

Preface

Thirty years ago, I taught my first undergraduate course in child development. In the following decades, I've interacted with thousands of students in over 100 course sections. *Child and Adolescent Development in Context*, Second Edition, is the result of my in-class and out-of-class discussions with my students about the nature of development. Students often find child development inherently interesting as they have observed and experienced many of the topics we discuss. Sharing observations and personal experiences is fun and engaging. But sometimes our individual experiences and observations don't completely match the theoretical and research conclusions we discuss. How do we make sense of the differences? In class and this text, I adopt a contextual perspective to help students understand variability in development and make sense of the growing body of findings in child and adolescent development. My goal in writing this text is to explain the sophisticated interactions that constitute development in a comprehensive yet concise way.

Themes: Context and Application

Child and Adolescent Development in Context focuses on three key themes for understanding child development: the centrality of context, the applied value of developmental science, and the relevance of intersectionality for understanding development. These themes are highlighted throughout the text and in critical thinking features. An accessible writing style helps students grasp these complex issues, and the text is firmly grounded in classic and cutting-edge science.

Contextual Perspective

The most central tenet of development is that it occurs in context. It is the result of dynamic transactions among individuals; their physical, cognitive, and socioemotional capacities; and the web of interacting contexts in which they are immersed, including family, peers, school, neighborhood, society, culture, and history. *Child and Adolescent Development in Context* discusses these processes, emphasizing how individual factors combine with the people, places, circumstances, and time in which children live to influence development. A contextual approach can provide the backstory to development and help us understand why children vary.

The contextual theme is infused throughout the text and highlighted specifically in *Lives in Context* sections that appear in each chapter. Examples of *Lives in Context* features include the effects of exposure to early life stress, cultural variations in children's sleep, whether masks influence children's ability to identify others' emotions, rural children's health, and the effects of parental "phubbing" or phone use while caregiving.

Development is multidimensional. Changes that occur in one domain, such as physical development, spill over to influence others, such as cognitive or socioemotional development. This second edition includes a new feature, *Developmental Cascades*, which highlights these relationships. Examples include the relationships between motor development and language development in infancy, the implications of screen use for fine motor development in young children, stuttering and development in middle childhood, and the effects of the COVID-19 pandemic on pubertal timing and adolescent depression.

Thinking in Context critical thinking items ask students to consider a range of developmental issues, including the impact of biological factors, applying developmental theory and themes, applying Bronfenbrenner's bioecological theory to address real-world problems, and the role of culture in development. *Thinking in Context* items also highlight the ways in which race, ethnicity, gender, and socioeconomic status overlap to determine developmental opportunities and outcomes.

Applied Emphasis

The field of developmental science is unique because so much of its content has immediate relevance to our daily lives. Students may wonder: Do the first 3 years shape the brain for a lifetime of experiences? Can we teach babies to communicate through sign language? Is learning more than one language beneficial to children? What does it mean to be a transgender child? Developmental science is increasingly applied to influence social policy. For example, why vaccinate infants? Can we outlaw bullying? Research in child and adolescent development can inform our understanding of each of these topics. Moreover, these topics fascinate students because they illustrate clear-cut examples of why developmental science matters.

Application is integrated throughout the text, including *Thinking in Context* items that ask students to apply the course content by generating examples, designing research studies, and explaining the material to different audiences and contexts. Each chapter concludes with an *Apply Your Knowledge* case that invites students to consider how the content can be applied to a realistic scenario.

Intersectionality and Development

A contextual and applied perspective highlights the role of intersectionality in development. Diverse identities and experiences accompany race, ethnicity, gender, sexual orientation, socioeconomic status, and other social category memberships. Inequities are experienced as racism, sexism, classism, heterosexism, and more, and shape children's and families' lived experiences, opportunities, and developmental outcomes. Until recently, people of color have either been excluded from research studies or grouped as "minorities," masking differences and contributing to a sense of invisibility among people of color. I examine development through an intersectional lens whenever possible.

Examples of intersectional and diversity, equity, and inclusion–related content include examining racial, ethnic, gender, sexual orientation, and SES differences and interactions in all of the following:

- Individuals' experiences of pregnancy and prenatal development, including access to reproductive technology and prenatal care, birth outcomes, barriers to breastfeeding, adolescent pregnancy, and reporting and criminal sanctions for drug use in pregnant women.
- Children's physical development and health, such as socioeconomic influences on brain development and health, including growth, activity, and nutrition, and illnesses, injuries, and mortality, as well as COVID-19 experiences and outcomes. Persistent problems such as food insecurity and exposure to stress and trauma influence brain development, stress reactivity, and pubertal timing and play a role in mental health, including rates of eating disorders, depression, and suicide.
- Cognitive and language development, such as facial perception and the other race–face effect, diagnoses of neurodevelopmental disabilities, rates and forms of child-directed speech, influences and outcomes of bilingualism, and even gene–IQ correlations.
- Socioemotional development, such as emotional regulation and the sense of self, including self-concept, self-esteem, and identity. Ethnic-racial identity, including ethnic socialization, experiences with discrimination, and its influence on children's adjustment. Gender identity, including transgender and nonbinary identities, adjustment, and gender-affirming care, as well as developmental transitions, risks, and supports for LGBTQ+ adolescents.
- Children's social contexts, including family formations, such as one-parent, cohabitating, adoptive, and foster families; parenting styles; and the effects of different family experiences, such as parental incarceration, parental deployment, and immigration. Contextual stressors that vary with intersectional factors include exposure to early life stress, neighborhood and community violence, war and terror, and experiences during the COVID-19 pandemic.

Accessible Writing Style

Having taught undergraduate students at a regional public university for 30 years, I write in a style intended to engage diverse readers like my own students. My day-to-day classroom experiences have helped me keep college students' interests and abilities at the forefront. Unlike many textbook authors, I teach four classes each semester. I taught my first online course in 2002, well before the COVID-19 pandemic. My daily exposure to multiple classes and many students helps keep me grounded in college students' ever-changing concerns and interests.

My institution is embedded in a diverse community in which about 40 languages are spoken. My students are similarly diverse in background, race, ethnicity, and socioeconomic status. Some students live on campus, but at least three-quarters commute. Most of my students are between the ages of 18 and 24, but my classes also include many adults over the age of 24. Many are veterans, a rapidly increasing population at my institution, with unique perspectives and needs.

I attempt to write in the same voice as I teach, carefully structuring sections to build explanations and integrating content with relevant examples that engage students. My experience teaching 12 courses during the COVID-19 pandemic in the spring of 2020 and the 2020–2021 academic year reinforced (for me) the importance of accessible, concise textbooks. Like many faculty, I was able to record only so many videos for my asynchronous classes, so I relied heavily on my text, asynchronous discussion posts, and, for the classes where available, Vantage, which enabled students to read the text interactively. I believe that accessible and engaging course materials can make a difference in students' learning despite difficult circumstances.

Pedagogical Features

Each year, I teach two to four sections of child development. I regularly use my own text in class, and students' responses, their learning, and especially their questions guide my writing. Current and former students worked with me in preparing this text. I have many opportunities to try new examples and activities, and I believe that what works in my classroom will be helpful to readers and instructors. *Child and Adolescent Development in Context* includes the following features.

Careers in Child Development

It is an understatement to say that my students are interested in careers—what they will do after college. Students often don't know where to begin in considering possible careers. Beginning with a discussion of transferable skills in Chapter 1, the *Career* feature highlights two to three careers that are related to or benefit from an understanding of child development in each chapter.

Lives in Context

Each chapter includes at least two *Lives in Context* sections that illustrate interactions among children and their contexts.

Developmental Cascades

Each chapter includes one *Developmental Cascades* feature that illustrates interactions among developmental domains as well as how contextual factors can trigger cascading effects.

Critical Thinking Questions

Thinking in Context critical thinking questions appear at the end of each main section of the chapter. The items encourage readers to compare concepts, apply theoretical perspectives, and consider applications of the research findings presented.

Case-Based Application

Each chapter closes with a case scenario, *Apply Your Knowledge*, followed by in-depth questions that require students to apply their understanding to address a particular situation or problem.

Learning Objectives and Summaries

Core learning objectives are listed at the beginning of each chapter. The end-of-chapter summary returns to each learning objective, recapping the key concepts presented in the chapter related to that objective.

What's New in *Child and Adolescent Development in Context*, Second Edition?

I approached writing this second edition with three goals:

1. **Increase the coverage of context, examine development through an intersectional lens, and present an integrated view of development.**

I addressed this multifaceted goal by adding findings and sections covering contextual and intersectional influences, as available, throughout each chapter. A new section of Chapter 1 defines intersectionality and its value for understanding development. I explain that the developmental science literature on intersectionality is in its infancy but rapidly growing. I include information about the interrelationships of ethnicity, race, gender, sexuality, socioeconomic status, and other relevant factors, as available.

2. **Create student-centered features to increase students' understanding and interest in developmental science.**

In the second edition, the *Lives in Context* sections were revamped and streamlined; two-thirds of the topics are new, and the remaining third were substantially updated. The *Developmental Cascades* feature is entirely new, highlighting exciting connections among developmental domains and the contexts in which we are embedded. Topics highlighted in these features examine current and classic issues of interest to students, including diversity, media use, and the effects of the COVID-19 pandemic.

3. **Update the text to include the most current research to date, increasing coverage while retaining length.**

Our knowledge of human development is rapidly expanding. My goal was to select, highlight, and integrate cutting-edge findings with existing theory and research, expanding several sections in each chapter to better cover developmental issues (such as the effects of socioeconomic status on development, spirituality, and gender identity). The second edition includes over 2,100 references published since 2020, including over 500 published since 2023. Despite these additions, the overall length of the text has remained largely the same. I worked to streamline discussions by carefully integrating new material with existing content, selecting the most appropriate examples and details to include, and paring down excess information.

As follows, I list some of the major revisions reflected in this second edition of *Child and Adolescent Development in Context*. Each chapter contains many other changes that are not documented here. It is my hope that this volume will improve instructors' and students' experiences in and out of class—and that students will be inspired to apply the findings of developmental science to their lives.

Chapter 1

- **Structural changes:** Broke the theories section into several smaller sections: classic theories (psychoanalytic, behaviorist); cognitive theories (which now includes Bandura's social cognitive

theory); and biological and systems theories (evolutionary developmental, bioecological, and dynamic systems theories). Broke the research section into two smaller sections: methods and designs.

- **New sections:** Applied Developmental Science, Ethics, and Intersectionality; Why Study Children?; Individual Differences: Is There One Developmental Path or Many?; Sociohistorical Context; Cultural Context; Lives in Context: Social Policy and Child Development; Lives in Context: Bronfenbrenner's Bioecological Systems Theory and the Effects of the COVID-19 Pandemic on Children and Families; Lives in Context: An Experience Sampling Study of Adolescent Social Media Use and Distraction; Developmental Cascades: Active Exploration; Career: Developmental Psychologist; Career: Transferrable Skills and Careers.
- Updated Figure 1.1: Developmental Domains.
- Removed the following boxed features and integrated the content into the chapter as appropriate: Lives in Context: Defining Culture; Applying Developmental Science: The Real-World Significance of Developmental Research; Lives in Context: Methods of Studying the Brain; Lives in Context: Effects of Exposure to Community Violence.

Chapter 2

- **New sections:** Lives in Context: Gene Editing; Lives in Context: Prenatal Sex Selection; Developmental Cascades: International Adoption and Child Development; Career: Genetic Counselor; Career: Diagnostic Medical Sonographer.
- Streamlined, removing complicated terms (such as *heterozygous* and *homozygous*) in favor of discussing concepts.
- Removed Lives in Context: Gene $\times$ Environment Interaction and Responses to Adversity.

Chapter 3

- **New sections:** Racial Disparities in Addressing Maternal Substance Use; Teratogen–Context Interactions; Race, Ethnicity, and Prenatal Care; Race, Socioeconomic Status, and Low Birthweight; Early Learning Capacities (updated and moved from Chapter 4); Cultural Childbirth Practices; Developmental Cascades: Prenatal Exposure to Maternal Stress; Lives in Context: The Placenta and Prenatal Development; Career: Midwife; Career: Doula; Career: Neonatal Nurse.
- Removed Lives in Context: HIV Infection in Newborns.
- Updated Lives in Context: Pregnancy and the Maternal Brain.

Chapter 4

- **New sections:** Solid Food; Malnutrition and Development; Vaccination Hesitancy; Mortality subsection: Race and Socioeconomic Status Differences; Lives in Context: Bedsharing; Lives in Context: Neonatal Circumcision (updated); Developmental Cascades: Motor and Language Development; Early Adversity and Brain Development; Visual Impairment; Posture; Career: Pediatrician; Career: Pediatric Nurse; Career: Audiologist.
- **New figures:** Food Insecurity (Figure 4.3); Infant Mortality Rates, 2022 (Figure 4.4); Sudden Unexpected Infant Death by Cause, 1990–2022 (updated trends in Figure 4.5); Infant Motor Skills (Figure 4.14); Dynamic Systems Theory (Figure 4.15); Hidden Motor Skills (Figure 4.16).

- Removed the following boxed features and integrated the content into the chapter as appropriate: Lives in Context: Failure to Vaccinate; Lives in Context: Co-Sleeping; Lives in Context: Intermodal Perception and Learning.
- Removed Growth Faltering; moved Early Learning Capacities to Chapter 3.

Chapter 5

- **Structural changes:** Integrated the sections on individual differences in cognitive abilities into the cognitive development section: Measuring Individual Differences in Mental Development; broke the sections on language development into two sections, examining theory and development.
- **New sections:** Lives in Context: Cultural and Infant-Directed Speech; Lives in Context: Screen Media Use in Infancy; Career: Early Head Start Teacher; Career: Early Intervention Specialist; Developmental Cascades: Language Development in Deaf Infants; Information Processing Assumptions; Attention.
- **New figures:** Joint Attention (Figure 5.5); Recall in Infancy (Figure 5.6).
- Removed the following boxed features and integrated the content into the chapter as appropriate: Lives in Context: Baby Videos and Infant Learning; Applying Developmental Science: Baby Signing; Lives in Context: Biological Factors—Poverty and Development.

Chapter 6

- **Structural changes:** Integrated Psychosocial Development in Infancy and Toddlerhood into the sections on attachment (trust versus mistrust) and self (autonomy versus shame and doubt).
- **New sections:** Recognizing Others' Emotions; Stranger Wariness; Caregiver Sensitivity and Emotional Development; Dynamic Caregiver–Infant Interactions; Emerging Autonomy; Mastery Motivation; Developmental Cascades: Caregiver Depression; Lives in Context: Exposure to Early Life Stress; Lives in Context: Father–Infant Attachment; Career: Child Care Center Director; Career: Social Worker.
- Removed the following boxed features and integrated the content into the chapter as appropriate: Lives in Context: Trauma and Emotional Development; Lives in Context: Infant Adjustment to Parental Deployment.

