certification.

The education field also includes administrative careers, overseeing educational programs and educators. *Preschool and childcare center directors* collaborate with early childhood educators to develop educational plans for young children, supervise staff, prepare budgets, and manage all aspects of the program. *Elementary, middle, and high school principals* supervise all school operations, including teachers, personnel, curricula, and daily school activities, and promote a safe and productive learning environment.

Health Care and Nursing

An understanding of child development is invaluable to those working in healthcare settings. Nurses of various specialties can benefit from developmental knowledge. Examples of nurses specializing in developmental science include *pediatric nurses* who work with infants, children, and adolescents. *Neonatal nurses* care for infants born preterm, have low birth weight, or suffer health problems from birth until they are discharged from the hospital. A *nurse midwife* provides gynecological care focusing on pregnancy, labor, and delivery.

All physicians must learn about human development during their medical education, but only some specialize in working with specific age groups. *Obstetrician-gynecologists* are physicians who concentrate on female reproductive health, pregnancy, and childbirth. *Pediatricians* treat infants, children, and adolescents. To specialize, physicians must complete additional training, often a fellowship after earning their medical degree and obtaining licensure.

Allied health is a field of health care that assists, facilitates, or complements the work of nurses, physicians, and other health care specialists. *Recreational therapists* assess clients and provide recreational activities to children and adolescents with physical or emotional disabilities in a variety of medical and community settings. *Physical therapists* design and provide treatments and interventions for individuals suffering pain, loss of mobility, or other physical disabilities. *Occupational therapists* help patients with physical, developmental, or psychological impairments, helping them develop, recover, and

maintain skills needed for independent daily living and activity. Physical therapists and occupational therapists require graduate degrees, while *assistant physical therapists* and *assistant occupational therapists* can be hired with specialized associate degrees and certifications.

Other allied healthcare specialists include s*peech-language pathologists*, who assess, diagnose, and treat speech, language, and social communication disorders in children, adolescents, and adults. A speech-language pathologist must earn a graduate degree. Depending on the U.S. state, assistant speech-language pathologists may be hired with associate or bachelor's degrees with specialized coursework and certification. *Child life specialists* typically work in hospital settings, helping children and families adjust to a child's hospitalization by educating and supporting families in the physically and emotionally demanding process of caring for hospitalized or disabled children. An entry-level position as a child life specialist requires a bachelor's degree and certification.

Knowledge about health and development is also needed to become a health educator.

Health educators design and implement educational programs (classes, promotional pamphlets, community activities) to educate individuals and communities about healthy lifestyles and wellness.

Social Work, Psychology, and Counseling

Children and adolescents have different communication needs and abilities compared to adults; these abilities undergo significant changes as they develop. Professionals who work closely with children must understand how their abilities change over time.

Social workers help people improve their lives by identifying needed resources (such as housing or food stamps) and providing guidance. *Clinical social workers* also conduct therapy and implement counseling treatments with individuals and families. Entry-level social workers require a bachelor's degree, whereas clinical social workers must earn a graduate degree and obtain licensure.

There are various types of counselors, generally requiring master's degrees. *Mental health counselors* assist people in managing and overcoming mental and emotional disorders. *School counselors* help elementary, middle, and high school students develop skills to enhance personal, social, and academic growth. *Marriage and family therapists* focus on the family system and treat individuals, couples, and families to help people overcome problems with family and relationships. *Substance use counselors* help people with addictions, helping them recover and modify behaviors through individual and group therapy sessions.

Applied behavior analysts apply scientific principles of learning to modify children and adolescents' behavior to improve social, communication, academic, and adaptive skills. They teach parents, teachers, and support professionals how to implement behavioral procedures, skills, and interventions. A position as an applied behavior analyst requires a graduate degree. *Assistant behavior analysts* support the work of applied behavior analysts. They assist in gathering data or information about clients, monitoring client progress and maintaining records, and administering assessments and treatment under the supervision of the applied behavior analysts.

Psychologists are doctoral-level mental health professionals. *Clinical psychologists* and *counseling psychologists* conduct therapy with children, adolescents, adults, and families. Clinical psychologists specialize in treating mental disorders, and counseling psychologists emphasize helping people adjust to life changes. *School psychologists* work within school settings, assessing individuals' learning and mental health needs, collaborating with parents, teachers, and school administrators, designing interventions to improve students' well-being, and counseling students. Depending on their training, *applied developmental psychologists* may assess and treat children, adolescents, and adults and design and evaluate intervention programs to address problems and enhance the development of people of all ages.

Research and Advocacy

Developmental scientists also work in educational and clinical research settings, such as universities, research institutions, and hospitals. These researchers design and conduct studies to investigate various aspects of child and adolescent development, ranging from cognitive, emotional, social, and

physical development to the impact of environmental factors on developmental outcomes. Their research can inform educational policies, parenting practices, clinical interventions, and the development of new assessment tools.

Developmental scientists design and conduct research on social problems and apply their findings to advocate for children, adolescents, and families. They are employed at social service agencies, nonprofits, think tanks, and government agencies. They conduct research to gather information about social problems and policies; assess and improve programs for children, youth, and families; and write reports and other documents to inform policymakers and the public. Some work as program directors and administrators for these programs, while others assess programs. Developmental scientists can contribute to policy development at the local, state, or national level by advising on creating and implementing policies that support the well-being of children, adolescents, and families.

Some developmental scientists head nonprofit organizations as *foundation directors*. They develop goals and strategies in line with the foundation's mission statement and oversee all activities within an organization, including program delivery, program evaluation, finance, and staffing. Other developmental scientists work as *grant writers*, submitting proposals to fund programs. Organizations that award grants to others have *grant directors* who oversee the funding process by analyzing grant proposals, communicating with applicants, and determining which proposals are suitable for funding. Developmental scientists who work for the government might evaluate government-supported social media–based health initiatives, such as those targeting distracted driving, or educational initiatives, such as the effects of providing free kindergarten to children.

Although developmental scientists generally have doctoral degrees in human development, psychology, or a related field, many individuals with bachelor's and master's degrees work alongside them as research associates, project coordinators, or research assistants, depending on their level of education and experience.

Expertise in child development is also needed in business and industry settings to help companies design materials, such as toys, products, and media, that cater to people's needs and abilities. They might determine the developmental appropriateness of toys and provide insight into children's abilities or examine children's and parents' reactions to particular toys, advertising, and promotional techniques. Others might provide developmental and educational advice to creators of children's media, such as by interpreting research on children's attention spans to inform creative guidelines for television programs such as *Sesame Street*.

We discuss many of the previously discussed job titles in upcoming Careers in Child Development profiles. For additional information on careers, consult *The Occupational Outlook Handbook*, published by the U.S. Bureau of the Census (https://www.bls.gov/ooh/).

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2 BIOLOGICAL AND ENVIRONMENTAL FOUNDATIONS OF DEVELOPMENT

LEARNING OBJECTIVES

- **2.1** Discuss the genetic foundations of development and patterns of genetic inheritance.
- **2.2** Identify examples of genetic disorders and chromosomal abnormalities.
- **2.3** Explain the choices of reproductive technology and prenatal diagnostic methods available to individuals and couples.
- **2.4** Examine interactions among heredity and environment, including behavior genetics, gene-environment correlations and interactions, and the epigenetic framework.

"Diego is your brother?" Alejandra's new friend asked, surprised. "He's so tall and you're . . ." "Not? I know. We look totally different. He's tall, dark, and brooding, with deep brown eyes and hair. And I'm just short and pale. Everyone wonders where I got my blond hair and blue eyes from—no one in my family looks quite like me," Alejandra said. "Diego and I are different in other ways, too. I'm outgoing and he's a homebody. He's into video games and hanging out at home. I play sports and am in the school play."

How can two people who have the same parents and live in the same home be so different? In this chapter, we discuss the process of genetic inheritance and principles that can help us understand how members of a family can share a great many similarities and also many differences.

GENETIC FOUNDATIONS OF DEVELOPMENT

2.1 Discuss the genetic foundations of development and patterns of genetic inheritance.

We are born with a hereditary "blueprint" that influences our development, including our appearance, physical characteristics, health, and even personality. This blueprint is inherited from our biological parents.

Genetics

Our body is composed of trillions of cells that make up all our tissues and organs. At the center of each cell is a nucleus containing 23 matching pairs of rod-shaped structures called **chromosomes** (Finegold, 2021). Each chromosome holds the basic units of heredity, known as **genes**, composed of stretches of **deoxyribonucleic acid (DNA)**, a complex molecule shaped like a twisted ladder or staircase. Genes carry the plan for creating all the traits that organisms carry. The human genome, or full set of human genes, consists of about 20,000 to 25,000 genes that influence all genetic characteristics (Taneri et al., 2020).

Much of our genetic material is not exclusive to humans. Although every species has a different genome, we share some genes with all organisms, from bacteria to primates. We share nearly 99% of our DNA with our closest genetic relative, the chimpanzee. There is even less genetic variation among humans. People around the world share 99.9% of their genes (Lewis, 2024). Although all humans share the same basic genome, every person has a slightly different code, making them genetically unique from other humans.

Cell Reproduction

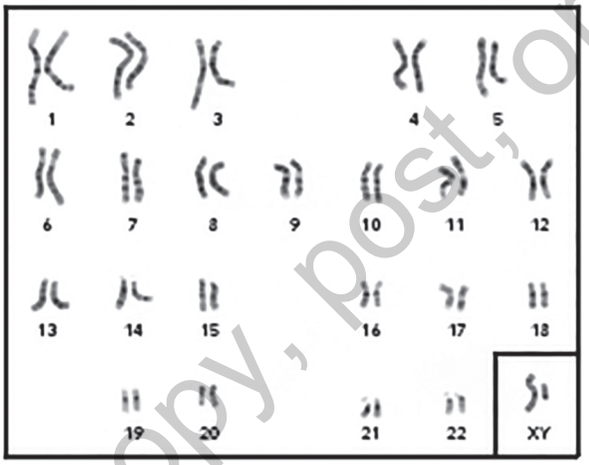
Cell reproduction in humans occurs through two processes: mitosis and meiosis. Most cells in the human body reproduce through **mitosis**, in which DNA replicates itself, duplicating its chromosomes and resulting in genetically identical new cells (Sadler, 2023). **Gametes**, sex cells specialized for reproduction, replicate through a different process, called **meiosis**. During meiosis the 46 chromosomes

duplicate and undergo a process called *crossing over*. The chromosome pairs align, and DNA segments cross over, moving from one member of the pair to the other, essentially *mixing up* the DNA segments to create unique combinations of genes (Padiath, 2023). The resulting gametes (sperm in males and ova in females) consist of only 23 single, unpaired chromosomes. Each gamete has a unique genetic profile, and it is estimated that individuals can produce millions of genetically different gametes (Brooker, 2022). When humans breed, ova and sperm join to create a **zygote**, or fertilized egg. The zygote contains 46 chromosomes, forming 23 pairs with half of each pair from the biological mother and half from the biological father.

Sex Determination

A single pair of chromosomes, known as sex chromosomes, determines whether a zygote will develop into a male or female. Twenty-two of the 23 pairs of inherited chromosomes are matched pairs (see Figure 2.1). They contain similar genes in almost identical positions and sequence. The 23rd pair of chromosomes are not identical because they are sex chromosomes that specify the genetic sex of the individual. In females, sex chromosomes consist of two large X-shaped chromosomes (XX). Males' sex chromosomes consist of one large X-shaped chromosome and one much smaller Y-shaped chromosome (XY).

FIGURE 2.1 ■ Chromosomes



Because females have two X sex chromosomes, all their ova contain one X sex chromosome. A male's sex chromosome pair is composed of one X and one Y chromosome; therefore, half of the sperm males produce contain an X chromosome and half contain a Y. The Y chromosome contains genetic instructions that will cause the fetus to develop male reproductive organs. Thus, whether the fetus develops into a male or female is determined by which sperm fertilizes the ovum. If the ovum is fertilized by a Y sperm, the fetus will develop male reproductive organs, and if the ovum is fertilized by an X sperm, it will develop female reproductive organs (see Figure 2.2).

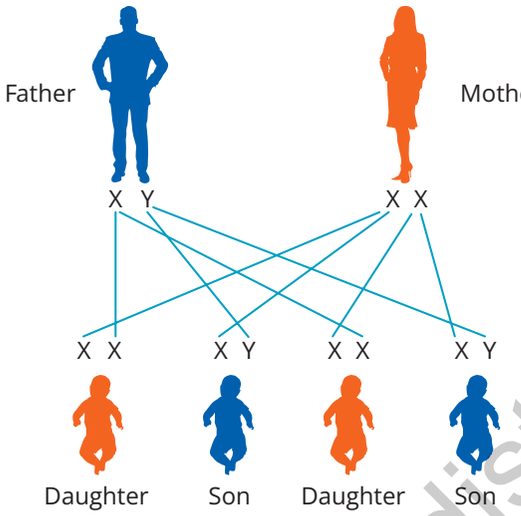
Genes Shared by Twins

Siblings who share the same biological parents inherit chromosomes from each parent. Despite this genetic similarity, siblings are often quite different from one another. Siblings who share the same womb at the same time are known as twins. Twins occur in about 1 out of every 33 births in the United States (Martin et al., 2018).

The majority of naturally conceived twins (over 70%) are **dizygotic (DZ) twins**, or fraternal twins, created when a woman releases more than one ovum and each is fertilized by a different sperm (Gill et al., 2022). Like siblings who are not twins, DZ twins share about one half of their genes and most differ in

FIGURE 2.2 ■ Sex Determination

Males carry both X and Y chromosomes while females carry two X chromosomes. When offspring inherit X chromosomes from both biological parents, they develop female reproductive organs. Offspring that inherit both X and Y chromosomes develop male reproductive organs.



appearance, including hair color, eye color, and height. In about half of fraternal twin pairs, one twin is a boy and the other a girl. DZ twins tend to run in families, suggesting a genetic component that controls the tendency for a woman to release more than one ovum each month (Hazel et al., 2020). Rates of DZ twins increase with maternal age and with each subsequent birth and have also been more common in pregnancies that result from in vitro fertilization where more than one embryo is transferred to the uterus (Gill et al., 2022; Pison et al., 2015). Since the 1980s, the rate of twinning has increased by one third worldwide, especially in wealthy nations where medically assisted reproduction, in vitro fertilization has become common (Monden et al., 2021). Twinning rates peaked in the U.S. in 2014 and declined 4% through 2020 (Osterman et al., 2023).

Monozygotic (MZ) twins, or identical twins, originate from the same zygote, sharing the same **genotype**, or set of genetic instructions for all physical and psychological characteristics. MZ twins occur when the zygote splits into two distinct separate but identical cells that develop into two infants. MZ twins are estimated to occur in about 3% of births in the United States (De Paepe, 2022). The causes of MZ twinning are not well understood (McNamara et al., 2016). Rates of MZ twins are not related to maternal age or the number of births, but in vitro fertilization increases the likelihood of MZ twins (Busnelli et al., 2019; Dallagiovanna et al., 2021).

Monozygotic, or identical, twins share 100% of their DNA.

Ray Evans/Alamy Stock Photo

Patterns of Genetic Inheritance

Genes combine in many ways to influence our **phenotype**, the characteristics that we display, such as hair color, health and propensities for specific diseases and disorders, and even personality. Traits and characteristics are inherited through several patterns.

Dominant-Recessive Inheritance

Lynn has red hair while her brother, Jim, does not—and neither do their parents. How did Lynn end up with red hair? Some traits, like hair color, are passed through **dominant-recessive inheritance** (Lakhani et al., 2023; Plomin, 2019). As we have discussed, each person has 23 pairs of chromosomes, half inherited

from the biological mother and half from the biological father. Some genes, like those for nonred hair, are *dominant* and are always expressed or displayed, regardless of the gene they are paired with. Other genes, such as for red hair, are *recessive* and are only expressed if paired with another recessive gene.

Suppose two biological parents each carry a dominant gene for nonred hair (symbolized by N in Figure 2.3) and a recessive gene for red hair (r). Since dominant genes override recessive genes, both parents will have nonred hair (phenotype). When children inherit a dominant nonred hair gene (N) they will show the phenotype for nonred hair, regardless of whether they have a second nonred hair gene (N) or a recessive red hair gene (r). The red hair phenotype can result only from inheriting two recessive genes (rr), one from each parent. Several characteristics are passed through dominant-recessive inheritance (see Table 2.1).

FIGURE 2.3 ■ Dominant-Recessive Inheritance

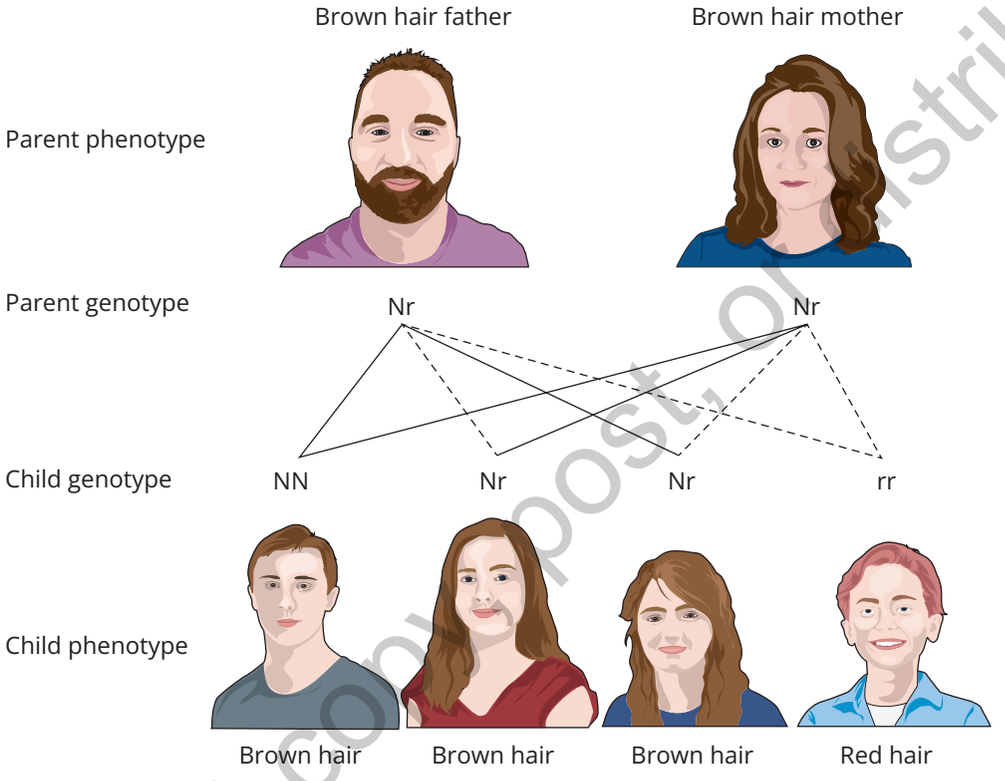


TABLE 2.1 ■ Dominant and Recessive Characteristics

Dominant Trait	Recessive Trait
Dark hair	Light hair
Curly hair	Straight hair
Hair	Baldness
Freckles	No freckles
Widow's peak hairline	Straight hair line
Facial dimples	No dimples
Brown eyes	Blue, green, hazel eyes

Source: McKusick-Nathans Institute of Genetic Medicine. 2020. *OMIM - Online Mendelian Inheritance in Man.* Johns Hopkins University School of Medicine. http://www.omim.org/about

Incomplete Dominance

In most cases, dominant-recessive inheritance is an oversimplified explanation for patterns of genetic inheritance. **Incomplete dominance** is a genetic inheritance pattern in which both genes jointly influence the characteristic (Lakhani et al., 2023). For example, consider blood type. Neither the genes for blood type A nor those for type B dominate each other. A person with one gene for blood type A and one for blood type B will express both and have blood type AB.

Sometimes a gene is stronger than but does not completely dominate another gene. In this case some, but not all, characteristics of the recessive gene appear. The gene that causes **sickle cell anemia** is recessive. Individuals who inherit two of these genes develop the disorder, in which red blood cells become crescent, or sickle, shaped. Cells that are sickle-shaped cannot distribute oxygen effectively throughout the circulatory system and can cause inflammation and damage the blood vessels (Ware et al., 2017). People who carry only one recessive sickle cell gene do not develop full-blown sickle cell anemia (Chakravorty & Williams, 2015). However, the gene for developing normal blood cells does not completely mask the sickle cell gene. Carriers of the trait for sickle cell anemia tend to function well but may show some symptoms such as reduced oxygen distribution throughout the body and exhaustion after exercise (Xu & Thein, 2019). About 5% of African American newborns carry the recessive sickle cell gene (Ojodu et al., 2014). The sickle cell gene is also common in Latino populations but relatively uncommon in white and Asian Americans (Valle et al., 2022). Sickle cell anemia is discussed later in this chapter.

Genomic Imprinting

Dominant-recessive inheritance and incomplete dominance inheritance account for over 1,000 human traits (Finegold, 2021). But a few traits are determined by **genomic imprinting**, in which the expression of a gene is determined by whether it is inherited from the biological mother or father (Hubert & Demars, 2022; Thamban et al., 2020) Prader-Willi syndrome and Angelman syndrome, for instance, are both caused by an abnormality in the 15th chromosome (Volkmar, 2021). Individuals who acquire the chromosome 15 abnormality from the biological father develop Prader-Willi syndrome, a set of specific physical and behavioral characteristics including insatiable hunger, which usually leads to obesity, short stature, mild to moderate developmental delays, and psychological problems, such as temper outbursts, obsessive behaviors, and anxiety (M. G. Butler et al., 2019; L. Schwartz et al., 2021).

When the abnormal chromosome 15 arises from the mother, individuals instead develop Angelman syndrome, characterized by developmental delays, severe intellectual disability, severe speech impairment, problems with movement and balance, and hyperactivity coupled with a characteristic happy demeanor (Dagli et al., 2021; Roche et al., 2022). Prader-Willi and Angelman syndromes are rare, occurring on average in 1 in 15,000–30,000 births (Volkmar, 2021).

Polygenic Inheritance

Despite the simple examples used in our discussion of inheritance this far, most traits result from the interaction of many genes, known as **polygenic inheritance** (Armstrong-Carter et al., 2021). Hereditary influences act in complex ways and researchers cannot trace most characteristics to only one or two genes. Examples of polygenic traits include height, intelligence, personality, and susceptibility to certain forms of cancer (Flint et al., 2020). As the number of genes that contribute to a trait increases, so does the range of possible phenotypes. Genetic propensities interact with environmental influences to produce a wide range of individual differences in human traits. Patterns of genetic inheritance are summarized in Table 2.2.

TABLE 2.2 ■ Summary: Patterns of Genetic Inheritance

Inheritance Pattern	Description
Dominant-recessive inheritance	Genes that are dominant are always expressed, regardless of the gene they are paired with. Recessive genes are expressed only if paired with another recessive gene.
Incomplete dominance	Both genes influence the characteristic, and aspects of both genes appear.
Polygenic inheritance	Polygenic traits are the result of interactions among many genes.
Genomic imprinting	The expression of a gene is determined by whether it is inherited from the mother or the father.