Chapter 7

- **New sections:** Activity and Coordination; Context and Opportunities for Movement; Career: Toy and Media Research; Developmental Cascades: Screen Use and Fine Motor Development; Lives in Context: Cultural Variations in Children's Sleep; Lives in Context: COVID-19 and Young Children; Career: Physical Therapist and Physical Therapy Assistant.
- Removed Figure 7.3.
- Removed the following boxed features and integrated the content into the chapter as appropriate: Lives in Context: Gene × Environment Interaction and Responses to Adversity; Applied Developmental Science: Picky Eating.

Chapter 8

- **Structural changes:** Created a new section focusing exclusively on Vygotsky's Sociocultural Theory; created a new section focusing exclusively on Theory of Mind with subsections: Cognitive Skills and False-Belief Understanding and Promoting Theory of Mind; revised section on memory to include Episodic Memory and Autobiographical Memory.

- **New sections:** Preoperational Reasoning and Education; Lives in Context: Childhood Amnesia; Memory Suggestibility; Lives in Context: Cultural Variations in Theory of Mind; Socioeconomic Status and Language Development; SES and Child-Directed Speech; Race and Socioeconomic Intersections and Language Development; Moral Development in Early Childhood; Social Domain Theory: Children's Conceptions of Moral, Social, and Personal Issues; Career: Speech–Language Pathologist; Career: Early Childhood Educator; Lives in Context: Cultural Variations in Theory of Mind; Lives in Context: Childhood Amnesia; Developmental Cascades: Childhood Stuttering.
- **New figure:** Mean Number of Spoken Words Reported on the MacArthur–Bates Communicative Development Inventories (CDI) by Age and Socioeconomic Status (SES) (Figure 8.6).
- Removed the following boxed features and integrated the content into the chapter as appropriate: Lives in Context: Television and Children's Development; Lives in Context: Brain-Based Learning.

Chapter 9

- **New sections:** Career: Art Therapist; Social Interaction and Emotional Understanding; Lives in Context: Masks and Emotion Recognition; Developmental Cascades: Language and Emotion in Young Children; Lives in Context: Parental Phubbing and Young Children's Development; Culture, Context, and Parenting, including subsections: Cross-Cultural Comparisons and North American Children; Gender Stereotypes and Gender Typing; Gender Schema Theory; Career: Applied Behavior Analyst.
- **New figures:** Proportion of Situations in Which Caregivers Give Praise and Encouragement to Toddlers (Figure 9.1); Parenting Styles (Figure 9.2); Trends in Prevalence of Spanking Within the Past Year Among 35-Year-Old Parents From 1993 to 2017 (Figure 9.3).
- Removed the following boxed features and integrated the content into the chapter as appropriate: Lives in Context: Children's Participation in Household Work; Applying Developmental Science: Transgender Children; Lives in Context: Physical Punishment.

Chapter 10

- **Structural changes:** Broke Health into two sections: Health in Middle Childhood and Threats to Health in Middle Childhood; moved Resilience in Middle Childhood to Chapter 12.
- **New sections:** Developmental Cascades: Exposure to Nature and Child Development; Adrenarche; Context and Disability: Race and Socioeconomic Status; Sleep; Screen Use; Lives in Context: Digital Media and Children's Body Dissatisfaction; Mortality; Lives in Context: Rural Children's Health; Career: Occupational Therapist and Occupational Therapy Assistant; Career: Child Life Specialist.
- Removed the following boxed features and integrated the content into the chapter as appropriate: Lives in Context: Screen Time and Sleep; Applying Developmental Science; Body Image Dissatisfaction; Lives in Context: Exposure to War and Terrorism and Children's Development.

Chapter 11

- **New sections:** Developmental Cascades: Transition to First Grade; Lives in Context: Identifying and Educating Gifted and Talented Children; Career: Elementary School Teacher; Sociohistorical Context and IQ; Socioeconomic Status and IQ; Group Differences and the Majority Culture; Stereotypes and IQ; Reducing Cultural Bias in IQ Tests; Career: Special Education Teacher.
- Revised/updated Lives in Context: Children's Understanding of Illness.

- Removed the following boxed features and integrated the content into the chapter as appropriate: Applied Developmental Science: Should Children Get “Left Back”?

Chapter 12

- **New sections:** Developmental Cascades: Neighborhood and Community Violence; Career: School Counselor; Career: Marriage and Family Therapist; Lives in Context: Grandparent-Headed Families; Adoption and Child Outcomes; Transracial Adoption; Children in Foster Care; Children Exposed to War and Terror; Children With Deployed Parents; Children With Incarcerated Parents; Children in Migrant Families; Resilience; COVID-19 and Families; Lives in Context: Racial Disparities in the Impact of the COVID-19 Pandemic.
- **Updated:** Achievement Motivation with new sections: Achievement Attributions, Mindset, Goals, and Mastery Orientation and Helpless Orientation; Peers.
- **Updated:** Gender in Middle Childhood with new sections: Gender Constancy and Gender Typing; Felt Gender Typicality; Gender Contentedness; Felt Pressure to Conform to Gender Roles; Transgender Identity.
- Removed the following boxed features and integrated the content into the chapter as appropriate: Lives in Context: Self-Concept and the Brain; Lives in Context: China’s One-Child Policy; Applying Developmental Science: Antibullying Legislation.

Chapter 13

- **New sections:** Lives in Context: Cultural Perspectives on Menarche; Developmental Cascades: The COVID-19 Pandemic and Pubertal Timing; Career: Clinical Neuropsychologist; Reward Sensitivity; Experience and the Adolescent Brain subsections: Socioeconomic Status and Substance Use; broke Adolescent Health into two sections: Adolescent Health and Threats to Adolescent Health; Sleep; Screen Use; COVID-19 and Eating Disorders; Career: Substance Abuse Counselor; Progression of Sexual Activities; Early Sexual Activity; Lives in Context: Challenges in Studying Sexual Diversity in Adolescence; Sexual Assault (revised); Affirmative Sexual Consent.

Chapter 14

- **New sections:** Lives in Context: Divided Attention and Multitasking; Changes in Moral Reasoning; Moral Reasoning and Behavior; Career: Middle School Teacher and High School Teacher; Civic Development; Critical Consciousness; Religiosity and Spirituality; Stage–Environment Fit subsections: Connections With Teachers and Racial and Ethnic Differences; Lives in Context: Academic Tracking; Developmental Cascades: Educational Attainment; College Student Development; First-Generation College Students; Career: College Admissions Counselor; Not Attending College.
- Removed the following boxed features and integrated the content into the chapter as appropriate: Applied Developmental Science: Legal Implications of Adolescent Decision Making; Lives in Context: Volunteer Work and Social Responsibility; Lives in Context: Evidence-Based Sex Education.

Chapter 15

- **New sections:** Career: Clinical Psychologist and Counseling Psychologist; Gender Intensification; Gender Diverse and Transgender Adolescents; Career: Applied Developmental Psychologist; Social Media and Peer Interaction; Lives in Context: Internet Gaming Disorder; Cyberbullying; Internalizing and Externalizing Issues; Anxiety Disorders; Developmental

Cascades: The COVID-19 Pandemic and Adolescent Depression; Problematic Social Media Use; Lives in Context: Two Paths of Delinquent Activity.

- **Updated and expanded:** Positive Youth Development.
- Removed the following boxed features and integrated the content into the chapter as appropriate: Lives in Context: Gender Roles and Acculturation in Mexican American Youth; Lives in Context: Adolescent Dating Violence; Lives in Context: Peer Interaction and the Brain.

Organization

Child and Adolescent Development in Context is organized into 15 chronological chapters, within five units, that depict the wide range of developments that occur over the lifespan. Part 1, Foundations of Child and Adolescent Development, includes Chapters 1, 2, and 3. Chapter 1 combines developmental theory and research design within a single chapter. I chose this approach because, given limited class time, many instructors do not cover stand-alone research chapters. The streamlined approach combines comprehensive coverage of methods of data collection, research design, developmental designs (such as sequential designs), and ethical issues in research with full coverage of the major theories in developmental psychology. Chapter 2 presents the biological foundations of development, including patterns of genetic inheritance, gene–environment interactions, and epigenetics. Chapter 3 describes prenatal development and birth, from conception to the newborn, including the emerging family system. I chose to present prenatal development, birth, and the newborn as a single chapter (rather than birth and the newborn as a stand-alone chapter) to reflect continuity in the perinatal period.

Parts 2 through 5 contain three chapters each, covering physical development, cognitive development, and socioemotional development, which reflect the major areas of development during infancy, early childhood, middle childhood, and adolescence. Therefore, *Child and Adolescent Development in Context* contains 15 chapters that correspond to the 15 weeks of the typical college semester.

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Chapter 1

Introduction to Child Development: Themes, Theories, and Research



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Learning Objectives

- 1.1 Describe developmental periods, developmental domains, and the contexts in which development occurs.
- 1.2 Discuss four core concepts in developmental science.
- 1.3 Differentiate between two psychoanalytic and two behaviorist theories.
- 1.4 Compare cognitive-developmental, information processing, sociocultural, and social cognitive theories.
- 1.5 Examine evolutionary developmental, bioecological, and dynamic systems theories.
- 1.6 Discuss the scientific method and describe observational, self-report, and physiological methods of collecting information about development.

- 1.7 Compare correlational, experimental, and developmental research designs.
- 1.8 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 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 like 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 will 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 occurs.

Individuals' bodies, minds, and social worlds change dramatically as they grow from infants to children and from children to adolescents. **Development** includes processes of growth and change, as well as how 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 will 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 following question: Why study children?

Why Study Children?

Perhaps the most obvious reason for studying 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, including growth and how children learn to crawl, walk, and run. They may also wonder about children's thinking and how it differs from the thinking of adults. How can caregivers and infants form strong emotional bonds, and how do these relationships help children develop?

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 academically with supporting their emotional development? School administrators, including principals and school boards, ask questions such as these: Should schools focus on academic learning or also emphasize physical and emotional development? Should recess and unstructured play be part of the school day?

Researchers work to answer these questions by conducting scientific studies. Most researchers narrow their study to specific areas of development, such as thinking or emotional development. Some researchers work in laboratory settings, conducting experiments and observational studies. Others study children in their homes, schools, and communities. For example, researchers study children's

adjustment and how they cope with adversity, such as living in poverty-stricken communities, witnessing violence, and experiencing discrimination. Researchers apply their findings to help children by creating interventions and making recommendations to parents, teachers, and policymakers.

Policymakers create and shape **social policy** and local, state, or federal government's plans and actions to support or improve the residents' welfare. Policymakers turn to researchers for accurate scientific information about child development. For example, what nutritional and health behaviors promote healthy birthweight? How is health care access related to children's and families' health and well-being? How are race and socioeconomic status related to children's exposure to developmental risks, such as poverty and toxins? 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 affect us? How do factors such as race, socioeconomic status, gender, language, and religion influence our development? Throughout this book, we examine interactions among demographic characteristics, 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, summarized as follows. Each developmental period is characterized by a predictable set of physical, cognitive, and social abilities.

Prenatal Period (Conception to Birth)

Upon conception, a single cell is formed. It multiplies repeatedly, and all of 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 improve. 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.

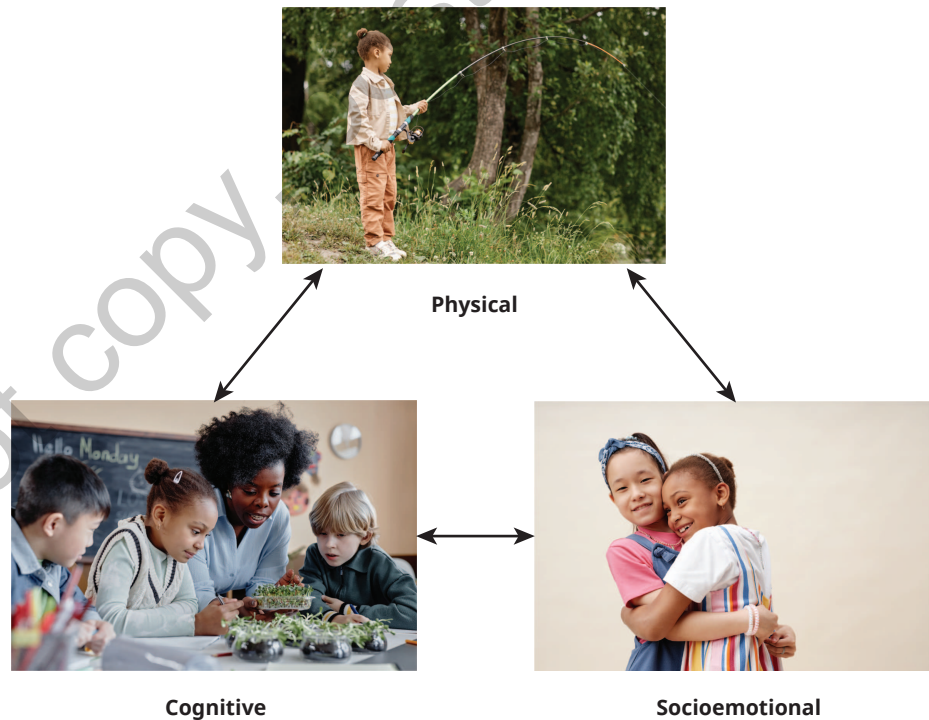
Developmental Domains

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 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.

These different areas of development are not isolated, independent changes, but rather, they co-occur and influence each other. Physical growth occurs alongside cognitive maturation, and socioemotional changes accompany both. Changes in one area spill over and trigger changes in others, a concept called **developmental cascades** (Bornstein et al., 2013; Masten & Cicchetti, 2010; Oakes, 2023). For example, the onset of walking precedes advances in language development in infants in the United States and China (He et al., 2015; Lücke 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, an aspect of physical development, influences language and social development (Kobaş et al., 2023). Developmental cascades are a central feature of child development that we will consider throughout this book. Figure 1.1 illustrates interactions among the domains of development, a central principle of development.

Figure 1.1 ■ Developmental Domains

Advances in physical, cognitive, and socioemotional development interact, permitting children to play sports, learn more efficiently, and develop close friendships.



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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.

At its simplest, **context** refers to where and when a person develops. It includes all aspects of the physical and social environments we are immersed in. Our context also includes abstract characteristics 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' child-rearing practices and your own values? How did your family's economic status affect your development? These questions examine a critical context for our development: 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 influenced not just by our surroundings but also by the 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 people born around the same time, called a **cohort**, share similar experiences and perspectives. Adults who were children during the Great Depression and World War II (roughly 1929–1945), for example, often share strong views on the importance of family and community. They grew up during a time of hardship and national unity, which shaped their values and beliefs. During the Great Depression, many families struggled to get enough food and often had to move in with relatives or seek help from their community. Many men served in the military during World War II, and many children grew up without their fathers present. As adults, members of this generation tend to have 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 technological changes, and so on. How might today's historical circumstances 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, 2024; 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). Researchers are still studying the effects of the COVID-19 pandemic to understand its long-term effects on children's and adolescents' development.

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 of 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. 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. Unlike in the United States and France, in Uganda, 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). Therefore, 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., 2021). Culture permeates all domains of development and contributes to the context in which we are embedded, transmitting values, attitudes, and ideas that shape our thoughts, beliefs, and behaviors.