THINKING IN CONTEXT 2.1

1. From an evolutionary developmental perspective (see Chapter 1), why are some characteristics dominant and others recessive? Is it adaptive for some traits to dominate over others? Why or why not?
2. Consider your own physical characteristics, such as hair and eye color. Are they examples of recessive traits or dominant ones? Which of your traits are likely polygenic?

CHROMOSOMAL AND GENETIC ABNORMALITIES

2.2 Identify examples of genetic disorders and chromosomal abnormalities.

Just as many traits and characteristics are products of genetic inheritance, so are many disorders and diseases. Other disorders result from chromosomal abnormalities. Some hereditary and chromosomal abnormalities are diagnosed before birth. Others are evident at birth or can be detected as an infant begins to develop. Some abnormalities are discovered only after many years—or not at all.

Genetic Disorders

Inherited genetic disorders and abnormalities are passed from biological parents to offspring through the inheritance processes that we have discussed. These include well-known conditions as sickle cell anemia, as well as others that are rare.

Dominant-Recessive Disorders

Some genetic disorders are inherited through dominant-recessive patterns (see Table 2.3). Recall that in dominant-recessive inheritance, dominant genes are always expressed regardless of the gene they are paired with, and recessive genes are expressed only if paired with another recessive gene. Few severe disorders are inherited through dominant inheritance because most disorders develop early in life. Children who inherit the dominant version of the gene often do not reach reproductive age to pass it to the next generation. One exception is Huntington's disease, a fatal disease in which the central nervous system deteriorates (Ghosh & Tabrizi, 2018; McKusick-Nathans Institute of Genetic Medicine, 2020). Individuals with the gene for Huntington's show typical functioning in childhood, adolescence, and early adulthood. Symptoms of Huntington's disease do not appear until age 35 or later. By then, many affected individuals have already had children, and one half of those children, on average, will inherit the dominant Huntington's gene.

Phenylketonuria (PKU) is a common recessive disorder that prevents the body from producing an enzyme that breaks down phenylalanine, an amino acid, from proteins (McKusick-Nathans Institute of Genetic Medicine, 2020). Without treatment, the phenylalanine builds up quickly to toxic levels that damage the central nervous system, leading to intellectual disability by 1 year of age. The United States and Canada require all newborns to be screened for PKU (Camp et al., 2014).

PKU illustrates how genes interact with the environment to produce developmental outcomes. Intellectual disability results from the interaction of the genetic predisposition for PKU and exposure to phenylalanine in the diet (Blau, 2016). Infants with PKU are placed on a diet low in phenylalanine, though it is difficult to remove nearly all phenylalanine from the diet. When children with PKU maintain a strict diet, they usually score in the average range on measures of intelligence, though often lower than children without PKU (Hofman et al., 2018; Romani et al., 2017). Some cognitive and psychological problems may appear in childhood and persist into adulthood, including poor attention, planning skills, and emotional regulation, as well as depression and anxiety (Christ et al., 2020; Romani et al., 2022; Spronsen et al., 2021).

TABLE 2.3 ■ Conditions Inherited Through Dominant-Recessive Inheritance

Condition	Occurrence	Mode of Inheritance	Description	Treatment
Huntington disease	1 in 20,000	Dominant	Degenerative brain disorder that affects muscular coordination and cognition.	No cure. Appears in adulthood, after age 35. Death typically occurs 10 to 20 years after onset.
Cystic fibrosis	1 in 2,000–2,500	Recessive	An overproduction of thick, sticky mucus clogs the lungs and digestive system, leading to respiratory infections, problems with digestion, and a short lifespan.	Therapy to loosen and drain mucus, diet, gene replacement therapy.
Phenylketonuria (PKU)	1 in 10,000–15,000	Recessive	Inability to digest phenylalanine that, if untreated, results in neurological damage and death.	Diet
Sickle cell anemia	1 in 500 African Americans	Recessive	Sickling of red blood cells leads to inefficient distribution of oxygen throughout the body that leads to organ damage and respiratory infections.	No cure. Blood transfusions, treatment of infections, bone marrow transplant(s). Death typically occurs by middle age.
Tay-Sachs disease	1 in 3,600 to 4,000 descendants of Central and Eastern European Jews	Recessive	Degenerative brain disease	No cure. Death typically occurs by age 4.

Source: McKusick-Nathans Institute of Genetic Medicine. 2020.

A newborn's blood is tested for phenylketonuria (PKU), a genetic disorder in which the body lacks the enzyme that breaks down phenylalanine. Without treatment, the phenylalanine builds up to toxic levels and can damage the central nervous system.

Marmaduke St. John/Alamy Stock Photo

X-Linked Disorders

A special instance of the dominant-recessive pattern occurs with genes that are located on the 23rd pair of chromosomes, the sex chromosomes (Shah et al., 2017). Some recessive genetic disorders, like the gene for red-green colorblindness, are carried on the X sex chromosome (see Table 2.4). Recall that females have two X chromosomes; as a result, a recessive gene located on one X chromosome will be masked by a dominant gene on the other X chromosome. But males carry an X and Y sex chromosome. Because they have only one X chromosome, any recessive genes on their X chromosome are expressed. Females are thereby less likely to display X-linked genetic disorders because both of their X chromosomes must carry the recessive genetic disorder for it to be displayed. A female carrier has a 50/50 chance of transmitting the gene to each child.

Fragile X syndrome is an example of a dominant-recessive disorder carried on the X chromosome (Salcedo-Arellano et al., 2020). Because the gene is dominant, it need appear on only one X chromosome to be displayed by both males and females. Fragile X syndrome is the most common form of inherited intellectual disability, and individuals with fragile X syndrome tend to display severe difficulties

with executive function (Hagerman & Hagerman, 2022; Schmitt et al., 2019). Cardiac abnormalities are common as well as several behavioral mannerisms, including poor eye contact and repetitive behaviors such as hand flapping, hand biting, and mimicking others, behaviors common in individuals with autistic spectrum disorders (Salcedo-Arellano et al., 2020). Fragile X syndrome is often diagnosed along with autism; about 40%–60% of boys and 16%–20% of girls with fragile X syndrome are estimated to meet the diagnostic criteria for autism (Bagni & Zukin, 2019; Kaufmann et al., 2017).

Hemophilia, a condition in which the blood does not clot normally, is recessive disease inherited through genes on the X sex chromosome (McKusick-Nathans Institute of Genetic Medicine, 2020; Pipe et al., 2022). As with fragile X syndrome, males with the hemophilia gene display the disorder because the Y chromosome does not have the corresponding genetic information to counter the gene. Females who inherit the gene for hemophilia typically do not show the disorder unless they inherit the gene from both parents, because the dominant gene on their second X chromosome promotes normal blood clotting (d'Oiron, 2019). Females, therefore, can carry the gene for hemophilia without exhibiting the disorder.

TABLE 2.4 ■ Diseases Acquired Through X-Linked Inheritance

Syndrome/Disease	Occurrence	Description	Treatment
Color blindness	1 in 12 males	Difficulty distinguishing red from green; less commonly difficulty distinguishing blue from green	No cure
Duchenne muscular dystrophy	1 in 3,500 males	Weakness and wasting of limb and trunk muscles; progresses slowly but will affect all voluntary muscles	Physical therapy, exercise, body braces; survival rare beyond late 20s
Fragile X syndrome	1 in 4,000 males and 1 in 8,000 females	Cognitive impairment; attention problems; anxiety; unstable mood; long face; large ears; flat feet; and hyper extensible joints, especially fingers	No cure
Hemophilia	1 in 3,000–7,000 males	Blood disorder in which the blood does not clot	Blood transfusions

Source: McKusick-Nathans Institute of Genetic Medicine. 2020.

Chromosomal Abnormalities

Not all inborn disorders or conditions are the result of genetic inheritance. Chromosomal abnormalities are the result of errors during cell reproduction, meiosis or mitosis, or damage caused afterward.

Down Syndrome

Occurring in about 1 of 1,500 births, trisomy 21, more commonly called **Down syndrome**, occurs when a third chromosome appears alongside the 21st pair of chromosomes (Akhtar & Bokhari, 2024). Down syndrome is associated with marked physical, health, and cognitive attributes, including a short, stocky build, and often a round face, almond-shaped eyes, and a flattened nose. Children with Down syndrome tend to show delays in physical and motor development relative to other children, and health problems, such as congenital heart abnormalities, vision impairments, poor hearing, and immune system deficiencies (Antonarakis et al., 2020; Bull, 2020).

Down syndrome is the most common genetic cause of intellectual disability, but children vary in their abilities (Santoro et al., 2021). Generally, children with Down syndrome show greater strengths in nonverbal learning and memory relative to their verbal skills. Expressive language (what children can say) is delayed relative to comprehension (what they can understand). Infants and children who participate in early intervention and receive sensitive caregiving and encouragement to explore their environment show positive outcomes, especially in the motor, social, and emotion areas of functioning (Antonarakis et al., 2020; Bull, 2020).

Advances in medicine have addressed many of the physical health problems associated with Down syndrome so that today, the average life expectancy is 60 years of age, as compared with about 25 during the 1980s (National Association for Down Syndrome, 2020). Many individuals live into their 70s and 80s. However, Down syndrome is associated with premature aging and an accelerated decline of cognitive functioning (Hithersay et al., 2017). Individuals with Down syndrome are more likely than other adults to show signs of Alzheimer's disease (a form or dementia) very early (Fortea et al., 2021; Tramutola et al., 2020). This is an example of how disorders and illnesses can be influenced by multiple genes and complex contextual interactions; in this case, Down syndrome and Alzheimer's disease share genetic markers (Handen, 2020; Lee et al., 2017).

Sex Chromosome Abnormalities

Some abnormalities occur in the 23rd pair of chromosomes, the sex chromosomes. These abnormalities result from either a missing sex chromosome or an additional sex chromosome. Given their different genetic makeup, sex chromosome abnormalities yield different effects in males and females (see Table 2.5)

One of the most common sex chromosome abnormalities is **Klinefelter syndrome**, in which males are born with an extra X chromosome (XXY) (McKusick-Nathans Institute of Genetic Medicine, 2020). Symptoms range in severity but most men are unaware of the disorder unless they are tested for infertility (Bird & Hurren, 2016; Gravholt et al., 2018). Symptoms in severe cases include a high-pitched voice, feminine body shape, breast enlargement, and infertility. Many boys and men with Klinefelter syndrome have short stature, a tendency to be overweight, and language and short-term memory impairments that can interfere with learning (Bonomi et al., 2017; G. Butler et al., 2023). Dyslexia, a learning disorder affecting reading comprehension, is diagnosed in half of all boys and men with Kleinfelter syndrome (Skakkebæk et al., 2021). As adults, men with Klinefelter syndrome are at risk for a variety of disorders that are more common in women, such as osteoporosis (Grande et al., 2023).

A second type of sex chromosome abnormality experienced by men is XYY syndrome, or **Jacob's syndrome**, a condition that causes men to produce high levels of testosterone (McKusick-Nathans Institute of Genetic Medicine, 2020; Pappas et al., 2017). Boys with Jacob's syndrome commonly show behavioral problems, delayed speech and language development, tall stature, and mild learning difficulties (Sood & Fuentes, 2022). Most males are not diagnosed unless they experience fertility problems (Zhang et al., 2020). The prevalence of XYY syndrome is uncertain given that most men go undiagnosed.

Women are susceptible to a different set of sex chromosome abnormalities. About 1 in 1,000 girls are born with three X chromosomes, known as **triple X syndrome** (McKusick-Nathans Institute of Genetic Medicine, 2020; Wigby et al., 2016). Triple X syndrome goes largely unnoticed. Girls with the syndrome tend to be taller than other children and taller than predicted by parents' heights. Triple X syndrome is associated with delayed language and motor skills, difficulty learning, and symptoms of attention-deficit/hyperactivity disorder and autism spectrum disorder (Freilinger et al., 2018; Otter et al., 2023). Because many cases of triple X syndrome go unnoticed, little is known about the syndrome.

The sex chromosome abnormality known as **Turner syndrome** occurs when a girl is born with only one X sex chromosome (McKusick-Nathans Institute of Genetic Medicine, 2020). Girls with Turner syndrome show abnormal growth, irregularities in ovary development, delayed puberty, and infertility (Davis et al., 2020; Gravholt et al., 2023). Turner syndrome is typically diagnosed in middle adolescence, at about age 15, but many cases remain undiagnosed (Gravholt et al., 2023). Children with Turner syndrome may show difficulty with visual-spatial reasoning, attention, motor skills, math skills, and executive functioning (Baker et al., 2020; Mauger et al., 2018). They are also prone to social difficulties, anxiety, and depression (Hutaff-Lee et al., 2019; Morris et al., 2020). If diagnosed early, regular injections of human growth hormones can increase stature and promote reproductive development (Isojima & Yokoya, 2023; Klein et al., 2020). As adults, women with Turner syndrome tend to be short in stature, have webbed necks (extra folds of skin), and are prone to health conditions affecting the heart as well as diabetes, autoimmune disorders, and early osteoporosis (Gravholt et al., 2023).

TABLE 2.5 ■ Sex Chromosome Abnormalities

Female Genotype	Syndrome	Description	Prevalence
XO	Turner	Abnormal growth patterns, delayed puberty, lack of prominent female secondary sex characteristics, and infertility. Short adult stature, webbing around their neck.	1 in 2,500 females
XXX	Triple-X	Taller than average height, by about an inch, with unusually long legs and slender torsos; normal development of sexual characteristics and fertility. Because many cases go undiagnosed, little is known.	Unknown
Male Genotype	**Syndrome**	**Description**	**Prevalence**
XXY	Klinefelter	High-pitched voice, short stature, feminine body shape, and infertility. Increased risk for osteoporosis and other disorders that are more common in women.	1 in 1,000 males
XYY	Jacob's	High levels of testosterone. Because many cases go undiagnosed, little is known.	Unknown

Source: McKusick-Nathans Institute of Genetic Medicine. 2020.

Mutation

Like chromosomal abnormalities, mutations are inborn characteristics that are not inherited. **Mutations** are sudden changes and abnormalities in the structure of genes that occur spontaneously, without apparent cause. Mutations may also be triggered by exposure to environmental toxins such as radiation and agricultural chemicals in food. A mutation may involve only one gene or many. It is estimated that as many as one half of all conceptions include mutated chromosomes (Taneri et al., 2020). Most mutations are fatal—the developing organism often dies very soon after conception, often before the woman knows she is pregnant (Sadler, 2023).

Sometimes mutations are beneficial. This is especially true if the mutation is induced by stressors in the environment and provides an adaptive advantage to the individual. The gene that causes sickle cell anemia (discussed earlier in this chapter) is a mutation that originated in areas where malaria is widespread, such as Africa, and serves a protective role against malaria (Esoh & Wonkam, 2021; Kavanagh et al., 2022). Children who inherited a single sickle cell gene were more resistant to malarial infection and more likely to survive and pass it along to their offspring (Gong et al., 2013; Uyoga et al., 2019). Though its advantages may outweigh its harm in places where malaria is common, the sickle cell gene has no benefit for individuals who live in places where malaria is not a risk. As we have discussed, sickle cell anemia poses serious health risks, including a reduced lifespan of about 54 years in North America (Kavanagh et al., 2022).

It may perpetuate racial disparities in health and wealth as African Americans are disproportionately likely to inherit sickle cell anemia and to lack consistent access to health care and economic resources needed to thrive with a chronic illness (Graf et al., 2022).

The sickle cell trait is becoming less common in places in the world where malaria is uncommon. For example, only 8%–10% of African Americans are carriers, compared with as many as 40% of Black Africans in some African countries (Tebbi, 2022). Therefore, the developmental implications of genotypes—and mutations—are context-specific, posing benefits in some contexts and risks in others.

THINKING IN CONTEXT 2.2

1. Give advice to prospective parents. Explain how genetic and chromosomal disorders are transmitted. What, if anything, can parents do to reduce the risks? Why?
2. Recall from Chapter 1 that most developmental scientists agree that nature and nurture interact to influence development. Choose a genetic or chromosomal disorder discussed in this section and explain how it illustrates the interaction of genes and context.

REPRODUCTIVE TECHNOLOGY AND GENETIC DISORDERS

2.3 Explain the choices of reproductive technology and prenatal diagnostic methods available to individuals and couples.

Although genetic inheritance may seem like a random roll of the dice, we can predict the likelihood of many genetic disorders before conception. Advances in technology enable individuals and couples to learn about the risk for genetic abnormalities, detect abnormalities, and often prevent them.

Genetic Counseling

Genetic risks can be detected. DNA tests coupled with **genetic counseling** can help individuals and couples understand the risk of conceiving a child with genetic or chromosomal abnormalities (Im et al., 2023). Candidates for genetic counseling include individuals and couples whose relatives have a genetic condition, women over the age of 35, and couples from the same ethnic group who might share recessive genetic disorders. Genetic testing can also help couples who have had difficulty conceiving or recurrent miscarriage determine whether chromosomal abnormalities carried by ova or sperm have played a part (Poornima et al., 2020; Softness et al., 2020).

Through interviews with a couple, a genetic counselor constructs a family history of heritable disorders for both prospective biological parents. If members of either parent's family have a genetic disorder or are at risk for a genetic disorder, blood tests may be carried out to detect the presence of dominant and recessive genes and chromosomal abnormalities. The tests determine whether each parent is a carrier for recessive disorders, such as Huntington's disease and estimate the likelihood that a child may be affected by a genetic disorder (Caceres et al., 2022). The genetic counselor interprets the results and helps the parents understand genetic concepts by tailoring the explanation to match the parents' knowledge (Abacan et al., 2019).

Once prospective parents learn about the risk of conceiving a child with a disorder, they can determine how to proceed—whether it is to attempt to conceive a child naturally or to use reproductive technology that can test for abnormalities at conception. Given advances in our knowledge of genetic disorders and ability to screen for them, the American College of Obstetricians and Gynecologists (2024) recommends that genetic counseling should be available to all prospective parents. Others argue that abnormalities are rare and that so few would be discovered that universal screening is of little utility (Larion et al., 2016). Whether to seek genetic counseling is a personal decision for prospective parents based on their history, view of their risks, and their values.

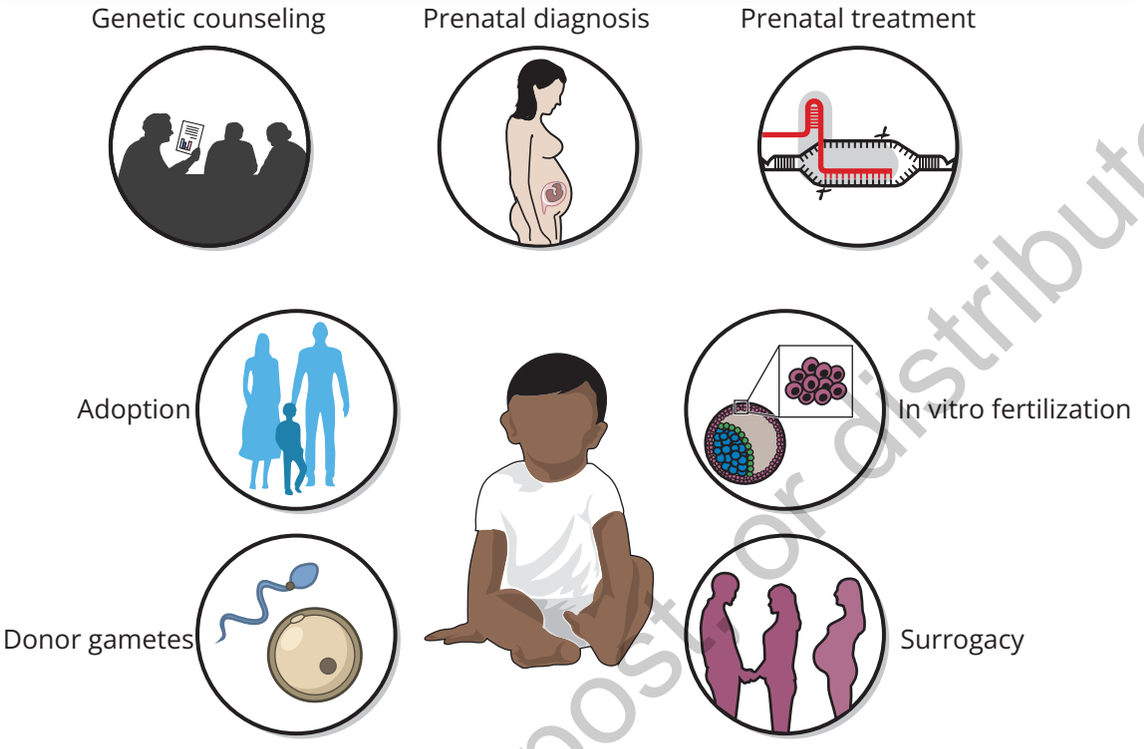
Assisted Reproductive Technology

About 2.3% of infants in the United States are conceived through **assisted reproductive technology (ART)**, alternative methods of conception that rely on medical technology (Centers for Disease Control, 2024). As noted above, some individuals and couples at risk for bearing children with genetic or chromosomal abnormalities seek ART, as do some couples experiencing infertility, which is defined as the inability to conceive naturally after 1 year of unprotected intercourse (Carson & Kallen, 2021). About 15% to 20% of couples in the United States experience infertility (about 25% of couples in developing countries) (Cox et al., 2022; Rezaeiyeh et al., 2022). Other candidates for ART include single adults and same-sex couples who wish to conceive.

There are racial, ethnic, and socioeconomic disparities in the use of ART. White, Asian-American, college-educated, and high socioeconomic status women are more likely to give birth via ART than Black and Hispanic women (Ebeh & Jahanfar, 2021; Tierney & Cai, 2019). Black women are less likely to use ART. Those who do, tend to use it later in life than women of other races and are more likely to experience poor outcomes related to later use (Butts, 2021; Lisonkova et al., 2022). Race and ethnicity are interwoven with socioeconomic status and disparities in health care in the United States—including

reproductive health and access to reproductive technology (Dieke et al., 2017; Shirazi & Rosinger, 2021), which can take several forms, including artificial insemination, in vitro fertilization, and surrogacy (see Figure 2.4).

FIGURE 2.4 ■ Reproductive Options



Source: Adapted from Turocy, J., Adashi, E. Y., & Egli, D. (2021). Heritable human genome editing: Research progress, ethical considerations, and hurdles to clinical practice. *Cell, 184*(6), 1561–1574.

Artificial Insemination

The simplest, least invasive type of alternative conception is **artificial insemination**, the insertion of sperm from a partner or donor into a woman. Artificial insemination is the least expensive alternative method of conception, but the success rate is low, usually requiring multiple cycles. The cost of the procedure ranges from about $300 to $1,000 per cycle (Harris, 2020). Women and couples who seek donor sperm may also expect to pay about $700 to $1,000 per vial.