Lives in Context

Social Policy and Child Development

Social policy refers to the framework of principles, guidelines, and practices that governments and institutions use to address social issues and distribute resources to support people's health, development, and well-being. It shapes child development by influencing access to critical resources and services. For example, policies aimed at reducing poverty can profoundly affect a child's access to nutritious food, quality health care, and safe housing—elements that are essential for healthy cognitive, social, and emotional development. Early childhood education programs, such as Head Start in the United States, help ensure that children from disadvantaged backgrounds get a strong start in life by providing high-quality learning environments. Moreover, policies supporting parental leave and affordable child care can alleviate family stress, enabling parents to create nurturing and stable environments. Social policies also address issues like child maltreatment prevention, access to mental health services, and educational equity, ensuring that all children have the opportunity to reach their full potential.

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

Thinking in Context 1.1

1. Identify personal examples of physical, cognitive, and socioemotional development. What changes did you experience 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 your experiences in these places have influenced your physical, cognitive, and socioemotional development? Provide examples.
3. How have your physical, cognitive, or socioemotional abilities influenced aspects of your context, the people and the places around you?

Core Concepts in Developmental Science

1.2 Discuss four core concepts in developmental science.

What causes development? What path does development take? What role do children play in their development? Does development follow one path, or are there many paths? Developmental scientists hold different views about these fundamental questions about child development. The following sections examine each of these questions.

Nature and Nurture: How Do Biology and Environment Influence Development?

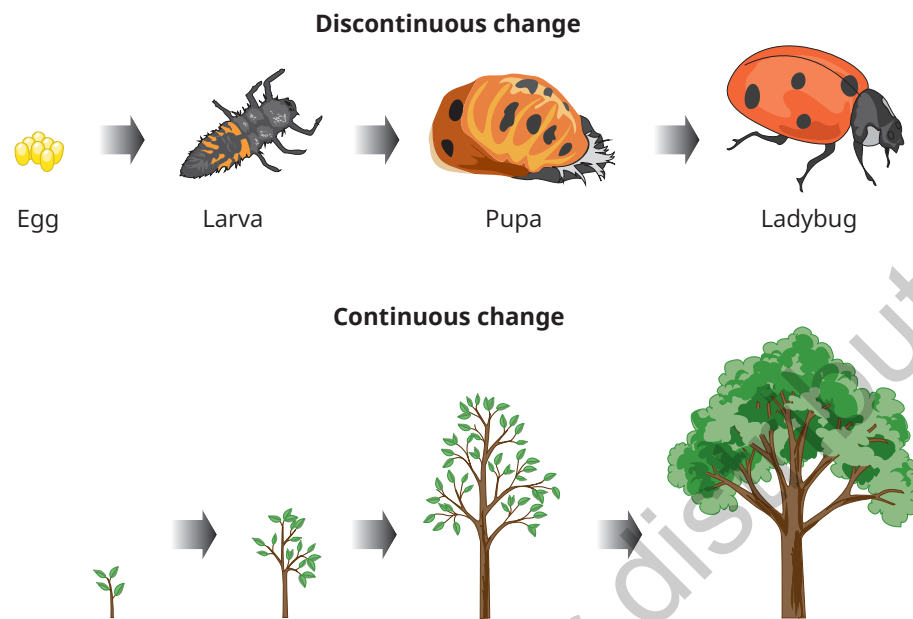
The simplest and oldest question about development is its cause: Are our characteristics and traits inborn or the result of experience? Often referred to as the **nature–nurture debate**, researchers once asked whether development is most influenced by biological factors (our inborn “nature”) or environmental factors (how we were raised, “nurture”). Explanations that rely on biology point to inborn genetic traits and maturation as causes of developmental change. Most infants crawl at roughly the same age, suggesting a maturational trend indicating 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 the environment work together to influence child development (Bjorklund, 2018b; Lickliter & Witherington, 2017)? For example, walking is heavily influenced by biological 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).

Continuities and Discontinuities: Are Developmental Changes Gradual or Abrupt?

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 adultlike 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.

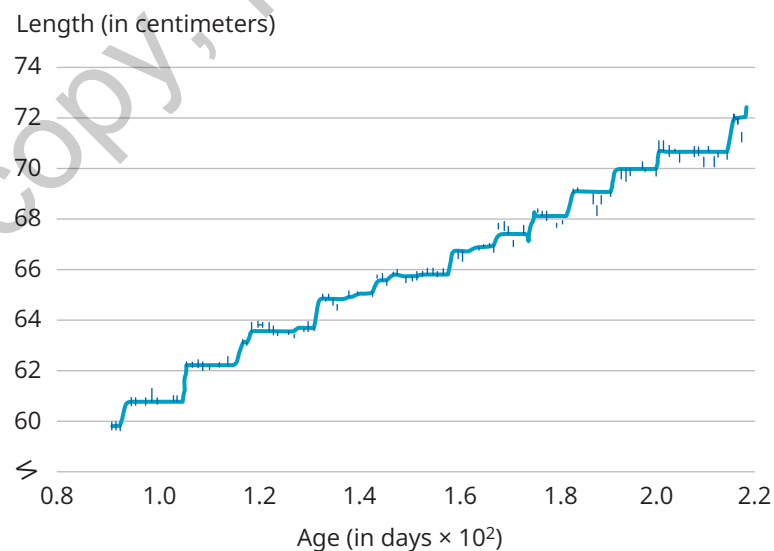
It was once believed that development was either continuous or discontinuous, but not both. Today, scientists agree that people show both types of change (Bornstein et al., 2017). Whether a particular developmental change appears continuous or discontinuous depends partly on our point of view. Consider physical growth. We often think of height increases as 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 daily, they found that on some days, infants showed rapid height growth, while on other days, infants’ height did not change, suggesting a pattern of discontinuous change (Lampl et al., 1992). In this example, monthly measurements of infant height suggest gradual increases, but daily measurements show growth spurts, each lasting 24 hours or less. Thus, whether a given phenomenon, such as height, is described as continuous

Figure 1.2 ■ Continuous and Discontinuous Change

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 1.3 ■ Infant Growth: A Continuous or Discontinuous Process?

Infants' 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 stasis: A model of human growth. *Science*, 258, 801–803.

The Active Child: Do Children Influence Their Own Development?

Children are influenced by the physical and social contexts in which they live, but they also interact with and change those contexts, thereby influencing their own development (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, simply smiling, 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, children actively shape their own development. Children’s emerging physical, cognitive, and socioemotional abilities influence how they view and interact with others—and how others interact with them.

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



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

iStock/Taras Grebinets

Developmental Cascades: Active Exploration

Children actively explore the world, and the nature of this exploration reflects cascading interactions among their growing physical, cognitive, and social capacities. As young children develop leg strength, balance, and coordination, they can run more smoothly, climb, and jump—and they become more confident in exploring their world. This newfound confidence encourages them to engage more actively with their environment, such as climbing playground structures and playing games like tag with other children. Soon, their social interactions include sharing, taking turns, and solving conflicts during play. These social interactions also influence children’s cognitive skills: They learn to communicate, plan, and problem solve. Physical development, such as coordinated running, enables children to interact with others and their environment in new ways, influencing social development—like forming friendships—and cognitive development, such as understanding rules and solving problems.

Individual Differences: Is There One Developmental Path or Many?

When does crawling begin? When do toddlers say their first words? When does self-esteem emerge? How does emotional control develop? What is typical behavior for a given age? Scientists who study questions about development obtain information about group averages, which is when most children acquire particular abilities. The research findings discussed throughout this book are based on studies that report averages on the typical child. However, there is no typical child. Children vary in their developmental paths, with some closely following the group average while others take a markedly different course. Individual differences occur in the onset of developmental phenomena, the course of change, and the ultimate abilities acquired.

Developmental scientists study these averages while recognizing that each child's path is unique. There are many developmental paths, and scientists seek to understand these individual differences and how children vary in their development. Individuals differ in the ages at which developmental changes occur, the rates of change, and their eventual abilities. Scientists also seek to understand the factors that influence these individual differences, including genetics, environmental contexts, interactions among biological and genetic factors, and epigenetics. Children also play an active role in their development, carving a unique developmental path through interactions with people and contexts.

Thinking in Context 1.2

1. Consider your traits and abilities. Which might be influenced by nature or biology? Nurture or environment? Give an example of a trait or ability that might be influenced by both nature and nurture.
2. Can you identify ways your physical, cognitive, or socioemotional abilities have changed gradually over the years? Were there other times you showed abrupt change, such as in physical growth, strength, and coordination; thinking abilities; or social skills? In other words, in what ways is your development continuous and discontinuous?
3. Give an example of your active role in your development. Identify how your childhood traits and actions may have influenced others and your environment and, in turn, how they influenced you.

Classic Theories: Psychoanalytic and Behaviorist Theories

1.3 Differentiate between two psychoanalytic and two behaviorist theories.

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** organizes a set of observations or facts into a comprehensive explanation of how something works. Theories are essential 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 (P. H. Miller, 2022).

An effective theory generates a specific **hypothesis**, or proposed explanation for a given phenomenon, that research can test, as described later in this chapter. A good theory is *falsifiable*, meaning it can generate testable hypotheses. As scientists conduct research and learn more about a topic, they modify their theories, test new hypotheses derived from those theories, and continue this process. Early understandings of development relied on two sets of theories, popular in the early to mid-1900s, with radically different views about the nature of human development and behavior.

Psychoanalytic Theories

Psychoanalytic theories describe human development and behavior as driven by powerful inner forces beyond our conscious control. Freud and Erikson are two key psychoanalytic theorists whose theories remain influential today.

Freud's Psychosexual Theory

A Viennese physician, Sigmund Freud (1856–1939), is credited as the father of the psychoanalytic perspective. Freud argued 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 explained that the task for parents is to strike a balance between overgratifying and undergratifying a child's desires at each stage to help the child develop a healthy personality with the capacity for mature relationships throughout life. He believed that the resolution of each stage and, ultimately, the adult personality is based on how parents gratify children's needs.

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. Suppose caregivers are too demanding, pushing the child before they are ready, or too lax. In that case, 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 abilities and doubt themselves.

(Continued)

Table 1.1 ■ Psychoanalytic Theories of Development (*Continued*)

Approximate Age	Freud's Psychosexual Theory		Erikson's Psychosocial Theory	
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 toward 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 unconscious 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.
6 years to puberty	Latency	This is not a stage but a calm time 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 experiencing 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.

Approximate Age	Freud's Psychosexual Theory		Erikson's Psychosocial Theory	
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 they feel despair over goals never reached and fear death.

Notably, Freud's theory grew from his work with female psychotherapy patients; he did not study children (Crain, 2016). In part because of its heavy emphasis on childhood sexuality, Freud's psychosexual stage framework is not widely accepted (Westen, 1998). Yet some of Freud's ideas have stood up well to the test of time and have permeated popular culture, such as the notion of unconscious processes of which we are unaware, the importance of early family experience, and the role of emotions in development (Bargh, 2013). However, Freud's theory, including unconscious drives and psychosexual stages, is not falsifiable, meaning that it cannot be tested because its parts cannot be directly observed and tested (P. H. Miller, 2016). How can we study unconscious drives, for instance, when we are unaware of them?

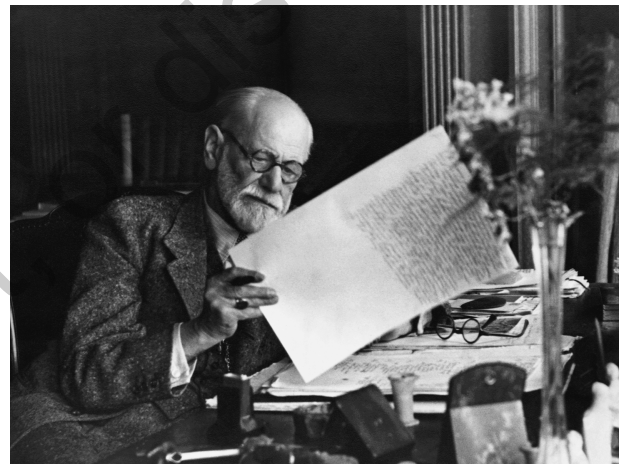
Erikson's Psychosocial Theory

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; see also summary in Table 1.1).

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 of the next development stage. The first developmental task or crisis is for infants to develop a sense of trust in others (vs. mistrust). 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 behavior, and the outcome of each stage influences the following stages.

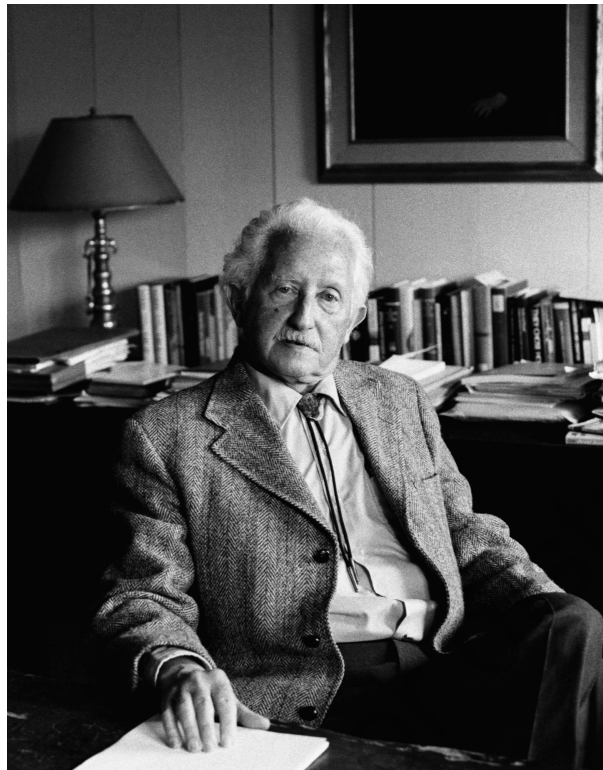
Regardless of their success in resolving a crisis of a given stage, children are driven by maturation and social expectations to the next psychosocial stage. No crisis is ever fully resolved, and unresolved crises are revisited throughout life. Although it is never too late, resolving a crisis from a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

Erikson's psychosocial theory views development as lifelong, 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 (untestable), Erikson's theory includes concepts that cannot be easily measured. Yet it has nonetheless sparked



Sigmund Freud (1856–1939), the father of the psychoanalytic perspective, believed that much of our behavior is driven by impulses that we are unaware of and cannot control.

Bettmann/Getty Images



Erik Erikson (1902–1994) posited that throughout their lifetime, people progress through eight stages of psychosocial development.

Ted Streshinsky Photographic Archive/Corbis Historical/Getty Images

research on specific stages, such as identity development during adolescence (Crain, 2016). We will revisit Erikson's theory throughout this book.

Behaviorist 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. Thoughts and emotions cannot be seen or objectively verified; therefore, behaviorists believe they cannot be studied. Behaviorist theories emphasize the role of the environment in controlling behavior. 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. In this section, we examine classical and operant conditioning, two forms of behaviorist learning, as well as social cognitive theory, a more modern view of learning.