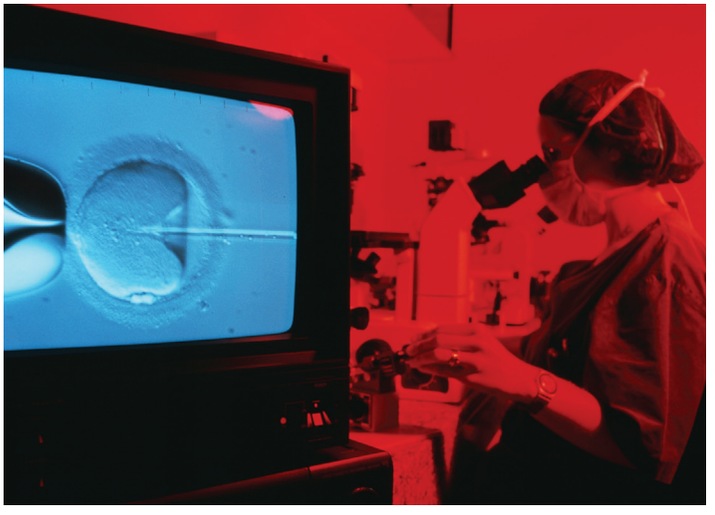
In Vitro Fertilization

In contrast to artificial insemination, where conception occurs inside of the women's body, **in vitro fertilization** initiates conception outside of the body. A woman is prescribed hormones to stimulate the maturation of several ova, which are surgically removed. The ova are placed in a dish and sperm are added in the hope that one or more ova will be fertilized and the resulting zygote will begin to divide. After several cell divisions, the cluster of cells are placed in the woman's uterus where, if all goes well, they will implant and begin to divide, resulting in pregnancy.

The success rate of in vitro fertilization is about 50% and varies with the mother's age and whether the ova are from the patient or donated (Centers for Disease Control, 2024). For instance, the percentage of embryo transfers resulting in live births from patients who use their own eggs is 45% for 35–37-year-old women, 40% in 38–40-year-old women, and 24% in women over age 40. In vitro fertilization is expensive, costing an average of over $12,400 per trial, not including medication, and

often requires multiple cycles, posing a financial burden too great for women and couples of low socioeconomic status (Asch & Marmor, 2020; Teoh & Maheshwari, 2014).

Controlling for maternal age, infants conceived by in vitro fertilization show no differences in growth, health, development, or cognitive function relative to infants conceived without assistance (Farhi et al., 2019; Wang et al., 2021). Because in vitro fertilization permits cells to be screened for genetic problems prior to implantation, in vitro infants are at lower risk of congenital (birth) abnormalities (Fauser et al., 2014). However, over one third of births from artificial insemination include more than one infant (twins or even triplets), either because the zygote that was transferred splits (resulting in MZ twins) or because multiple zygotes are transferred to increase the odds of success (resulting in DZ twins) (Sunderam et al., 2019). Multiple gestations increase the risk for low birth weight, prematurity, and other poor outcomes (Sullivan-Pyke et al., 2017).



In vitro fertilization is a form of reproductive technology in which an ovum is fertilized outside of the womb.

Mauro Fermariello/Science Source

Intravaginal culture (IVC) is a less expensive alternative to in vitro fertilization (Cooper, 2022). In IVC the ova and sperm are placed in a tiny incubator that is placed inside the woman's vagina. After several rounds of cell duplication, the incubator is removed and the cells are placed in the woman's uterus, similar to in vitro fertilization. IVC is a more financially accessible form of ART, but its availability is limited, and research is just beginning to examine long-term outcomes associated with IVC (Kaye et al., 2022).

Surrogacy

Surrogacy is an alternative form of reproduction in which a woman (the surrogate) is impregnated and carries a fetus to term and agrees to turn the baby over to another person or couple who will raise it. Single parents, same-sex couples, and couples in which one or both members are infertile are those most likely to choose surrogacy. Sometimes the surrogate carries a zygote composed of one or both couple's gametes. Other times, the ova, sperm, or zygote are donated. Despite several highly publicized cases of surrogate mothers deciding not to relinquish the infant, most surrogacies are successful.

Roughly 3,000 babies are born through surrogacy in the United States each year (Beitsch, 2017). Longitudinal research suggests no psychological differences through age 14 between children born through surrogacy compared with other methods, including children born to gay father and lesbian mother families (Carone et al., 2018, 2020; Golombok, 2013; Golombok et al., 2017). In addition, mothers of children who were the product of surrogates do not differ from those conceived using other methods, and surrogate mothers show no negative effects (Jadva et al., 2015; Söderström-Anttila et al., 2015).

We have seen that reproductive technology is expensive. Surrogacy is often prohibitively expensive for most prospective parents, limiting its access to high socioeconomic status parents. Prospective parents pay for the surrogate's medical care, attorney, travel expenses, health care, and more, which can amount to $100,000 or more (Caron, 2020). Finally, surrogacy may pose ethical issues. Carrying a fetus to term poses physical and mental health risks to the surrogate. Relinquishing a newborn is difficult, even with planning, posing emotional risks to the surrogate. The financial incentives to surrogate a fetus are substantial. Although paying a surrogate is illegal in many U.S. states, women are often compensated for the physical and emotional burden of surrogating a fetus (Caron, 2020). A surrogate tends to receive at least $30,000 to $55,000 to carry a fetus, sums that may be difficult for some marginalized women to resist (Harrison, 2017).

Adoption

Another reproductive option for prospective parents is **adoption**. Adoptive parents typically undergo extensive screening to ensure that they can provide a home that is safe, nurturing, and stimulating to

children. Many prospective parents endure lengthy waiting times to receive children. The ability to provide a suitable home is linked with socioeconomic status, and adoption itself can cost tens of thousands of dollars, therefore it is not surprising that adoptive children tend to be raised by parents with higher levels of education and income than other children (Drozd et al., 2018; Family Equality, n.d.).

Children's experiences prior to adoption, especially neglect and maltreatment, and their developmental status at the time of adoption influence their short- and long-term adjustment (Blake et al., 2022; Hornfeck et al., 2019). Adopted children tend to experience greater stress prenatally, early in life, prior to adoption, and during the adoption process that influences their long-term adjustment after adoption (Pace et al., 2022; Wiley, 2017).

The quality of adoptive parent-child relationships influences children's outcomes and the long-term effects of preadoption adversity (Farr & Grotevant, 2019). Children who develop a close bond with adoptive parents tend to show better emotional understanding and regulation, social competence, and also self-esteem (Drozd et al., 2018; Schoemaker et al., 2020). This is true also of children who have experienced emotional neglect, regardless of the child's age at adoption (Brodzinsky et al., 2022; Paine et al., 2021). Once the effects of early adversity are considered, adoptees from childhood through middle adulthood do not differ from their nonadopted peers in distress or internalizing problems, such as anxiety and depression (Brown et al., 2019; Sehmi et al., 2020).

Prenatal Diagnosis

Prenatal testing is a routine procedure that enables physicians to examine a fetus and determine its health. Prenatal testing is especially important and recommended when genetic counseling has determined a risk for genetic abnormalities, when the woman is older than age 35, when both parents are members of an ethnicity at risk for particular genetic disorders, or when fetal development appears abnormal (Krstić & Običan, 2020). Technology has advanced rapidly, equipping professionals with an array of tools to assess the health of the fetus.

Methods of Prenatal Diagnosis

The most widespread and routine diagnostic procedure is **ultrasound**, in which high-frequency sound waves are directed at the mother's abdomen to provide clear images of the womb represented on a video monitor. Ultrasound enables physicians to observe the fetus, measure fetal growth, judge gestational age, determine the sex of the fetus, detect multiple pregnancies (twins, triplets, etc.), and detect physical abnormalities. Many abnormalities can be observed, such as cardiac malformations, cleft palate, and microencephaly (small head size). At least 80% of women in the United States receive at least one prenatal ultrasound scan (Sadler, 2023). Three to four screenings over the duration of pregnancy are common to evaluate fetal development. Repeated ultrasound of the fetus does not appear to affect growth and development (Abramowicz, 2019; Stephenson, 2005)

Amniocentesis is a prenatal diagnostic procedure in which a small sample of the amniotic fluid that surrounds the fetus is extracted from the mother's uterus through a long, hollow needle that is guided by ultrasound as it is inserted into the mother's abdomen (Odibo, 2015). The amniotic fluid contains fetal cells, which are then grown in a laboratory dish to create enough cells for genetic analysis. Genetic analysis is then performed to detect genetic and chromosomal anomalies. Amniocentesis is safe, posing no additional risks to the fetus than other procedures (Homola & Zimmer, 2019; Likar et al., 2020). Despite its safety, many women find the procedure stressful, even if they are provided with information about what to expect (Mojahed et al., 2021).

Amniocentesis is recommended for women aged 35 and over, especially if the woman and partner are both known carriers of genetic diseases or when other prenatal tests suggest abnormalities (Vink & Quinn, 2018a). Usually, amniocentesis is conducted between the 15th and 18th week of pregnancy. Conducted any earlier, an amniocentesis may increase the risk of miscarriage (Akolekar et al., 2015).

Chorionic villus sampling (CVS) also samples fetal genetic material and can be conducted earlier than amniocentesis, between 9 and 12 weeks of pregnancy (Vink & Quinn, 2018b). CVS requires studying a small amount of tissue from the chorion, part of the membrane surrounding the fetus. The tissue sample is obtained through a long needle inserted either abdominally or vaginally, depending on

the location of the fetus. CVS is relatively painless, poses few risks to the fetus, and, like amniocentesis, has a diagnostic success rate of over 99% (Likar et al., 2020; Salomon et al., 2019). CVS should not be conducted prior to 10 weeks gestation because some studies suggest an increased risk of limb defects and miscarriages (Jones & Montero, 2021).

Fetal MRI applies MRI technology to image the fetus' body and diagnose abnormalities (Aertsen et al., 2020). It is often used as a follow-up to ultrasound imaging to provide more detailed views of any suspected abnormalities. Fetal MRI can detect abnormalities throughout the body, including the central nervous system (Masselli et al., 2020). MRI is safe for mother and fetus in the second and third trimesters but is expensive and has limited availability in some areas (Patenaude et al., 2014).

Noninvasive prenatal testing (NIPT) screens the mother's blood to detect chromosomal abnormalities. Cell-free fetal DNA (chromosome fragments that result from the breakdown of fetal cells) circulates in maternal blood in small concentrations that can be detected and studied by sampling the mother's blood (Alberry et al., 2021; Hartwig et al., 2017). Testing can be done as early as 9 weeks (Ravitsky et al., 2021). Given that the test involves drawing blood from the mother, there is no risk to the fetus.

NIPT can provide accurate sex determination, but NIPT cannot detect as many chromosomal abnormalities as amniocentesis or CVS and is less accurate because fetal DNA is not sampled (Samura, 2020; Villela et al., 2019). Currently, NIPT produces a high rate of false positive results, incorrectly identifying nonexistent anomalies (Johnston et al., 2022). However, researchers have identified the entire genome sequence using NIPT, suggesting that NIPT may eventually be as effective as other, more invasive techniques (Alberry et al., 2021).

In consultation with their obstetrician, pregnant women and their partners should carefully weigh the risks and benefits of any procedure designed to monitor prenatal development. Table 2.6 summarizes methods of prenatal diagnosis.