Pavlov's Classical Conditioning

Classical conditioning is a type of learning in which a person or animal forms associations between environmental stimuli and physiological and emotional responses. The Russian physiologist Ivan Pavlov (1849–1936) discovered classical conditioning when he observed that dogs salivate not only when they

taste food but also in response to specific sights and sounds they encounter before eating, like the clattering of their food bowl or their owner opening the food cupboard. To test his observation, Pavlov paired the sound of a tone with the dog's food; the dogs heard the tone and then received food. Soon, the tone alone started to trigger the dogs' salivation.

In classical conditioning, a neutral stimulus, such as the tone in Pavlov's experiment, begins to elicit a response produced initially by another stimulus, in this case, the food. Many fears and other emotional associations are the result of classical conditioning. For example, if a child gets sick after drinking spoiled milk, they might feel queasy when seeing or smelling milk because they associate it with the unpleasant experience of being ill. Conversely, a child may feel excited and even hungry when they hear the ice cream truck's bell because they associate it with a tasty treat.

Classical conditioning only applies to involuntary physiological and emotional responses, yet it is a cornerstone of psychological theory. A second behaviorist theory, operant conditioning, accounts for voluntary 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 who is scolded for writing on a wall with crayons may be less likely to do so. These two examples illustrate the basic tenet of B. F. Skinner's (1904–1990) theory of **operant conditioning**, which holds that behavior becomes 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.

All people and animals—even insects—can learn through operant conditioning. It can explain 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 (Crain, 2016). Controlling children's environments can influence their development, but recall that children play an active role in their development. Children think and act on their own accord. A child can devise new ideas and learn independently without reinforcement or punishment.



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.

Sovfoto/Universal Images Group/Getty Images

Thinking in Context 1.3

1. Suppose you wanted to change your messy roommate's behavior so that they keep their area clean. Would you choose classical or operant conditioning? How would you apply the theory to change their behavior?
2. Reflect on one of Erikson's psychosocial stages you have experienced, and provide a personal example illustrating that stage.

Cognitive Theories

1.4 Compare cognitive-developmental, information processing, sociocultural, and social cognitive theories.

Even the most casual observer of children will note that their thinking changes with age. Developmental scientists agree that infants, children, and adolescents have different cognitive capacities, but they offer varying explanations for these differences. Some view cognition as developing in spurts (discontinuous change), such as cognitive-developmental theory, and others as gradual increases in abilities (continuous change), such as information processing theory.

Piaget's Cognitive-Developmental Theory

Swiss scholar Jean Piaget (1896–1980) was the first to systematically examine infants' and children's thinking. He 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. They are driven to learn by interacting with the world around them, organizing what they learn into **cognitive schemas**. Think of a cognitive schema as a concept, a belief, or something known. Through exploration, such as grasping, touching, and interacting with objects, infants, and children construct and refine their cognitive schemas and their understanding of the world. The earliest schemas are inborn motor responses, such as the reflex response that causes infants to close their fingers around an object when it touches their palm. As infants grow and develop, these early motor schemas are transformed into cognitive schemas, or thoughts and ideas.

At every age, we rely on our schemas to make sense of the world, and our schemas are constantly adapting and developing in response to our experiences. Piaget emphasized the importance of two developmental processes that enable us to cognitively adapt to our world: assimilation and accommodation.

Frequently, we encounter information that is similar to something we already know. We can apply existing learning strategies to learn that information. **Assimilation** involves integrating a new experience into a preexisting cognitive schema. Suppose a child has a cognitive schema for a dog based on their own large dog who has big ears and a long tail. The child encounters a labrador retriever and says, "Dog!" Then they see a German shepherd and say, "Dog!" Finally, they see a mixed-breed dog and say, "Dog!" The child understands that each of these creatures fits their schema or concept of the characteristics that comprise a dog. The child develops an understanding of the new creatures through assimilation by fitting them into their preexisting schema of a dog.

Sometimes, we encounter experiences or information that do not fit within an existing schema, so we must adapt and modify the schema in light of the new information. This process is called **accommodation**. Suppose the child encounters a tiny creature with small ears and a short tail. When told that the creature is a dog, the child must change their schema of a dog or create a new one to incorporate the new information—that dogs can be small. We change our cognitive schemas, ways of thinking, and knowledge through accommodation.

As you read these words, perhaps your knowledge about development (a cognitive schema) has changed after reading these new ideas (accommodation). Maybe you were already familiar with these ideas and instead incorporated this information into your existing framework (assimilation).

The processes of assimilation and accommodation enable people to adapt to their environment, absorbing the constant flux of information they encounter daily (see Figure 1.4). We constantly encounter new information. Some of the information is assimilated into cognitive schemas. Some schemas are accommodated for the new information. Piaget proposed that people are driven to find equilibrium, or a balance between assimilation and accommodation, a process he called **cognitive equilibrium**. When assimilation and accommodation are balanced, people neither incorporate new information into their schemas nor change their schemas in light of new information. They do not need to because their schemas match the outside world and represent it clearly. However, a state of cognitive

equilibrium is rare and fleeting. People frequently experience a mismatch, or **cognitive disequilibrium**, between their schemas and the world.

Figure 1.4 ■ Assimilation vs. Accommodation

Bobby sees a cat that fits his schema for a kitty (left). He has never seen a cat like this before (middle). He must accommodate his schema for a kitty to include a hairless cat (right).



iStock/GlobalP; iStock/YouraPechkin

Disequilibrium leads to cognitive growth because the mismatch between schemas and reality leads to confusion and discomfort. It motivates individuals to modify their cognitive schemas so that their view of the world matches reality. This modification occurs through cognitive equilibration and the coordination of assimilation and accommodation to restore balance. Piaget proposed that children's drive for equilibration and to construct more sophisticated cognitive schemas that match reality propels them through four stages of cognitive development, from infancy through adolescence. As shown in Table 1.2, these stages represent four progressively more sophisticated forms of reasoning: sensorimotor, preoperational, concrete operational, and formal operational reasoning.

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.
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 (Crain, 2016). 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 everyday life. For example, a researcher might give a 5-year-old child a toy maze with a dog, a 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 take in, use, and store 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 (P. H. Miller, 2016). We will examine information processing theory in greater detail throughout this book.

Vygotsky's Sociocultural Theory

We are immersed in a culture that influences how we think and approach the world. Russian scholar Lev Vygotsky (1896–1934) emphasized the importance of culture in development. 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 is transmitted from one generation to the next through social interaction.

Children and adolescents interact with adults and more experienced peers as they talk, play, and work alongside them. Through these formal and informal social contacts, individuals learn about their culture and what it means to belong to it and acquire cultural tools, including a culture's language, which transmits ways of thinking (Daniels, 2017). 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). Children and adolescents adopt their culture's perspectives and practices by participating in cooperative dialogues and receiving guidance from adults and more expert peers, learning to think and behave as group members (Rogoff, 2016). Over time, they can apply these ways of thinking to guide their actions, thus requiring less assistance from adults and peers (Rogoff et al., 2014).

Like Piaget, Vygotsky emphasized that children and adolescents actively participate in their development by engaging with the world around them. However, Vygotsky also viewed development as a social process that relies on interactions with adults, more mature peers, and other members of their culture. Vygotsky's sociocultural theory is an important addition to the field of human development because it is the first theory to emphasize the role of the cultural context in influencing people's development throughout life. Critics of sociocultural theory argue that it overemphasizes the role of context, minimizes the role of individuals in their own development, and undervalues the influence of genetic and biological factors (Crain, 2016). We will revisit Vygotsky's ideas about the roles of culture, language, and thought in Chapter 8.

Bandura's Social Cognitive Theory

Like behaviorist theorists, Albert Bandura (1925–2021) viewed the environment as a vital influence on behavior. Bandura also argued 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 development as the result of interactions among individuals' physical and social environment, their cognition and personal characteristics, and behavior, a concept he called **reciprocal determinism** (Figure 1.5). Essentially, individuals and the environment interact and influence each other over time (Bandura, 2011, 2018).

Bandura argued that children's thoughts and characteristics determine their behavior and the environments they seek. Children who are athletically inclined (a 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 will discuss throughout this book.

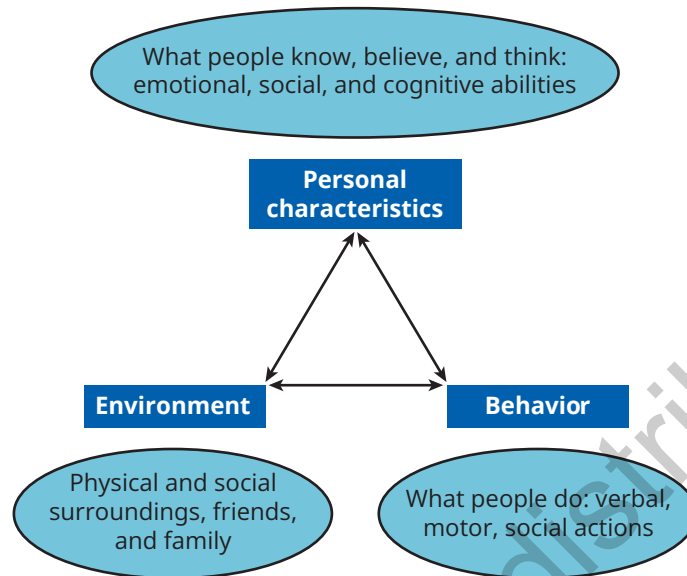
One of Bandura's most enduring ideas about development is that children learn by observing and imitating others, which he referred to as **observational learning** (Bandura, 2012). Our observations influence our beliefs about a given behavior, which influence our future behavior. Children do not need to experience punishment or reinforcement to change their behavior (Bandura, 2012). They can learn by observing others and the consequences of their behavior and thinking about those consequences. 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 of learning.



Lev Vygotsky's (1896–1934) sociocultural theory examines how cultural tools, such as language, are transmitted from one generation to the next through social interaction.

Heritage Images/Hulton Archive/Getty Images

Figure 1.5 ■ Bandura's Model of Reciprocal Determinism



Thinking in Context 1.4

1. A common criticism of cognitive theories is that they only look at the mind, ignoring the environment as well as other types of development, such as physical and socioemotional. Do you believe this is true? Examine each of the four theories: Is there a role for the environment? Are other types of development addressed? Consider:
 - Piaget's cognitive developmental theory
 - Vygotsky's sociocultural theory
 - Information processing theory
 - Social learning theory
2. Which theory, in your view, best accounts for the individual, the environment, and other aspects of development? Why?

Biological and Systems Theories: Evolutionary Developmental, Bioecological, and Dynamic Systems Theories

1.5 Examine evolutionary developmental, bioecological, and dynamic systems theories.

Many theories examine a specific aspect of development, such as cognition, the sense of self, and environmental determinants of behavior. Other developmental theories take a broader approach. Ethology and evolutionary developmental theories emphasize the biological and evolutionary roots of development. In contrast, systems theories emphasize the role of context in development. We examine each of these perspectives next.

Ethology and Evolutionary Developmental Theory

What motivates parents of most species to care for their young? Some researchers argue 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. Specifically, traits that enable a species to adapt, thrive, and mate tend to be passed to succeeding generations because they improve the likelihood of the individual's and species' survival.

Several early theorists applied the concepts of evolution to behavior. Konrad Lorenz and Niko Tinbergen, two European zoologists, observed animal species in their natural environments and noticed patterns of behavior that appeared to be inborn. They emerged early in life and ensured the animals' survival. For example, shortly after birth, goslings imprint to their mother, meaning they bond to and follow her. Imprinting aids the goslings' survival by ensuring 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 with survival value and promoting 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 they will be safe and cared for. Such behaviors have adaptive significance because they meet infants' needs and form bonds with caregivers who 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 your abilities, personality, and competencies result from your genes or 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).

According to evolutionary developmental theory, genetic factors 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 (Bjorklund, 2018a; Witherington & Lickliter, 2016). Children are viewed 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. 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.

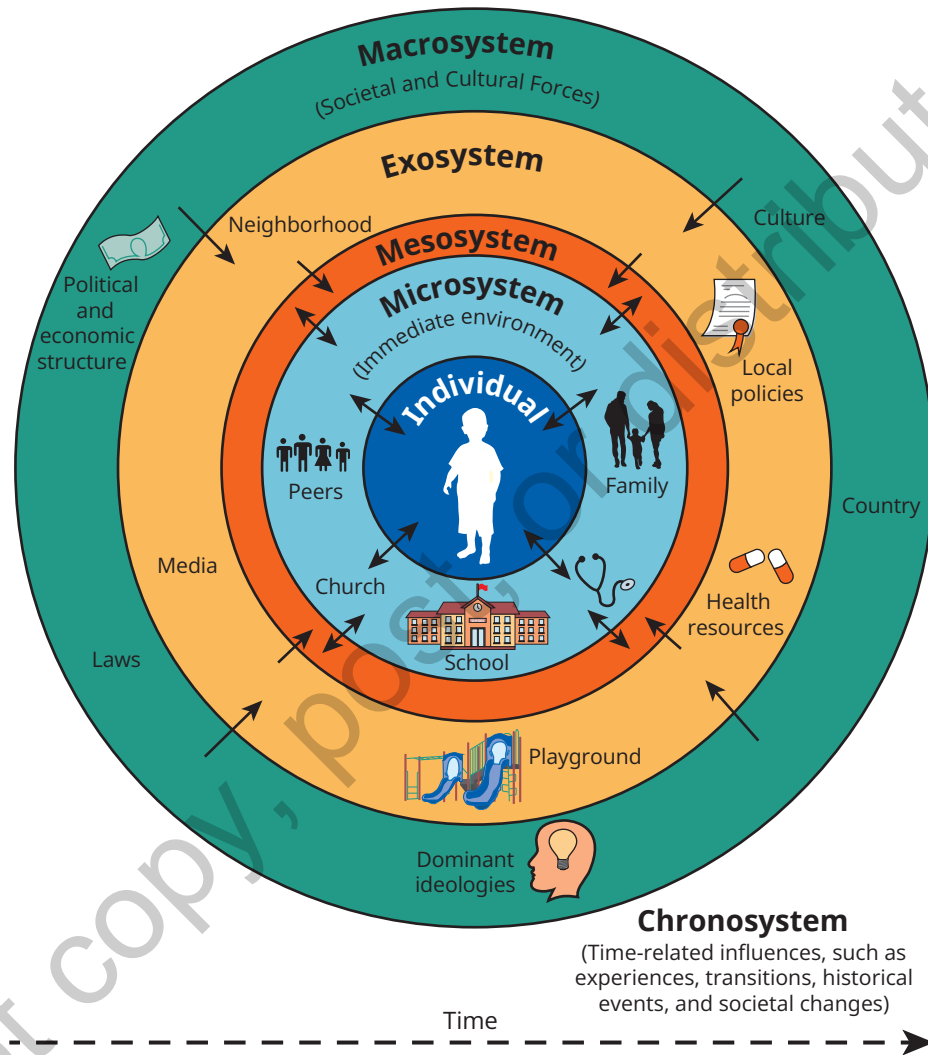
Bronfenbrenner's Bioecological Systems Theory

Systems theories examine development through a broad lens, 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 interconnected interacting parts that work together as a network. We are composed of multiple interacting systems that make up the physical, cognitive, and socioemotional developments we have discussed. We are also embedded in systems, or contexts, with which we interact. These interactions take place throughout our lives, changing over time. Bronfenbrenner's bioecological theory is the most well-known systems theory in developmental science.

Like other developmental theorists, Urie Bronfenbrenner (1917–2005) believed that children influence their development. He also emphasized the importance of context in development. As shown in Figure 1.6, Bronfenbrenner proposed that all individuals are embedded in and interact with a series of contexts that influence development, including home, school, neighborhood, culture, and society.

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.

Figure 1.6 ■ 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* (pp. 793–828). Wiley.

Ontogenetic Development

At the center of the bioecological system is the individual. **Ontogenetic development** refers to the changes 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 influenced by, but also influences, the many contexts in which we 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 directly influences 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. The exosystem is an important contribution to our understanding of development because it shows us how the effects of outside factors trickle down and indirectly affect individuals.

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 the 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 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 accompanying war, natural disasters, and epidemics, can affect 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.

Lives in Context

Bronfenbrenner's Bioecological Systems Theory and the Effects of the COVID-19 Pandemic on Children and Families

Bronfenbrenner's bioecological systems theory offers a comprehensive framework for analyzing complex problems, like the effects of the COVID-19 pandemic on children's development.

At the microsystem level, the pandemic reshaped children's immediate environments. Remote work and schooling brought families closer, increasing time spent together as well as stress and friction over shared resources such as space and technology (Frankel & Sampige, 2022). For essential workers, long hours away from home elevated family stress and potentially reduced emotional support for children. The shift to remote learning disrupted classroom routines and face-to-face interactions with teachers and peers, affecting children's academic progress, motivation, and social skills. Social distancing also limited in-person friendships, pushing children toward online communication, which may have affected their emotional development and well-being.

At the mesosystem level, the interactions between the child's home and school environments shifted. Increased parent–teacher communication was vital to support remote learning, yet many parents struggled to guide their children's learning while working remotely with limited shared resources such as space, computers, and internet bandwidth (Brigandi et al., 2022). The blurring of home and school boundaries added extra pressure on children and their families.

At the exosystem level, broad economic and community factors indirectly affected children. Economic instability, job losses, and altered parental work schedules increased household stress and reduced access to resources (Egan & Pope, 2022). Limited in-person health care led to gaps in prevention and well-child checkups, with implications for children's health (Henderson et al., 2020). Additionally, the closure of community facilities like parks and social restrictions such as mask mandates reduced opportunities to support physical activity and well-being.

The macrosystem includes cultural values, laws, and societal norms. National public health measures, including school closures, were driven by collective attitudes emphasizing physical safety (Egan & Pope, 2022). The rapid development of vaccines, coupled with intense media scrutiny, fostered an atmosphere of uncertainty and fear, indirectly shaping children's perceptions and emotional responses.

Finally, the chronosystem refers to the influence of time and historical context. The COVID-19 pandemic is a defining historical event that disrupted developmental trajectories, with long-term effects including altered academic paths and shifts in social relationships. A child's age during the pandemic influenced their experience, with younger children missing early school experiences. Older children and adolescents may have missed social opportunities to learn how to develop and sustain friendships, interact with peers in group settings, manage emotions in social interactions, and speak up in a classroom—experiences that promote emotional and social skills. The long-term effects of the pandemic on development are still unfolding.

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; Varum & 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 model's validity. In contrast, proponents of bioecological theory argue that rather than conducting large studies to test all of the model's components at once, smaller studies can examine each component over time (Jaeger, 2016; Tudge, Merçon-Vargas, & Payir, 2022; Tudge, Payir, et al., 2016). In any case, bioecological theory remains an important contribution toward explaining children's development and is a theory we will consider throughout this book.

Thelen's Dynamic Systems Theory

A more recent theory, devised in the 1990s, is the **dynamic systems theory**, proposed by Esther Thelen. Like others, this theory examines the interaction between biological and environmental factors in development. However, dynamic systems theory highlights the individual's active role in shaping their developmental path through interactions with their surroundings.

Dynamic systems theory emphasizes the dynamic interplay among children's maturation, contextual circumstances, support (factors that promote development), and constraints (factors that can hinder

development), along with drive to engage the world (Thelen, 1995, 2000). These elements collectively form an integrated system with constantly changing interactions that drive developmental change and the emergence of new abilities in children.

Dynamic systems theory places children at the center of their development. Each child is unique, with specific goals and environmental circumstances that offer distinct opportunities and constraints for moving, learning, and 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. Children's behavior and development result from their motivation to master their unique environment, capitalizing on opportunities and adapting to constraints. For example, infants' desire to reach objects drives them to crawl, but how they crawl and the time frame 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).

Developed initially to describe infants' motor skills, the theory has been extended to account for children's cognitive and emotional development as well as the nature of development itself over different ages (Adolph, 2020; Perone et al., 2021; Sosnowska et al., 2020). Dynamic systems theory offers a complex view of human development over time. The complex perspective it provides is also a challenge because, like bioecological theory, it is impossible to measure and account for all the interacting influences on development (P. H. Miller, 2022). We explore this theory in Chapter 4.

The various theories we have discussed in this chapter provide a range of explanations for development. Table 1.3 compares the theories on the core issues of development, namely, the degree to which each views (1) the role of biology (nature) and environment (nurture) in development, (2) development as characterized by abrupt (discontinuous) or gradual (continuous) change, (3) individuals as active in their development, and (4) development as taking one or many paths.

Table 1.3 ■ Comparing Theories of Human Development

	Role of biology and environment in development	Is developmental change gradual or abrupt?	Do children influence their development?	Is there one developmental path or many?
Freud's psychosexual theory	<i>Greater emphasis on biology:</i> People are driven by inborn drives, but the extent to which the drives are satisfied influences developmental outcomes.	Abrupt stages	Children are passively driven by inborn instincts and are not active participants in their development.	<i>One path:</i> All people progress through the psychosexual stages.
Erikson's psychosocial theory	<i>Both biology and environment:</i> Biological and social forces propel children through the stages, and social and psychosocial influences determine the outcome of each stage.	Abrupt stages	Children actively interact with their social world to resolve psychosocial tasks.	<i>One path:</i> All people progress through the psychosocial stages; their expression can vary with context and culture.

(Continued)

Table 1.3 ■ Comparing Theories of Human Development (*Continued*)

	Role of biology and environment in development	Is developmental change gradual or abrupt?	Do children influence their development?	Is there one developmental path or many?
Behaviorist theory	<i>Environment:</i> Environmental influences shape behavior.	Gradual process of learning new behaviors	Children are passively shaped and molded by their environment.	<i>Many paths:</i> Although learning processes are universal, the content learned varies with context.
Bandura's social learning theory	<i>Both biology and environment:</i> Inborn characteristics and the physical and social environment influence behavior.	Gradual process of learning new behaviors	<i>Children are active:</i> Children are influenced by the environment but also play an active role in their development through reciprocal determinism.	<i>Many paths:</i> Context-specific reciprocal interactions influence development.
Piaget's cognitive-developmental theory	<i>Both biology and environment:</i> An inborn ability to learn coupled with brain development leads children to interact with the world.	Abrupt stages	Children actively interact with the world to create their own schemas.	<i>One path:</i> All people progress through the cognitive-developmental stages.
Information processing theory	<i>Both biology and environment:</i> Children are born with processing capacities that develop through maturation and environmental influences.	Gradual increase of skills and capacities	Individuals actively attend to, process, and store information.	<i>One path:</i> All people show advances in cognitive abilities.
Vygotsky's sociocultural theory	<i>Both biology and environment:</i> Children learn through interactions with more skilled members of their culture; capacities are influenced by genes, brain development, and maturation.	Gradual increase of skills and capacities.	Children actively interact with members of their culture.	<i>Many paths:</i> Interactions with context and culture influence development.

	Role of biology and environment in development	Is developmental change gradual or abrupt?	Do children influence their development?	Is there one developmental path or many?
Bronfenbrenner's bioecological systems theory	<i>Both biology and environment:</i> Children's inborn and biological characteristics interact with an ever-changing context to influence behavior.	Gradual increase of skills and capacities	Children actively 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.	Many paths: Interactions with context and culture influence development.
Dynamic systems theory	<i>Both biology and environment:</i> Developmental domains, maturation, and environment form an integrated system.	Gradual increase of skills and capacities	Children actively influence their development by goal-driven behavior.	Many paths depending on individuals' goals and contexts
Ethology and evolutionary developmental theory	<i>Both biology and environment:</i> 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.	People gradually grow and change throughout life, but there are sensitive periods in which specific experiences and developments must occur.	Children interact with their physical and social environment.	Many paths depending on interactions between children's genetic predispositions and the environments in which they live

Thinking in Context 1.5

1. Just after delivering a healthy baby girl, Latisha and Devonne are overwhelmed by their intense love for her. Like most new parents, they also worry about their new responsibility. They hope that their baby will develop a strong, secure, and close bond with them. They want their baby to feel loved and to love them.
2. How might an evolutionary developmental theorist explain the bonding between parents and infants? What advice might an evolutionary developmental theorist give to Latisha and Devonne?
3. Considering bioecological systems theory, what microsystem and mesosystem factors influence the parent-child bond? What role might exosystem and macrosystem factors take?

Methods of Collecting Data About Children

1.6 Discuss the scientific method and describe observational, self-report, and physiological methods of collecting information about development.

Developmental scientists create theories, such as those we have discussed, to organize their observations of children's and adolescents' behavior in various settings and circumstances. Theories suggest new hypotheses to test in research studies. In turn, research findings are used to modify theories. Developmental scientists refine their theories about child and adolescent development by conducting multiple studies over time.

The Scientific Method

Developmental scientists employ the **scientific method**, a process of posing and answering questions by making careful and systematic observations, gathering and summarizing information, and drawing 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 the world at large.

This four-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. In this way, scientific research is often a cyclical process.

Methods of Collecting Data

The basic challenge that developmental scientists face in conducting research is determining how to measure their topic of interest. What information is important? How can it be gathered? Scientists use the term *data* to refer to the information they collect. How can we gather data about adolescents? Should we simply talk with them? Watch them as they progress through their days. Hook them up to machines that measure physiological activity such as heart rate or brain waves. Developmental scientists use various methods, summarized in Table 1.4 and discussed next.

Table 1.4 ■ Data Collection Methods

	Advantage	Disadvantage
Observational Measures		
Naturalistic observation	Gather 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.

	Advantage	Disadvantage
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		
Electroencephalogram (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)	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.

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 and colleagues (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 behavior patterns 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 (Kemper-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



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

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

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 playing with another child or completing 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 cataloging 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 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 via videoconferencing.

In an **open-ended interview**, a trained interviewer uses a conversational style encouraging 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 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.

(Piaget, 1929)

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. Instead, they may reflect differences in how the interviewer posed and followed up the questions.

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 actual differences among participants and not merely differences in the manner of interviewing. Evans and colleagues (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? (Evans et al., 2002, p. 49)

After compiling and analyzing the children's responses and 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 names). For instance, the Monitoring the Future study is an annual survey of 50,000 eighth-, tenth-, and twelfth-grade students collecting 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 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, understand questions, and provide responses. It is not until late childhood, and more often adolescence, that questionnaires become feasible data sources.

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—someone who does not cheat on exams. Self-report data 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).

Lives in Context

An Experience Sampling Study of Adolescent Social Media Use and Distraction

As heavy users of social media, adolescents typically receive notifications and messages all day from various apps. Do these constant interruptions affect their ability to focus and concentrate on tasks? Siebers and colleagues (2022) applied the experience sampling method (ESM) to study this issue. The ESM involves “sampling” participants’ experiences by contacting them at varying times throughout the day to learn about what they are doing and feeling at a particular moment. In this study the researchers examined adolescents’ use of social media and feelings of distraction throughout the day. They asked: Are adolescents who use more social media than their peers more distracted? Do moment-to-moment changes in social media activity affect distraction?

In their study, 383 students (average age 14) received six notifications per day for 21 days. Each notification prompted a brief survey asking them to report the number of minutes they spent on their preferred social media apps in the past hour and to rate how distracted they felt during that time.

The findings were revealing. On average, adolescents who spent more time on social media over the 3-week period reported higher overall levels of distraction compared to their peers. Adolescents experienced more distraction during hours when they used more social media, regardless of the time or day.

Importantly, there was considerable individual variation. While most (83%) adolescents experienced increased distraction with higher social media use, 16% showed no change, and about 2% reported *less* distraction with increased use. In addition, high social media use was linked to increased distraction even 2 hours later, suggesting that social media engagement might have a lingering effect on attention and a prolonged period of difficulty in regaining focus. When adolescents become preoccupied with social media, it may disrupt their ability to concentrate and may trigger a stronger tendency to check their devices repeatedly—creating a self-perpetuating cycle of distraction.

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 researchers might measure. 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 & Wetzels, 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 bloodstream to monitor the flow of blood (Gellman, 2020). Because blood flows more readily to active brain areas, 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 brain areas 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-Piedrafito, 2018). DTI gauges the thickness and density of the brain's connections, permitting researchers to measure the brain's white matter and determine changes 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.

Thinking in Context 1.6

Suppose Lua wanted to study aggressive behavior in preschoolers.

1. How might she apply natural observation and structured observation? What are the advantages and disadvantages of each approach?
2. How might she use self-report measures from children, parents, or teachers to learn about aggressive behavior in children?
3. Can you identify a physiological measure that can be used to understand aggression in preschoolers?

Research Designs

1.7 Compare correlational, experimental, and developmental 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.

Table 1.5 ■ Comparing Research Designs

Design	Strengths	Limitations
Research Designs		

(Continued)

Table 1.5 ■ Comparing Research Designs (Continued)

Design	Strengths	Limitations
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.

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 of 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 shed 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 and colleagues (2017) examined the effect of playing violent video games on children's physiological stress and aggressive thoughts. Children were randomly assigned to play a violent video game (*Superman*) or a nonviolent video game (*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 video game. 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 video games showed higher levels of physiological stress and aggressive thoughts than did the children who played nonviolent video games. They concluded that the type of video game 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 video game). The independent variable is manipulated or varied systematically by the researcher during the experiment (a child plays with a violent or a nonviolent video game). Specifically, this manipulation is administered to one or more *experimental groups*, or test groups (children who are asked to play a violent video game). 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 video game). 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.



Do video games cause aggression? Only an experiment can address this question.

Shannon Fagan/The Image Bank/Getty Images

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.

Career: Transferrable Skills and Careers

Transferrable skills are those abilities that can easily “transfer” or move with you across different careers and settings. Employers in all fields highly value five skills: problem solving, analytical and quantitative abilities, teamwork, communication, and a strong work ethic (Gray & Koncz, 2025). Students often develop these skills without realizing it. Consider problem-solving and analytical skills—the skills employed when carrying out the scientific method. Effective problem solvers gather and synthesize information from various sources, analyze issues and evaluate evidence, and generate creative solutions—skills that students naturally build in college. Group discussions and projects are also more than just academic exercises; they are opportunities to enhance teamwork skills, which are essential in today's collaborative work environments. Communication skills are honed with every paper, homework assignment, and email you write. Ultimately, these transferable skills make you more versatile, adaptable, and collaborative, no matter where your career takes you.