TABLE 2.6 ■ Methods of Prenatal Diagnosis

	Explanation	Advantages	Disadvantages
Ultrasound	High-frequency sound waves directed at the mother's abdomen provide clear images of the womb viewed on a video monitor.	Can measure fetal growth, reveal the sex of the fetus, and determine physical abnormalities in the fetus.	Many abnormalities are not easily observed.
Amniocentesis	A small sample of the amniotic fluid that surrounds the fetus and contains fetal cells is extracted from the mother's uterus through a long, hollow needle inserted into the mother's abdomen. The fetal cells are grown in a laboratory and analyzed for genetic abnormalities	Thorough analysis of the fetus' genotype with 100% diagnostic success rate.	Safe, but greater risk to the fetus than ultrasound. If conducted before the 15th week of pregnancy, it may increase the risk of miscarriage.
Chorionic villus sampling (CVS)	A small sample of tissue from the chorion, part of the membrane surrounding the fetus, is obtained through a long needle inserted either abdominally or vaginally, depending on the location of the fetus. The sample is tested for genetic abnormalities.	Thorough analysis of the fetus' genotype with 100% diagnostic success rate. Can be conducted earlier than amniocentesis, between 10 and 12 weeks.	It may pose a higher rate of spontaneous abortion and limb abnormalities when conducted prior to 10 weeks' gestation.
Fetal MRI	Uses a magnetic scanner to record detailed images of fetal organs and structures.	Provides detailed and accurate images.	It is expensive. At present there is no evidence to suggest that it is harmful to the fetus.
Noninvasive prenatal testing (NIPT)	Cell-free fetal DNA are examined by drawing blood from the mother.	There is no risk to the fetus. It can diagnose several chromosomal abnormalities.	It cannot yet detect all abnormalities. It may be less accurate than other methods.

Sources: Akolekar et al., 2015; Chan et al., 2013; Gregg et al., 2013; Odibo, 2015; Shahbazian et al., 2012; Shim et al., 2014; Theodora et al., 2016

Prenatal Treatment of Genetic Disorders

What happens when a genetic or chromosomal abnormality is found? Advances in genetics and in medicine have led to therapies that can be administered prenatally to reduce the effects of many genetic abnormalities. **Fetoscopy** is a technique in which a small camera is inserted through a small incision on the mother's abdomen or cervix and placed into the amniotic sac that encases the fetus. The camera is used to examine the fetus and facilitate procedures performed on the fetus during pregnancy. Risks of fetoscopy include infection, rupture of the amniotic sac, premature labor, and fetal death. When serious abnormalities are suspected, fetoscopy permits a visual assessment of the fetus, which aids in diagnosis and treatment. Hormones and other drugs, as well as blood transfusions, can be given to the fetus by inserting a needle into the uterus (Kurtz, 2023). Surgeons rely on the images provided by fetoscopy to surgically repair defects of the heart, lungs, urinary tract, and other areas prior to birth (Ahmad et al., 2023; Peiro & Scorletti, 2019).

Gene therapy is becoming increasingly available, in which genetic material that may be missing or abnormal is injected into fetal cells. These cells reproduce and replace those containing the abnormal gene (Peranteau & Flake, 2020). Similar to gene therapy, stem cell therapy involves delivering stem cells (which can reproduce into any type of cell) into the umbilical cord that connects the fetus to the mother (O'Connell et al., 2020). These therapies have successfully treated heritable disorders in animals (Neff, 2019). In human fetuses, gene and stem cell therapies are currently applied to treat severe conditions that may cause death or lifelong disabilities (Kiani et al., 2020; Rytting et al., 2022). However, prenatal use of these therapies is new, and there is much to learn. Gene and stem cell therapies are expensive and not widely available, posing economic and social barriers to members of marginalized groups (Turocy et al., 2021). In addition, the long-term effects of these therapies on mothers' and children's physical, cognitive, and socioemotional development and development are not known (Hendriks et al., 2022).

THINKING IN CONTEXT 2.3

1. Compare and contrast reproductive options for a woman in her mid-30s who wishes to conceive a child without a partner. What are the pros and cons of each option? What considerations do you deem most important in choosing an option?
2. What information would you give to a person considering becoming pregnant about prenatal diagnosis? How would you explain the various options, including their advantages and disadvantages? What would you suggest?

HEREDITY AND ENVIRONMENT INTERACTIONS

2.4 Examine interactions among heredity and environment, including behavior genetics, gene-environment correlations and interactions, and the epigenetic framework.

Our genotype, inherited from our biological parents, influences all our traits, from hair and eye color to personality, health, and behavior. However, genes do not work alone. The traits and characteristics we display, our phenotype, result from interactions among our genotype and our experiences.

Behavior Genetics

Behavior genetics is the study of how genetic and environmental variations influence the phenotypes people show, including traits, characteristics, abilities, and behavior (Harden, 2021). All traits, even those with a strong genetic component, such as height, are modified by environmental influences (Jelenkovic et al., 2016; Plomin, 2019). For example, healthy nutrition (an environmental factor) can promote children's growth in height, and malnutrition can stunt growth.

Behavior Genetics Research Methods

Behavior geneticists attempt to tease apart the role of biology and environment in development. They estimate the *heritability* of various traits, the degree to which variation among people is due to genetic differences. The remaining variation is assumed to be the result of environmental influences and experiences. Heritability research therefore examines the contributions of both the genotype and the role of experience in determining phenotypes, the traits that people show (Barry et al., 2023; Fowler-Finn & Boutwell, 2019). Methods that behavior geneticists to examine hereditary influences on behavior include selective breeding, twin, and adoption studies.

Selective breeding studies. Through selective breeding, researchers modify the genetic makeup of animals in a laboratory setting to study the contribution of heredity to attributes and behavior. Mice can be bred to very physically active or very sedentary by mating highly active mice only with other highly active mice or, similarly, breeding mice with very low levels of activity with each other. Over subsequent generations, mice bred for high levels of activity become many times more active than those bred for low levels of activity (N. L. Schwartz et al., 2018). Selective breeding in rats, mice, and other animals such as chickens has revealed genetic contributions to many traits and characteristics, such as aggressiveness, emotionality, sex drive, and even maze learning (Bubac et al., 2020).

Unlike animals, people cannot be bred. Behavior geneticists who study humans must rely on observing natural variations in hereditary and environmental influences. Family members share varying amounts of genes and environmental experiences. Behavior geneticists study siblings, especially twins and adopted siblings, to compare people who live together and share varying degrees of relatedness (Friedman et al., 2021; York, 2020).

Twin studies. Twin studies compare identical and fraternal twins to estimate how much of a trait or behavior is attributable to genes. Recall that identical (MZ) twins share 100% of their genes because they originated from the same zygote. Like all nontwin siblings, fraternal (DZ) twins share 50% of their genes because they are the result of two different ova fertilized by two different sperm, and therefore two genetically different zygotes. If a given attribute is influenced by genes, identical twins should be more similar than fraternal twins because identical twins share 100% of their genes, whereas fraternal twins share about half.

Adoption studies. Whereas twin studies examine biologically related persons, adoption studies compare the degree of similarity between people who are not biologically related but share an environment. Some studies compare adopted children to their biological parents, with whom they share genes (50% with each parent) but no environment, and to their adoptive parents with whom they share an environment but not genes (Friedman et al., 2021; York, 2020). If the adopted children share similarities with their biological parents, even though they were not raised by them, it suggests that the similarities are genetic. The similarities are influenced by the environment if the children are more like their adoptive parents.

Observations of adoptive siblings also shed light on the extent to which attributes and behaviors are influenced by the environment. The degree to which two genetically unrelated adopted children reared together are similar speaks to the role of environment. Likewise, comparisons of identical twins who are reared in the same home with other sets of twins who were separated and reared in different environments also illustrate environmental contributions to phenotypes. If identical twins reared together are more similar than those reared apart, an environmental influence can be inferred.

Heritability and Personal Characteristics

Twin and adoption studies have suggested that genes contribute to many traits, such as sociability, temperament, emotionality, and susceptibility to various conditions such as obesity, heart disease, cancer, anxiety, poor mental health, and a propensity to be physically aggressive (Ask et al., 2021; Bralten et al., 2019; Isen et al., 2022; Loos & Yeo, 2022; Morneau-Vaillancourt et al., 2019).

Identical twins consistently have more similar intelligence scores than do fraternal twins (Plomin, 2019). A classic study of intelligence in over 10,000 twin pairs showed a correlation coefficient of .86

for identical and .60 for fraternal twins (Plomin & Spinath, 2004). Recall from Chapter 1 that correlational research examines relationships among variables. Correlations range from 0 to 1, with higher scores indicating a stronger relationship between the two variables. Table 2.7 summarizes the results of comparisons of intelligence scores from individuals who share different genetic relationships with each other. Notice that correlations rise not only with genetic relatedness but also when kin live together, supporting the role of environment. Notice that even identical twins who share 100% of their genes are not 100% alike. Those differences are due to the influence of environmental factors unique to each sibling.

TABLE 2.7 ■ Average Correlation of Intelligence Scores From Family Studies for Related and Unrelated Kin Reared Together or Apart

Type of Kin	Reared Together	Reared Apart
MZ twins (100% shared genes)	.85	.74
DZ twins (50% shared genes)	.59	.52
Siblings (50% shared genes)	.46	.24
Biological parent/child (50% shared genes)	.41	.22
Half-siblings (25% shared genes)	.31	—
Unrelated (adopted) siblings (0% shared genes)*	.34	—
Nonbiological parent/child (0% shared genes)*	.20	—

Notes: *Estimated correlation for individuals sharing neither genes nor environment = .0; MZ = monozygotic; DZ = dizygotic.

Source: Adapted from Bouchard & McGue, 1981 and Devlin, B., Daniels, M., & Roeder, K. (1997). The heritability of IQ. *Nature, 388*(6641), Article 6641. https://doi.org/10.1038/41319

Nonshared Environment

Siblings may be raised in the same house, by the same parents, and thereby share an environment and many everyday experiences. Despite this **shared environment,** siblings, even twins, are often very different in personality, interests, and competencies. In addition to heredity, behavior geneticists point to environmental factors, specifically the **nonshared environment**, as a contributor to differences among siblings (Hetherington et al., 2013).

The nonshared environment refers to experiences that are unique to a particular child. Even with the same parents and in the same home, siblings are often treated differently. The oldest sibling often has a very different parenting and family experience than the youngest child. With each child, parents gain experience and knowledge about child development and rearing, which might influence their confidence and parenting. In addition, parents' interactions are influenced by children's personalities, leading to unique experiences for each child. A shy child might elicit different reactions from parents than a very outgoing child. We examine the ways that children evoke reactions in their environment later in this chapter.

Even twins who share the womb and a birthday have a nonshared environment—different friends, activities, teachers, and interactions with parents that are influenced by their unique personality and characteristics. The nonshared environment contributes to many of the differences we see among siblings and interacts with genetics to influence children's development.

Gene-Environment Interactions

At 6 feet 2 inches in height, 16-year-old Deondre towers over his 5-foot-tall mother and is substantially taller than his father, who is 5 feet 11 inches. Why is Deondre so much taller than his biological parents? Shared genes account for only part of the story of development. As we have discussed, genes and the environment work together in complex ways to determine our characteristics, behavior,

development, and health (Morgan et al., 2020; Ritz et al., 2017). **Gene-environment interactions** refer to the dynamic interplay between our genes and our environment. Several principles illustrate these interactions and can help us account for differences among family members.