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 the first, third, and fifth grades. 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. As you may recall, 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 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

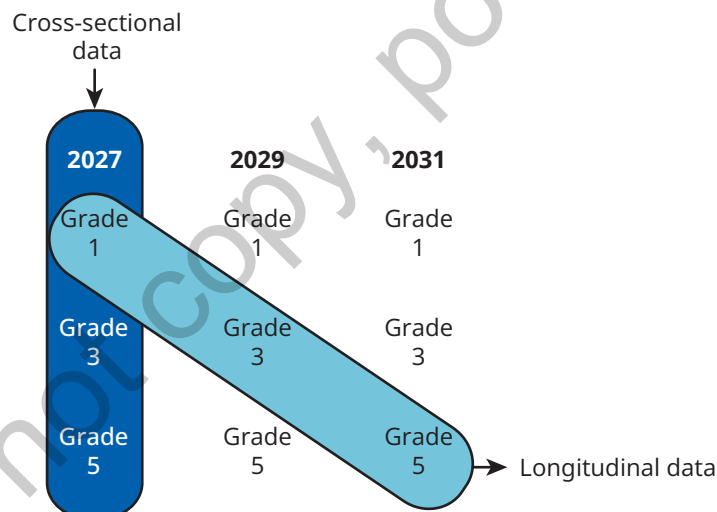
can describe how they change and the circumstances that surround their development. We can witness development unfolding. Returning to the previous example, a developmental scientist using longitudinal research would measure children's vocabulary size in first grade, then follow up two years later in third grade, and then two 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 (Figure 1.7). 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 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 grade and have aged out of the study, a new group of first-grade children are introduced to the study, and so on.

Figure 1.7 ■ Developmental Designs



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

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 capture 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 each 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.

Thinking in Context 1.7

Maura believes that children who are physically active do better at school. How can she test her hypothesis?

1. How might she conduct a correlational study?
2. Suppose she wanted to examine whether physical activity *causes* children to perform well academically. What kind of design should she use? What might the study look like?
3. What if Maura wanted to know whether physical activity changes with age? What method might she use to determine whether older children get more physical activity than younger children? What are some advantages and disadvantages of this method? Identify alternatives, if any.

Applied Developmental Science, Ethics, and Intersectionality

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

Many developmental scientists apply their research to help children, adolescents, and families. **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, (4) and respect participants' autonomy (American Psychological Association, 2017).

Help and Not Harm Participants

Researchers must protect and help the children, families, and communities in their work. They must maximize the benefits for participants and minimize the potential harm of their research. Above all, research participation must never pose threats to children or families beyond those they might encounter

in everyday life. Researchers are also responsible for aiding individuals by, for example, 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 people's autonomy also means protecting minors and others incapable 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 (Cayouette et al., 2022; Tait & Geisser, 2017; Weisleder, 2020).

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). 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, their cognitive and social development increases, and they can better understand the nature of science and engage meaningfully in decisions about research participation. Moreover, seeking assent has the benefit of helping children learn how to make decisions and participate in decision making within safe contexts (Neelakantan et al., 2023; Weisleder, 2020).

Career: Developmental Psychologist

Developmental psychologists examine children, adolescents, and adults to understand how their behavior—including physical, cognitive, and socioemotional functioning—changes over time.

They conduct research on topics such as memory, thinking, aggression, emotional regulation, and attachment. Some also design and evaluate programs in hospitals, social service agencies, mental health clinics, and schools. For example, a developmental psychologist might assess the effectiveness of a parenting education program on caregiver–child interactions. Becoming a developmental psychologist requires attending graduate school and earning a doctoral degree, typically 4 to 5 years after the bachelor's degree.

Intersectionality and Development

Children's interactions in their contexts (home, school, neighborhood, and so on)—and the meaning they derive from these experiences—vary with their membership in social categories, such as gender, race, and ethnicity. Increasingly, developmental scientists recognize that children's experiences, perspectives, and developmental paths are shaped by **intersectionality**—the complex interplay of identities related to gender, race and ethnicity, sexual orientation, and social factors such as socioeconomic status and disabilities (Crenshaw, 1989).

We are all members of multiple interconnected social categories, and our experience of each category is influenced by our membership in others. Children's understanding of gender may be filtered through the lens of another social category, such as ethnicity. Their experiences as members of an ethnic group are intertwined with their gender. For example, Latina girls' views of themselves and their worlds may differ considerably from those of Latino boys, as well as from those of girls from other ethnic backgrounds, such as Black or Native American girls. In this instance, ethnicity and gender intersect to affect how girls view themselves. Most individuals belong to several social categories beyond ethnicity and gender, and these interact to shape their perceptions. Moreover, the importance and meaning of these social categories vary with context, with some becoming more salient and meaningful at specific times and in certain environments—creating distinct experiences for subgroup members with developmental implications (Ghavami et al., 2016; Mathews et al., 2020; Stein et al., 2023).

Intersectionality emphasizes a contextual approach to understanding how perceptions, stereotypes, and discrimination regarding gender, ethnicity, race, sexual orientation, and socioeconomic status overlap and interlock, creating distinct experiences for subgroup members with implications for their development (Crenshaw, 1989; Syed & Ajayi, 2018). For instance, intersecting expectations about race and gender may uniquely shape the classroom experiences of Black boys, affecting how they are perceived and treated in ways that differ from boys of other races and ethnicities and from Black girls—ultimately influencing 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, or coasts.

In the past, research studies have often excluded people of color or grouped participants of different ethnicities and races together, masking differences and contributing to a sense of invisibility among people of color (Syed et al., 2018). For example, an analysis of articles published in leading developmental science journals between 2006 and 2010 found that only 14% of the studies included samples predominantly composed of people of color, while a surprisingly high 28% did not mention the ethnic-racial composition at all (Nielsen et al., 2017).

Intersectional research, rooted in Black feminism, has traditionally focused on examining privilege and oppression among individuals identifying as Black and White. This work has shed light on how structural inequalities limit opportunities for Black youth in areas such as education, employment, and community participation. More recently, there has been an increasing call from Latino, Indigenous, and Asian-origin scholars and activists to address the experiences of other cultural and ethnic-racial communities that have a long history of oppression and discrimination in the United States and elsewhere (Azmitia et al., 2023; White et al., 2023; Yip et al., 2023). Multiracial youth, who must integrate multiple ethnic identities, remain understudied despite their growing numbers—expected to exceed 11% of the U.S. population by 2060 (Nishina & Witkow, 2020). Moreover, the scope

of intersectionality has expanded to include religious identities, sexual identities, and body image, in addition to gender and race (Ahmed & Abdallah, 2023; Coulter et al., 2021; Morrison et al., 2020).

The study of intersectionality examines how discrimination, marginalization, oppression, and privilege combine to shape the experiences of children, adolescents, and families in distinct ways (Crenshaw, 1989). It is an emerging approach in developmental science with a growing body of research that recognizes how factors like gender, ethnicity and race, sexual orientation, religion, socioeconomic status, and disability interact to influence development (Godfrey & Burson, 2018). Throughout this book, we will examine development through an intersectional lens whenever possible.

Thinking in Context 1.8

1. Suppose, as part of your research, you wanted to interview children in first and seventh grades. What ethical principles are most relevant to your work in studying schoolchildren? 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 sniffing. 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 is 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 occurs.

Development begins at conception and progresses through the prenatal period, 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 within a variety of contexts in which the developing person interacts, such as home, school, and peer group, which are embedded in broader sociohistorical and cultural contexts.

1.2 Discuss four core concepts in developmental science.

Developmental scientists examine four 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? Third, in what ways is developmental change continuous, characterized by slow and gradual change, or discontinuous, characterized by sudden and abrupt change? Finally, does development follow one path, or are there many paths? Most developmental scientists agree that development reflects the interplay of nature and nurture; children influence their own development; some aspects of development appear continuous, while others appear discontinuous; and development follows multiple paths.

1.3 Differentiate between two psychoanalytic and two behaviorist theories.

Psychoanalytic theories describe human development and behavior as being driven by powerful inner forces that are beyond our awareness and conscious control. They 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. Scientists who study behaviorism examine only observable behavior. Behaviorist theories, such as classical and operant conditioning, emphasize the role of the environment in controlling behavior.

1.4 Compare cognitive-developmental, information processing, sociocultural, and social cognitive theories.

Cognitive theories examine how children's thinking changes with development. According to Piaget's cognitive-developmental theory, our cognitive schemes evolve through the processes of assimilation, accommodation, and equilibration. Cognitive development is an active process that proceeds through four stages. Information processing theorists study the processes involved in cognition, including perceiving and attending, representing, encoding, retrieving, and problem solving. Vygotsky's socio-cultural theory examines the importance of culture and context in cognition. Children learn through social interactions and guidance from more mature thinkers. Bandura's social cognitive theory explains

development as the result of reciprocal determinism, which involves interactions among individuals' physical and social environments, their cognition and personal characteristics, and behavior, as well as observational learning.

1.5 Examine evolutionary developmental, bioecological, and dynamic systems theories.

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.

1.6 Discuss the scientific method and describe observational, self-report, and physiological methods of collecting information about development.

The scientific method is an organized process of posing and answering questions by making careful and systematic observations, gathering and summarizing information, and drawing conclusions. Observational measures collect information by watching and monitoring people's behavior. Naturalistic observation occurs in everyday settings, while structured observation takes place in controlled environments, which are constructed by the experimenter. Interviews and questionnaires are known as self-report measures because participants, such as children and their parents, answer questions about their experiences, attitudes, opinions, beliefs, and behaviors. In open-ended interviews, a trained interviewer employs a conversational style, encouraging children to elaborate on their responses. A structured interview poses the same set of questions in the same order to each child. Questionnaires or surveys enable scientists to collect information from many people quickly, inexpensively, and anonymously. Physiological measures use technology to measure biological functions such as heart rate, brain waves, and blood pressure.

1.7 Compare correlational, experimental, and developmental research designs.

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 over multiple time points. Sequential research combines the best features of cross-sectional and longitudinal designs by assessing multiple cohorts over time.

1.8 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 between individuals and their contexts, applying these findings to prevent and intervene in problems and promote positive development in people of all ages. Ethical research involves helping and not harming participants, taking responsibility to ensure that others understand their role and the scope of their research findings, being honest and fair to participants, debriefing them, and ensuring that risks and benefits are distributed justly. Developmental scientists 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. By recognizing children's diverse experiences, developmental scientists are better equipped to identify and address disparities in power, privilege, and opportunity, promoting positive development in all children.

Key Terms

accommodation	experiment
applied developmental science	functional magnetic resonance imaging (fMRI)
assimilation	hypothesis
autonomy	independent variable
behaviorism	information processing theory
bioecological systems theory	informed consent
case study	intersectionality
child assent	justice
chronosystem	longitudinal research study
classical conditioning	macrosystem
cognitive disequilibrium	mesosystem
cognitive equilibrium	microsystem
cognitive schemas	naturalistic observation
cognitive-developmental theory	nature–nurture debate
cohort	observational learning
computerized tomography (CT)	ontogenetic development
context	open-ended interview
continuous change	operant conditioning
correlational research	positron emission tomography (PET)
cross-sectional research study	psychoanalytic theories
culture	punishment
debriefing	questionnaires
dependent variable	random assignment
development	reciprocal determinism
developmental cascades	reinforcement
developmental domains	scientific method
developmental science	sequential research
diffusion tensor imaging (DTI)	social cognitive theory
discontinuous change	social policy
dynamic systems theory	sociocultural theory
electroencephalography (EEG)	sociohistorical context
ethology	structured interview
evolutionary developmental theory	structured observation
exosystem	theory

Chapter 2

Biological and Environmental Foundations of Development



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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** Identify reproductive technologies available to individuals and couples.
- 2.4** Describe methods of prenatal testing.
- 2.5** Examine the interactions between heredity and environment, including behavioral 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 to 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 made up of trillions of cells that form all of our tissues and organs. At the center of each cell is a nucleus containing 23 matching pairs of rod-shaped structures called **chromosomes** (Padiath, 2025). Each chromosome contains the basic units of heredity, known as **genes**. Genes are stretches of **deoxyribonucleic acid (DNA)**, a complex molecule that resembles a twisted ladder or staircase. Genes carry instructions for building all the traits found in organisms. In humans, the complete set of genes, known as the genome, is made up of about 20,000 to 25,000 genes (Taneri et al., 2020). The study of genes is known as **genetics**.

Much of our genetic material is shared with other species. Although each species has its own unique genome, we share some genes with all living organisms, from bacteria to primates. In fact, we share nearly 99% of our DNA with chimpanzees, our closest genetic relatives. There is even less variation among humans; people across the globe share about 99.9% of their genes (Lewis, 2024). While we all have the same basic set of genes, the slight differences in our genetic code make each person unique.

Cell Reproduction

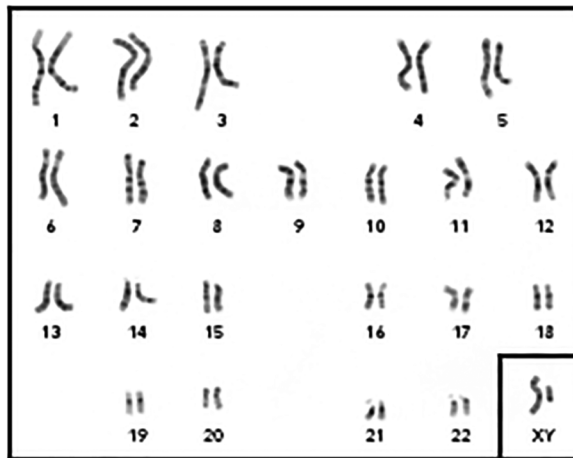
Cell reproduction in humans occurs through two processes: mitosis and meiosis. Most cells in the human body reproduce through **mitosis**, a process in which the cell's DNA and chromosomes are duplicated, resulting in new cells that are identical to the original (Sadler, 2023). In contrast, **gametes**, which are specialized sex cells for reproduction, are produced through a process known as **meiosis**. During meiosis, the 46 chromosomes duplicate and undergo a process called *crossing over*. This means that the paired chromosomes swap pieces of DNA, creating new, unique combinations of genes (Padiath, 2025). The resulting gametes (sperm in males and ova in females) each have 23 unpaired chromosomes, giving every gamete its own unique genetic profile; it's estimated that an individual can produce millions of genetically distinct gametes (Brooker, 2022). When an ovum and sperm join during fertilization, they form a **zygote** with 46 chromosomes, 23 from the biological mother and 23 from the biological father.

Sex Determination

A single pair of chromosomes, known as sex chromosomes, determines whether a zygote develops into a male or female. Out of the 23 pairs of inherited chromosomes, 22 are matched pairs that carry similar genes in nearly the same positions. (Figure 2.1). The 23rd pair of chromosomes is different because they are sex chromosomes that specify our genetic sex. Females have two large X-shaped chromosomes (XX), and males have one X-shaped chromosome and one much smaller Y-shaped chromosome (XY).