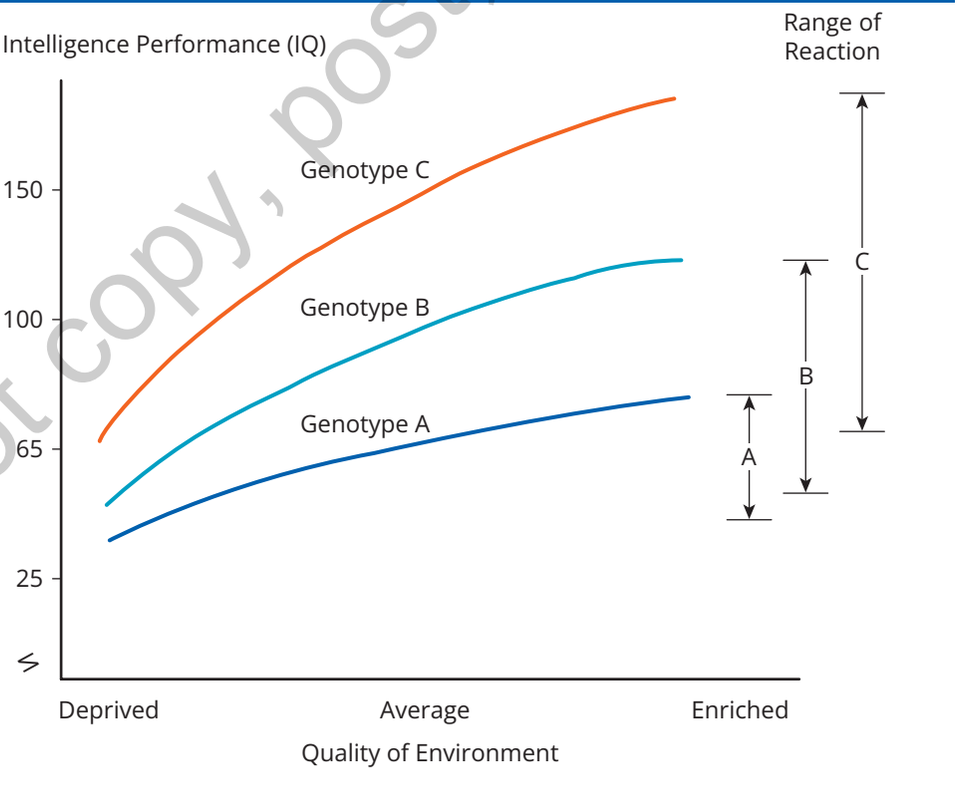
Range of Reaction

The effects of the environment varies with the genetic makeup of the individual (Briley et al., 2019). Everyone has a different genetic makeup and therefore responds to the environment in a unique way. In addition, any one genotype can be expressed in a variety of phenotypes. There is a **range of reaction**, a wide range of potential expressions of a genetic trait, depending on environmental opportunities and constraints (see Figure 2.5; Gottlieb, 2007).

Consider height. Height is largely a function of genetics, yet an individual may show a range of sizes depending on environment and behavior (Jelenkovic et al., 2016; Thompson, 2021). Children born to two very tall parents may have the genes to be tall. But unless they have adequate nutrition, they will not fulfill their genetic potential for height. In societies where nutrition has improved dramatically over a generation, it is common for children to tower over their parents. Enhanced environmental opportunities, in this case nutrition, enable the children to meet their genetic potential for height.

Therefore, a person's genetic makeup sets boundaries on the range of possible developmental outcomes; the environment influences where, within that range, the phenotype will fall (Manuck & McCaffery, 2014; Morgan et al., 2020). Gene-environment interactions are complex and often difficult to predict, partly because individuals vary in their sensitivity to environmental stimuli. Children's genetic makeup can make them more sensitive to environmental stimuli, or to particular stimuli, than other children (Briley et al., 2019; Harden, 2021).

FIGURE 2.5 ■ Range of Reaction



Adapted from Gottlieb, G. (2007). Probabilistic epigenesis. *Developmental Science, 10*(1), 1–11.

Some traits have a narrow reaction range, with a very small array of phenotypes or outcomes. This is known as **canalization**. Canalized traits are biologically programmed, and only powerful environmental forces can change their developmental path (Posadas & Carthew, 2014; Takahashi, 2019).

For example, infants follow an age-related sequence of motor development, from crawling, to walking, to running, suggesting that motor development is a canalized trait. Around the world, most infants walk at about 12 months of age. Generally, only extreme experiences, such as severe deprivation, can prevent this developmental sequence from occurring (Adolph & Franchak, 2017). We examine the role of experience in motor development in Chapter 4.

Gene-Environment Correlation

Heredity and environment each contribute to development. Not only do they interact, but environmental factors often support hereditary traits (Briley et al., 2019; Scarr & McCartney, 1983). **Gene-environment correlation** refers to the finding that many genetically influenced traits tend to be associated with environmental factors that promote their development (Saltz, 2019). That is, genetic traits often influence children's behavior, which is then supported or encouraged by the environment (Knafo & Jaffee, 2013). There are three types of gene-environment correlations: passive, evocative, and active.

Passive gene-environment correlation. Adults naturally create home environments that support their own preferences. Because parents are genetically similar to their children, the homes they create may also correspond to their child's genotype—an example of a *passive gene-environment correlation* (Wilkinson et al., 2013). Parents might provide genes that predispose a child to develop music ability and create a home environment that supports the development of music ability, such as by playing music in the home and owning musical instruments (Corrigall & Schellenberg, 2015; see Figure 2.6). This is a passive gene-environment correlation because the environment just happens to support the child's abilities. This type of gene-environment correlation tends to occur early in life because parents create rearing environments for their infants and young children.

Evocative gene-environment correlation. People naturally evoke responses from others and the environment, just as the environment and the actions of others evoke responses from the individual. In an *evocative gene-environment correlation*, a child's genetic traits (e.g., personality characteristics including openness to experience) influence the social and physical environment, which shape development in ways that support the genetic trait (Pieters et al., 2015; Saltz, 2019).

Active, happy infants tend to receive more adult attention than do passive or moody infants (Deater-Deckard & O'Connor, 2000), and even among infant twins reared in the same family, the more outgoing and happy twin receives more positive attention than does the more subdued twin (Deater-Deckard, 2001). Why? Babies who are cheerful and smile often influence their social world by evoking smiles and affection from others, including their parents, which in turn support the tendency to be cheerful (Klahr et al., 2013). In this way, the child's trait leads them to behave in ways that influence the physical and social environment to support the genetic trait. To return to the music example, a child with a genetic trait for musical talent will evoke adult approval when the child plays music; this environmental support, in turn, encourages further development of the child's musical trait.

Active gene-environment correlation. Children also take a hands-on role in shaping their development. As children grow older, they have increasing freedom in choosing their own activities and environments. An *active gene-environment correlation* occurs when the child creates experiences and seeks environments that correspond to and support their genetic predisposition. The child with a genetic trait for interest and ability in music seeks experiences and environments that support that trait, such as friends with similar interests and after-school music classes (Corrigall & Schellenberg, 2015). This tendency to actively seek out experiences and environments compatible and supportive of our genetic tendencies is called **niche picking** (Saltz, 2019; Scarr & McCartney, 1983).

Developmental shifts in gene-environmental correlations. The strength of passive, evocative, and active gene-environment correlations changes with development, as shown in Figure 2.7 (Lynch, 2016; Scarr, 1992). Passive gene-environment correlations are common at birth as caregivers determine infants' experiences. Correlations between their genotype and environment tend to occur because their environments are made by genetically similar parents (Armstrong-Carter et al., 2021). Evocative

FIGURE 2.6 ■ Gene-Environment Correlation

The availability of instruments in the home corresponds to the child's musical abilities, and she begins to play piano (passive gene-environment correlation). As she plays piano, she evokes positive responses in others, increasing her interest in music (evocative gene-environment correlation). Over time, she seeks opportunities to play, such as performing in front of an audience (niche picking) and may obtain additional instruments, further supporting her musical abilities.

AJ_Watt/istock; Fancy/Veer/Corbis/Getty Images; SA2RN/Getty Images

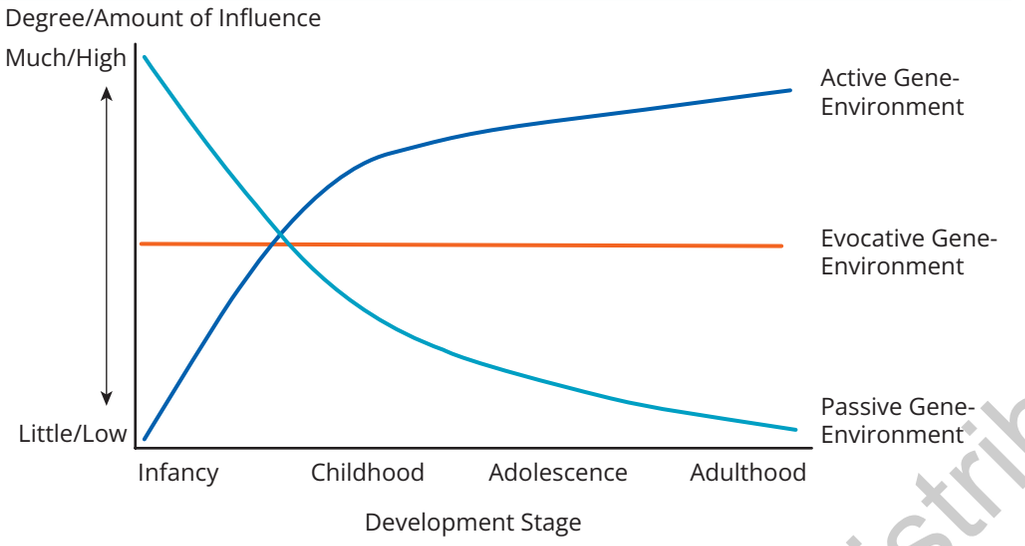
gene-environment correlations also occur from birth, as infants' inborn traits and tendencies influence others, evoking responses that support their own genetic predispositions.

In contrast, active gene-environment correlations take place as children grow older and more independent. As they become increasingly capable of controlling parts of their environment, they engage in niche picking by choosing their own interests and activities, shaping their own development. Niche picking contributes to the differences we see in siblings, including fraternal twins, as they grow older. Interestingly, identical twins tend to become more similar over time, perhaps because they are increasingly able to select the environments that best fit their genetic propensities (contributing to a shared environment). As adults, identical twins—even those reared apart—tend to become alike in attitudes, personality, cognitive ability, strength, mental health, and preferences, and they tend to select similar spouses and best friends (McGue & Christensen, 2013; Plomin & Von Stumm, 2018; York, 2020).

Gene-Environment (G x E) Interactions

Despite our growing understanding of genetic influences on behavior, phenotypes (the traits people ultimately show) are often unpredictable (Flint et al., 2020). Not only do the effects of genes vary with environmental influences, but not all genotypes respond to environmental influences in the same way (Fowler-Finn & Boutwell, 2019; Harden, 2021).

FIGURE 2.7 ■ Gene-Environment Correlations Over the Life Span



In a classic longitudinal study, boys who experienced trauma and abuse tended to show developmental and behavioral problems (Caspi et al., 2002). Their adaptation varied depending on the presence of a gene that controls monoamine oxidase A (MAOA), an enzyme that regulates specific chemicals in the brain. Maltreated boys were about twice as likely to develop problems with aggression, violence, and to even be convicted of a violent crime—but only if they carried the low-MAOA gene. Maltreated boys who carried the high-MAOA gene were no more likely to become violent than nonmaltreated boys. In addition, the presence of the low-MAOA gene itself was not associated with violence, but it predicted violence only for boys who experience abuse early in life. These findings have been replicated in another 30-year longitudinal study of boys (Fergusson et al., 2011) as well as a meta-analysis of 27 studies (Byrd & Manuck, 2014).

Similar findings of a MAOA gene x environment interaction in which low MAOA, but not high MAOA, predicts negative outcomes in response to childhood adversity have been extended to include other mental health outcomes such as antisocial personality disorder and depression (Dash et al., 2023; Manuck & McCaffery, 2014; Mariz et al., 2022). Many of these studies have examined only males. Females show a more mixed pattern, with some studies showing that girls display the MAOA gene x environment interaction on emotional reactivity and aggression but to a much lesser extent than boys, whereas other studies suggest no relationship (Byrd et al., 2018). Other genes interact with the environment in similar ways. For example, the 5-HTTLPR gene interacts with environmental factors to influence parenting sensitivity, depression, stress, and responses to trauma (Baião et al., 2020; Li et al., 2013).