Because females have two X sex chromosomes, all their ova contain one X sex chromosome. In contrast, a male's sperm carries either an X or a Y chromosome; about half of the sperm carry an X, and half have a Y. The Y chromosome contains genetic instructions for the development of male reproductive

Figure 2.1 • Chromosomes



organs. The genetic sex of the fetus is determined by which type of sperm fertilizes the ovum. Sperm carrying a Y chromosome leads to a genetic male, and sperm bearing an X chromosome leads to a genetic female (Figure 2.2).

Genes Shared by Twins

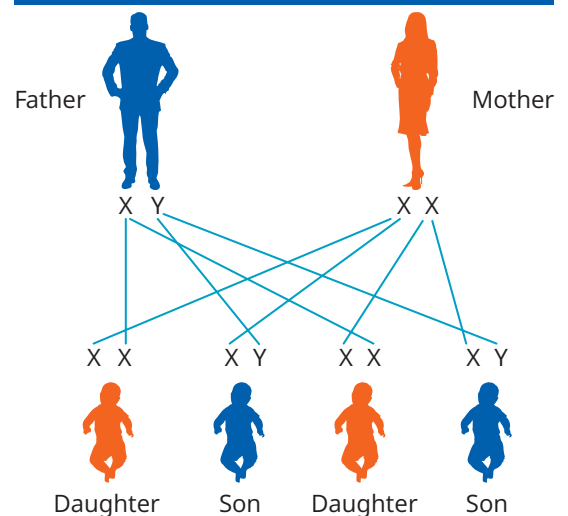
Siblings who share the same biological parents inherit chromosomes from each parent. Despite this genetic similarity, siblings are often quite different from one another. Siblings who share the same womb at the same time are known as twins. About 3% of all births result in twins (Roman et al., 2022).

The majority of naturally conceived twins (over 70%) are **dizygotic (DZ) twins** or fraternal twins. Fraternal twins form when a woman releases more than one ovum during her cycle, and a different sperm fertilizes each ovum (Gill et al., 2022). Like other siblings, DZ twins share about one-half of their genes, and most have different physical features like 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 that there may be a genetic factor influencing a woman's tendency 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. They are also more common in pregnancies that result from in vitro fertilization, where multiple embryos are transferred to the uterus (we discuss in vitro fertilization later in this chapter) (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, such as in vitro fertilization, has become common (Monden et al., 2021). Twinning rates peaked in the United States in 2014 and have declined roughly 2% annually since (Horon & Martin, 2022; Osterman et al., 2023).

Monozygotic (MZ) twins, also known as identical twins, come from a single zygote that splits into two separate but genetically identical cells. The resulting two individuals share the same **genotype** or set of genetic instructions for all physical and psychological traits. MZ twins occur in about 3% of births in the United States (De Paepe, 2022). The reasons for a zygote splitting to create MZ twins are not well understood (McNamara et al., 2016). MZ twinning is not related to maternal age or the number of previous births; however, in vitro fertilization increases the likelihood of MZ twins (Busnelli et al., 2019; Dallagiovanna et al., 2021).

Figure 2.2 • Sex Determination



Males carry both X and Y chromosomes, while females have 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.

Patterns of Genetic Inheritance

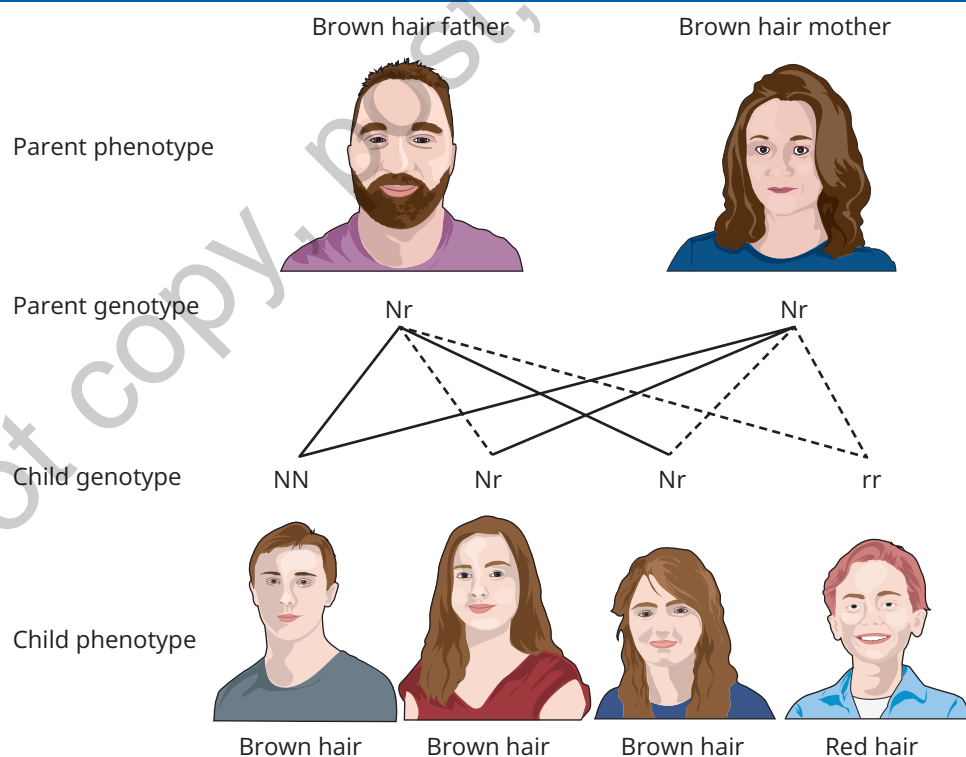
Genes combine in many ways to influence our **phenotype**, which refers to the traits that we display. Inherited phenotypes include eye and hair color, health and propensities for specific diseases and disorders, and even personality. Traits and characteristics are inherited through several patterns.

Dominant-Recessive Inheritance

Lynn has red hair, but 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, every person inherits 23 pairs of chromosomes—half from the mother and half from the father. Some genes, such as those for non-red hair, are dominant, meaning they are expressed regardless of the gene with which they are paired. Other genes, such as the one for red hair, are *recessive* and are only expressed if the person inherits two copies of the recessive gene.

For instance, suppose two parents each carry one dominant gene for non-red hair (symbolized by N in Figure 2.3) and one recessive gene for red hair (r). Because dominant genes overpower recessive genes, both parents will display non-red hair. When children inherit a dominant non-red hair gene (N), they will show the phenotype for non-red hair regardless of whether they have a second non-red hair gene (N) or a recessive red hair gene (r). However, if a child inherits the recessive gene for red hair from each parent, the recessive trait (rr) will be expressed, and the child will have red hair. That's how Lynn could end up with red hair, even though neither of her parents has it.

Figure 2.3 ■ Dominant-Recessive Inheritance



Several characteristics are passed through dominant-recessive inheritance (Table 2.1).

Table 2.1 • Dominant and Recessive Characteristics

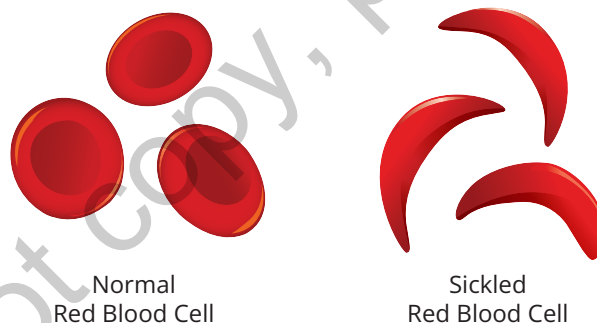
Dominant Trait	Recessive Trait
Dark hair	Light hair
Curly hair	Straight hair
Hair	Baldness
Freckles	No freckles
Widow's peak hairline	Straight hair line
Facial dimples	No dimples
Brown eyes	Blue, green, hazel eyes

McKusick-Nathans Institute of Genetic Medicine, 2020

Incomplete Dominance

In many cases, explaining genetic inheritance solely in terms of dominant and recessive traits oversimplifies the process of how traits are passed on. In **incomplete dominance**, both versions of a gene jointly influence the characteristic (Lakhani et al., 2023). For example, consider blood type. The genes for blood types A and B do not override 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 override another gene. In this case, some, but not all, characteristics of the recessive gene appear. For example, the gene that causes **sickle cell anemia** is recessive. Individuals who inherit two copies of these genes develop the disorder, which causes red blood cells to become crescent-shaped or sickle-shaped. Sickle-shaped cells cannot distribute oxygen effectively throughout the body, leading to inflammation and damage in the blood vessels (Ware et al., 2017).



Recessive sickle cell alleles cause red blood cells to become crescent-shaped and unable to distribute oxygen effectively throughout the circulatory system. Alleles for normal blood cells do not mask all the characteristics of recessive sickle cell alleles, illustrating incomplete dominance.

Suriya Siritam/Alamy Stock Photo

People who carry only one copy of the recessive sickle cell gene typically do not develop full-blown sickle cell anemia (Pecker & Lanzkron, 2021). However, the gene for normal blood cells does not completely mask the sickle cell gene. Carriers of the sickle cell trait may function well but may experience some symptoms such as reduced oxygen distribution throughout the body and exhaustion after exercise (Xu & Thein, 2019). About 8% of African Americans carry the recessive sickle cell gene (Sanyaolu et al., 2020). The sickle cell gene is also found in Latino populations but is 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 (Padiath, 2025). 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, which is characterized by developmental delays, severe intellectual disability, speech impairment, problems with movement and balance, and hyperactivity, as well as 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 to 30,000 births (Volkmar, 2021).

Polygenic Inheritance

Despite the simple examples used so far, most traits result from the combined effect of many genes, a process known as **polygenic inheritance** (Armstrong-Carter et al., 2021). Hereditary influences are complex, and researchers often cannot trace a characteristic to just one or two genes. Traits like height, intelligence, personality, and susceptibility to certain forms of cancer are polygenic (Flint et al., 2020). As the number of genes that contribute to a trait increases, so does the range of possible phenotypes or outcomes. Genetic predispositions interact with environmental influences to produce a wide range of individual differences in human characteristics. Patterns of gene inheritance are summarized in Table 2.2.

Table 2.2 ■ Summary: Patterns of Genetic Inheritance

Inheritance Pattern	Description
Dominant–recessive inheritance	Dominant genes are always expressed, regardless of the gene with which they are paired. 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 result from the interaction of multiple genes.
Genomic imprinting	The expression of a gene is determined by whether it is inherited from the mother or the father.

Lives in Context

Gene Editing

DNA shapes many of our observable traits, but our genetic code isn't set in stone. Advances in genetic engineering, particularly gene editing using a technology known as CRISPR–Cas9 (often called CRISPR), enable scientists to modify DNA (J. Y. Wang & Doudna, 2023). Gene editing involves adding, deleting, or modifying genetic material at specific locations in the genome (MedLine Plus, n.d.). This technology is widely used in agriculture to improve crop yields, enhance resistance to environmental stressors, and boost nutritional content.

Gene therapy, using tools like CRISPR, has shown promise as treatment for genetic disorders, including some cancers and sickle cell disease (Chehelgerdi et al., 2024; Frangoul et al., 2021; Stein, 2019). Although these applications remain largely experimental and are mostly conducted in research settings, with long-term outcomes still under investigation, recent clinical trials have reported successes (Stein, 2019).

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 the result of genetic inheritance, many disorders and diseases are also inherited. Others result from chromosomal abnormalities. Some hereditary and chromosomal abnormalities can be detected 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 sometimes 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 such as sickle cell anemia, as well as others that are rare.

Dominant–Recessive Disorders

Some genetic conditions follow a dominant–recessive inheritance pattern (Table 2.3). Recall that dominant genes are always expressed, while recessive genes are expressed only when paired with another recessive gene. Severe disorders are rarely passed through dominant inheritance because most affected individuals often do not live long enough to reproduce and pass it to the next generation. One exception is Huntington's disease, a fatal disease in which the central nervous system gradually deteriorates (Ghosh & Tabrizi, 2018; McKusick-Nathans Institute of Genetic Medicine, 2020). Individuals carrying the Huntington's gene typically function normally during 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 on average, about half of their children will inherit the dominant Huntington's gene.

Table 2.3 ■ Conditions Inherited Through Dominant-Recessive Inheritance

Condition	Occurrence	Mode of Inheritance	Description	Treatment
Huntington's 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 to 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 to 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, which leads to organ damage and respiratory infections.	No cure. Blood transfusions, treatment of infections, bone marrow transplant. 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.

McKusick-Nathans Institute of Genetic Medicine, 2020

Phenylketonuria (PKU) is a common recessive disorder in which the body cannot produce the enzyme needed to break down phenylalanine, an amino acid found in proteins (McKusick-Nathans Institute of Genetic Medicine, 2020). Without treatment, phenylalanine builds up quickly to toxic levels that damage the central nervous system, leading to intellectual disability by 1 year of age. Because of this risk, all newborns in the United States and Canada are screened for PKU (Camp et al., 2014).

PKU illustrates how genes interact with the environment to influence developmental outcomes. The intellectual disability associated with PKU results from both a genetic predisposition and exposure to high levels of phenylalanine in the diet (Blau, 2016). Infants diagnosed with PKU are placed on a diet low in phenylalanine, though it is difficult to eliminate this amino acid entirely from the diet. When children with PKU adhere to a strict diet, they typically score in the average range on measures of intelligence, although often lower than their peers without PKU (Elhawary et al., 2022; Hofman et al., 2018). Some cognitive and psychological issues 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).



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 PKU 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 involves the sex chromosomes, the genes located on the 23rd pair of chromosomes (Shah et al., 2017). Some recessive genetic disorders, like red–green colorblindness, are linked to the X chromosome (Table 2.4). Recall that females have two X chromosomes; a recessive gene located on one X chromosome will be masked by a dominant gene on the second X chromosome. But males carry one X chromosome paired with a Y chromosome, so any recessive genes on the X chromosome will be expressed. Females are thereby less likely to show 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.

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 hyperextensible joints, especially fingers	No cure
Hemophilia	1 in 3,000 to 7,000 males	Blood disorder in which the blood does not clot	Blood transfusions

McKusick-Nathans Institute of Genetic Medicine, 2020

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 needs to 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). Individuals

with fragile X may also experience cardiac abnormalities and display behaviors like poor eye contact and repetitive actions (e.g., hand flapping, hand biting, mimicking others), which are common in autism spectrum disorders (Salcedo-Arellano et al., 2020). Fragile X syndrome is often codiagnosed with autism; about 40% to 60% of boys and 16% to 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 a 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 carry the gene to counterbalance it. Females typically do not show the disorder unless they inherit the hemophilia gene from both parents, since the dominant gene on their second X chromosome promotes normal blood clotting (d'Oiron, 2019). This means that females can be carriers of hemophilia without exhibiting the disorder themselves.

Chromosomal Abnormalities

Not all inborn disorders are solely caused by inherited genes. Some conditions are caused by chromosomal abnormalities, errors during cell reproduction, meiosis or mitosis, or damage incurred afterward.