Just as some genes increase our susceptibility to environmental risks, others might increase our sensitivity to, and therefore the effectiveness of, environmental interventions (Bakermans-Kranenburg & van IJzendoorn, 2015; Chhangur et al., 2017). The effects of genes vary with environmental influences and not all genotypes respond to environmental influences in the same way (Fowler-Finn & Boutwell, 2019). Moreover, most human traits, such as intelligence, are influenced by multiple genes, each of which have multiple variants that can each interact with the environment in different ways (Armstrong-Carter et al., 2021; Briley et al., 2019; Plomin et al., 2016).

We have learned a great deal about how our genes and environments work together to influence our development. However, it is worth noting that these conclusions pertain to populations, large groups of people, and not to specific individuals. Conclusions from behavior genetic research cannot predict individual behavior (Turkheimer, 2019). In addition, behavior genetic research, like many other areas of research, is based on samples that are not diverse. Ethnically diverse samples and those of low socioeconomic status are underrepresented in behavior genetics research, limiting the conclusions that we can draw (Sirugo et al., 2019). Although we have learned much about behavior genetics, the genetics of most traits still poorly understood (Brandes et al., 2022).

Epigenetic Framework

By now it is clear that development is the product of a dynamic interaction of biological and contextual forces. Recently scientists have determined that environmental factors do not simply interact with genes to determine people's traits. Environmental factors can determine *how* genes are expressed through a process known as **epigenetics** (Carlberg & Molnar, 2019; von Lüpke, 2021). The epigenome is a molecule that stretches along the length of DNA and provides instructions to genes, determining how they are expressed, whether they are turned on or off. The epigenome carries the instructions that determine what each cell in your body will become, whether heart cell, muscle cell, or brain cell. Those instructions are carried out by directing genes to turn on and off (O'Donnell & Meaney, 2020).

At birth, each cell in our body turns on only a fraction of its genes. The epigenome instructs genes to be turned on and off over the course of development and also in response to the environment (Paro et al., 2021). Epigenetic mechanisms determine how genetic instructions are carried out to determine the phenotype, the characteristics shown (Pinel et al., 2018). Environmental factors such as toxins, injuries, crowding, diet, and responsive parenting can influence the expression of genetic traits through epigenetic mechanisms (O'Donnell & Meaney, 2020). These processes were first discovered in animals.

Epigenetic Processes in Animals

One of the earliest examples of epigenetics is the case of agouti mice, which carry the agouti gene. Mice that carry the agouti gene have yellow fur, are extremely round and obese, and are prone to diabetes and cancer. When agouti mice breed, most of the offspring are identical to the parents—yellow, obese, and susceptible to life-shortening disease. A groundbreaking study showed that yellow agouti mice can produce offspring that look very different (Waterland & Jirtle, 2003). The mice in this photo both carry the agouti gene, yet they look very different; the brown mouse is slender, is lean, has a low risk of developing diabetes and cancer, and is likely to live well into old age. Why are these mice so different? Epigenetics. In the case of the yellow and brown mice, the phenotype of the brown mouse has been altered, but the DNA remains the same. Both carry the agouti gene, but in the yellow mouse, the agouti gene is turned on all the time. In the brown mouse, it is turned off.

These two mice are genetically identical. Both carry the agouti gene, but it is turned on all the time in the yellow mouse and turned off in the brown mouse.

Randy Jirtle and Dana Dolinoy, CC BY 3.0

How is the agouti gene turned on or off? An environmental factor: The pregnant female's diet, specifically the presence of chemical clusters that attach to, or mark, the gene, determines the offspring's phenotype (Waterland & Jirtle, 2003). These chemical clusters are found in many foods such as onions, garlic, beets, soy, and the nutrients in prenatal vitamins. Yellow agouti mothers that were fed a diet high in these chemical clusters passed along the agouti gene to their offspring, but the presence of epigenetic marks (the chemical clusters) turned it off. The offspring looked radically different from the mothers (brown instead of yellow) and were healthier (lean, not susceptible to disease) even though they carried the gene.

Epigenetic Processes in People

Epigenetic processes also influence human development. Just as in animals, the human epigenome can be influenced by the environment before birth. The epigenome can even be transmitted from one generation to the next through epigenetic marks passed on ova and sperm (Ghai & Kader, 2022; Legoff et al., 2019). This means that what you eat and do today could affect the epigenome of your descendants, including the development, characteristics, and health of your children, grandchildren, and great-grandchildren (Breton et al., 2021; Ghai & Kader, 2022; Grover & Jenkins, 2020).

The epigenome is also influenced by our experiences after birth. Early exposure to trauma and adversity can reprogram children's development, leading to accelerated aging (Kim et al., 2023; Raffington et al., 2021). The quality of maternal caregiving predicts epigenetic changes linked with socioemotional development and adjustment to adversity (Mariani Wigley et al., 2022; Provenzi et al., 2020). Experiences can place epigenetic marks on genes that influence our physical, cognitive, and socioemotional competencies, including physical and mental health (Manczak et al., 2021; O'Donnell & Meaney, 2020; Raffington et al., 2023).

To date most epigenetic research focuses on exposure to adversity, but epigenetic processes operate for all people, at all ages, and in all environments. Interactions between heredity and environment change throughout development as does the role we play in constructing environments that support our genotypes, influence our epigenome, and determine who we become (Lickliter & Witherington, 2017).

THINKING IN CONTEXT 2.4

1. Suppose you wanted to determine the influence of genetics and environment on a characteristic, such as intelligence, body weight, or athletic ability.
   a. What kind of study would you conduct? Consider twin and adoption study methods.
   b. What would you measure? Choose one aspect (intelligence, body weight, or athletic ability), and explain how you would study it in groups of people.
   c. Considering your design and measure, how would you determine the degree to which the characteristic is influenced by genes and environment?
   d. What are the challenges of conducting research such as this?
2. Give a personal example of a passive gene-environment correlation, evocative gene-environment correlation, and active-gene environment correlation. Which types of gene-environment correlations do you most commonly encounter?

APPLY YOUR KNOWLEDGE

Sitting in her doctor's office, Zinnia tells Dr. Rasheed, "I want to have a baby. I have no partner, but I'm ready. I'm 37 and financially stable. It's time. What are my options?" Dr. Rasheed replies, "There are a number of choices. It's a matter of figuring out what's right for you. In addition to a full examination to assess your health, we will seek assistance from a genetic counselor to determine the risk for genetic disorders. This information can help you decide among reproductive options."

1. Identify three ways that genetic disorders are passed. Why does Dr. Rasheed advise genetic testing?
2. What are some of the reproductive options available to Zinnia? What are some of the advantages and disadvantages to each option? Which option do you suggest for Zinnia? Why?

After much deliberation, Zinnia decided to pursue in vitro fertilization using a sperm donor. Soon Zinnia was delighted to learn that she was pregnant—with twins!

1. What types of prenatal screening tests might Zinnia experience? Discuss some of the advantages and disadvantages of each.
2. Do you expect Zinnia to carry identical or fraternal twins? Why?
3. Describe the portions of genetics and environment you expect the twins to share. Discuss the nonshared environment and examples of experiences that the twins may not share.

CHAPTER SUMMARY

2.1 Discuss the genetic foundations of development and patterns of genetic inheritance.
Genes are composed of stretches of deoxyribonucleic acid (DNA). Most cells in the human body reproduce through mitosis, but sex cells reproduce by meiosis, creating gametes with 23 single, unpaired chromosomes. Some genes are passed through dominant-recessive inheritance, in which some genes are dominant and will always be expressed, and others are recessive and will only be expressed if paired with another recessive gene. Other patterns include incomplete dominance, in which both genes are shown, and genomic imprinting, in which the expression of a gene is determined by whether it is inherited from the biological mother or father. Most traits are polygenic, the result of interactions among many genes.

2.2 Identify examples of genetic disorders and chromosomal abnormalities.
Genetic disorders carried through dominant-recessive inheritance include PKU, a recessive disorder, and Huntington's disease, carried by a dominant gene. Some recessive genetic disorders, like the gene for hemophilia, are carried on the X chromosome. Males are more likely to be affected by X-linked genetic disorders. Fragile X syndrome is an example of a dominant-recessive disorder carried on the X chromosome. Other X-linked genetic disorders include Klinefelter syndrome, Jacob's syndrome, triple X syndrome, and Turner syndrome. Some disorders, such as trisomy 21, known as Down syndrome, are the result of chromosomal abnormalities. Others result from mutations.

2.3 Explain the choices of reproductive technology and prenatal diagnostic methods available to individuals and couples.
Artificial insemination, the simplest ART, involves inserting sperm into a woman. In vitro fertilization involves fertilizing ova with sperm outside the body and implanting the resulting cluster of cells in the woman's uterus. Surrogacy involves a woman (the surrogate) carrying a fetus to term for another person or couple who will raise it. There are many options for monitoring fetal health. Ultrasound enables physicians to observe the fetus, measure fetal growth, judge gestational age, and determine physical abnormalities in the fetus. Fetal MRI applies MRI technology to image the fetus' body and diagnose malformations and is often used as a follow-up to ultrasound imaging. Amniocentesis involves extracting a small sample of the amniotic fluid that surrounds the fetus, then growing and analyzing it. Chorionic villus sampling (CVS) also samples genetic material and can be conducted earlier than amniocentesis. Noninvasive prenatal testing (NIPT) screens the mother's blood to detect chromosomal abnormalities but is not as accurate as amniocentesis and CVS. Fetoscopy involves inserting a camera into the womb to examine the fetus and perform procedures, including surgery, during pregnancy.

2.4 Examine interactions among heredity and environment, including behavior genetics, gene-environment correlations and interactions, and the epigenetic framework.
Behavior genetics is the field of study that examines how genes and experience combine to influence the diversity of human traits, abilities, and behaviors. Heritability research examines the contributions of the genotype in determining phenotypes but also provides information on the role of experience through three types of studies: selective breeding studies, family studies, and adoption studies. Genetics contribute to many traits, such as intellectual ability, sociability, anxiety, agreeableness, activity level, obesity, and susceptibility to various illnesses. Passive, evocative, and active gene-environment correlations illustrate how traits often are supported by both our genes and environment. Reaction range refers to the idea that there is a range of potential expressions of a genetic trait, depending on environmental opportunities and constraints. Some traits illustrate canalization and require extreme changes in the environment to alter their course. People's genes and environment interact in complex ways such that the effects of experience may vary with a person's genes. The epigenetic framework is a model for understanding the dynamic ongoing interactions between heredity and environment whereby the epigenome's instructions to turn genes on and off throughout development are influenced by the environment.

KEY TERMS

adoption
amniocentesis
artificial insemination
assisted reproductive technology (ART)
behavior genetics
canalization
chorionic villus sampling (CVS)
chromosome
deoxyribonucleic acid (DNA)
dizygotic (DZ) twin
dominant–recessive inheritance
Down syndrome
epigenetics
fetal MRI
fetoscopy
fragile X syndrome
gamete
gene
gene–environment correlation
gene–environment interactions
genetic counseling
genomic imprinting
genotype
hemophilia
in vitro fertilization
incomplete dominance
Jacob's syndrome
Klinefelter syndrome
meiosis
mitosis
monozygotic (MZ) twin
mutation
niche-picking
noninvasive prenatal testing (NIPT)
nonshared environment
phenotype
phenylketonuria (PKU)
polygenic inheritance
range of reaction
sickle cell anemia
surrogacy
Triple X syndrome
Turner syndrome
ultrasound
zygote