Down Syndrome

Down syndrome, also known as trisomy 21, occurs in about 1 out of every 1,500 births (Akhtar & Bokhari, 2024). It occurs when an extra copy of the 21st chromosome is present. Down syndrome is characterized by distinct physical features, including a short, stocky build; a round face; almond-shaped eyes; and a flattened nose, as well as associated health and cognitive challenges. Children with Down syndrome often experience delays in physical and motor development compared to other children and may experience health problems, such as congenital heart abnormalities, vision and hearing impairments, and immune system deficiencies (Antonarakis et al., 2020; Bull, 2020).

Down syndrome is the most common genetic cause of intellectual disability, although children with this condition show a wide range of abilities (Santoro et al., 2021). Generally, children with Down syndrome tend to show greater nonverbal learning and memory skills than verbal skills. They can typically understand more than they can express. Infants and children who participate in early intervention and receive sensitive caregiving and encouragement to explore their environment show positive outcomes, especially in their motor, social, and emotional development (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 in the 1980s (National Association for Down Syndrome, 2024). Many individuals live into their 70s and 80s. However, Down syndrome is associated with premature aging and a faster decline in cognitive functioning (Hithersay et al., 2017). People with Down syndrome are more likely than other adults to show signs of Alzheimer's disease (a form of dementia) very early (Fortea et al., 2021; Tramutola et al., 2020). This is an example of how multiple genes and complex contextual interactions can influence disorders and illnesses; 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 can arise from either a missing sex chromosome or an extra one. Because males and females have different patterns of sex chromosomes, sex chromosome abnormalities affect them differently (Table 2.5).

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, and 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	Jacobs Syndrome	High levels of testosterone. Because many cases go undiagnosed, little is known.	Unknown

McKusick-Nathans Institute of Genetic Medicine, 2020

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). In severe cases, symptoms can 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 Klinefelter syndrome (Skakkebaek 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 seen in men is XYY syndrome, or **Jacobs syndrome**. This condition is associated with high levels of testosterone (McKusick-Nathans Institute of Genetic Medicine, 2020; Pappas et al., 2017). Boys with Jacobs syndrome commonly show tall stature, delayed speech and language development, mild learning difficulties, and behavioral problems (Sood & Fuentes, 2022). Most cases go undiagnosed, and many men are not identified as having the syndrome until they encounter fertility problems (Zhang et al., 2020). As a result, the true prevalence of XYY syndrome remains uncertain.

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 (Freiling 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 can 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).

Mutation

Like chromosomal abnormalities, mutations are inborn characteristics that are not passed down through inheritance. **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 occurs in response to environmental stressors and provides an adaptive advantage to the individual. For example, 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 offered protection against the disease (Esoh & Wonkam, 2021; Kavanagh et al., 2022). Children who inherit one copy of the gene are more resistant to malaria, increasing their chances of survival, reproduction, and passing the gene to their offspring (Gong et al., 2013; Uyoga et al., 2019). Although the sickle cell gene is beneficial in places where malaria is common, it has no advantage and instead poses health risks where malaria is not a threat. In North America, sickle cell anemia is associated with health challenges and a reduced lifespan of about 54 years (Kavanagh et al., 2022).

Moreover, this mutation may contribute to racial disparities in health and wealth. African Americans are disproportionately affected by sickle cell anemia and are often less likely to have consistent access to health care and economic resources needed to manage a chronic illness (Graf et al., 2022). The sickle cell trait is becoming less common in regions of the world where malaria is rare. For example, only 8% to 10% of African Americans are carriers, compared with as many as 40% of Black Africans in some regions (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. Suppose you are leading a workshop about genetic and chromosomal disorders for prospective parents. Explain how these 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. Select a genetic or chromosomal disorder discussed in this section and explain how it illustrates the interaction between genes and their environmental context.

Reproductive Technology and Genetic Counseling

2.3 Identify reproductive technologies available to individuals and couples.

Although genetic inheritance may seem like an unpredictable roll of the dice, we can estimate the risk of many genetic disorders even before conception. Advances in technology now allow individuals and couples to learn about, detect, and, in many cases, prevent genetic abnormalities.

Genetic Counseling

Genetic risks can be identified through DNA testing and **genetic counseling**. Genetic counseling is recommended for individuals and couples with a family history of genetic conditions, women over the age of 35, and couples from the same ethnic group who might share recessive disorders. Genetic testing can also help couples having difficulty conceiving or recurrent miscarriage determine whether chromosomal abnormalities in the ova or sperm are at play (Poornima et al., 2020; Softness et al., 2020).

Through interviews with a couple, a genetic counselor constructs a detailed 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 one, blood tests may be performed to detect the presence of dominant and recessive genes, as well as chromosomal abnormalities. The tests determine whether a parent is a carrier for recessive disorders, such as Huntington's disease, and help estimate the likelihood that a child might inherit the condition (Caceres et al., 2022). The genetic counselor then interprets the results and explains the genetic concepts in a way parents can understand (Abacan et al., 2019).

Once prospective parents learn about the risk of conceiving a child with a genetic condition, they can consider a range of options, such as pursuing pregnancy, using reproductive technologies that allow for genetic testing, or exploring other family-building paths. Given advances in our knowledge of genetic disorders and the ability to screen for them, the American College of Obstetricians and Gynecologists (2025) recommends that genetic counseling be made available to all prospective parents. However, some argue that abnormalities are so rare that universal screening is not necessary (Larion et al., 2016). Ultimately, whether to seek genetic counseling is a personal decision for prospective parents based on their family history, perception of their risks, and personal values.

Career: Genetic Counselor

Genetic counselors help individuals and couples assess the risk of passing genetic conditions to their children. They gather family history, educate clients about the risks of particular genetic conditions, and inform them about the various genetic tests available to them. Genetic counselors interpret DNA and other laboratory test results, clarifying what these findings might mean for future offspring. Genetic counselors work in hospitals, in clinics, and in private practice. To become a genetic counselor, one usually needs a master's degree in genetics or genetic counseling from an accredited program and must pass a national certification exam. Some genetic counselors focus on specialized areas such as cancer, psychiatric conditions, or genomic health. Some hospitals and clinics employ genetic counselor assistants to support the work of genetic counselors. A bachelor's degree in a health care field, biology, or genetics is usually required for positions as genetic counselor assistants. For more information, visit the National Society of Genetic Counselors: www.nsgc.org.

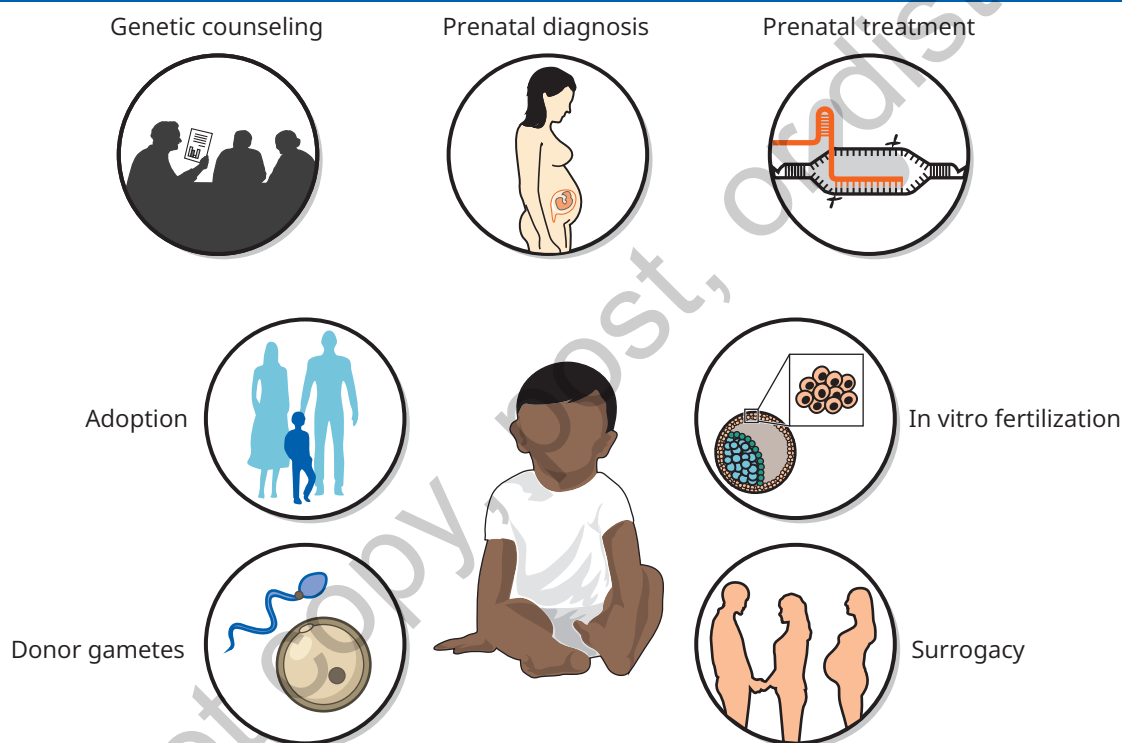
Assisted Reproductive Technology

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 and Prevention, 2025). As noted earlier, 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 (compared with about 25% of couples in developing countries) experience infertility (Cox et al., 2022; Rezaeiye 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 the least 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). There are several types of reproductive technology, including artificial insemination, in vitro fertilization, and surrogacy (Figure 2.4).

Figure 2.4 ■ Reproductive Options



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.

Intrauterine Insemination

The simplest, least invasive type of alternative conception is **intrauterine insemination**, often called *artificial insemination*, which involves inserting sperm from a partner or donor into a woman's uterus. 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, 2025). 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 takes place inside a woman's body, **in vitro fertilization (IVF)** initiates conception outside of the body. In IVF, a woman is prescribed hormones to stimulate the ovaries so that several ova mature. The ova are surgically removed and placed in a laboratory dish where they are combined with sperm in the hope that one or more ova will be fertilized. Once an ova is fertilized, the resulting zygote begins to divide. After several cell divisions, which takes a few days, the cluster of cells is transferred to the woman's uterus where, if all goes well, it will implant and continue to develop, resulting in pregnancy.

The success rate of IVF is about 50% and varies with the mother's age and whether the ova are from the patient or donated (Centers for Disease Control and Prevention, 2025). For instance, the percentage of embryo transfers resulting in live births from patients who use their own ova is 45% for women aged 35 to 37, 40% for those aged 38 to 40, and 24% for women over 40. IVF is expensive, costing an average of over \$12,400 per trial, not including medication, and often requires multiple cycles, posing a financial burden for women and couples of low socioeconomic status (Asch & Marmor, 2008; Teoh & Maheshwari, 2014).

Children conceived by IVF show similar physical, cognitive, and psychological development as those conceived without assistance, once maternal age is accounted for (Farhi et al., 2019; Imrie & Golombok, 2020). Because IVF permits cells to be screened for genetic problems before implantation, in vitro infants are at lower risk of congenital (birth) abnormalities (Fauser et al., 2014; Y. Wang et al., 2021). However, over one-third of births from artificial insemination result in multiple births (twins or even triplets). This can occur 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 birthweight, prematurity, and other poor outcomes (Sullivan-Pyke et al., 2017).

Intravaginal culture (IVC) is a less expensive alternative to IVF (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 IVF. 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) carries a fetus to term and transfers custody of the baby 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. In some cases, the surrogate carries a zygote conceived from one or both of the couple's gametes. In other instances, donor ova, sperm, or zygotes are used. Despite a few highly publicized cases where a surrogate mother chose not to relinquish the baby, most surrogacies are successful.

Roughly 3,000 babies are born through surrogacy in the United States each year (Beitsch, 2017). Longitudinal research following children through age 14 found that those born via surrogacy are psychologically similar to children born through other methods to both opposite-sex and same-sex parents (Carone, Baiocco, et al., 2020; Carone, Barone, et al., 2021; Imrie & Golombok, 2020). In addition, mothers of children born by surrogacy do not differ from mothers who conceive using other methods, and surrogate mothers themselves do not experience lasting negative effects (Pawlak et al., 2025; Yau et al., 2021).

We have seen that reproductive technology is expensive. Surrogacy is often prohibitively costly for many 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 \$125,000 to nearly \$200,000 (Caron, 2020; Mushro, 2024). Finally, surrogacy can raise ethical concerns. Carrying a fetus to term involves physical and mental health risks to the surrogate. Relinquishing a newborn can be emotionally challenging, 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 \$60,000 to carry a fetus, sums that may be difficult for some low socioeconomic status women to refuse (Harrison, 2017; Mushro, 2024).

Adoption

Another option for prospective parents is **adoption**. Adoptive parents typically undergo extensive screening to ensure that they can provide a safe home that is nurturing and stimulating to children. Many prospective parents face long waiting periods to adopt. 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 adopted children tend to be raised by parents with higher levels of education and income than other children (Tan, Yi, & Camras, 2020).

Children's experiences before 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; Brodzinsky et al., 2022). Adopted children often experience greater stress prenatally, early in life, before 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; Rodrigues et al., 2024). Children who form close bonds with their adoptive parents generally show better emotional understanding, regulation, social competence, and self-esteem (Droz 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).

Developmental Cascades: International Adoption and Child Development

Early exposure to adversity can have devastating consequences for development. Children adopted from orphanages in developing countries often face substandard conditions, without adequate food, clothing, shelter, or supportive caregivers. With high infant-to-caregiver ratios, these children endure prolonged periods of deprivation from consistent human contact, setting off a cascade of developmental challenges.

Malnutrition and poor caregiving pose risks for physical development, including atypical brain growth, which can spill over to affect motor, cognitive, and socioemotional development (Tan, Liu, & Smith, 2020). For example, poor motor skills can inhibit children's ability to explore their environment and interact with caregivers, while difficulty taking others' perspectives and managing emotions can increase their risk for behavior problems (Holmgren et al., 2020).

Given that most internationally adopted children must learn a new language, that of their adoptive parents, it is not surprising that speech and language delays are among the most consistent deficiencies observed, particularly in children adopted after the age of 1 year (Glennen, 2020). Communication difficulties, compounded by the socioemotional effects of physical deprivation, further influence children's relationships with caregivers. Generally, the younger the child is at the time of adoption, the more quickly they will adapt to a new language. A high-quality parent–child relationship promotes development in language, speech, and other developmental outcomes, and most children reach age-expected levels (Glennen, 2020).

Unsurprisingly, the longer the children are institutionalized, the more developmental challenges they face (Tan, Liu, & Smith, 2020). Early deficiencies do not remain isolated; instead, they trigger a series of interrelated challenges that cascade across physical, cognitive, and emotional domains. Although some internationally adopted children show deficits in executive function years later (Merz et al., 2016; Peñarrubia et al., 2020), most show positive adjustment. With sensitive postadoption care, many children show signs of recovery, reaching normative age expectations within 1 to 2 years

postadoption (Finet et al., 2021). Although there are individual differences, adopted children overall show great developmental gains and resilience in physical, cognitive, and emotional development after experiencing early adversity (Brodzinsky et al., 2022).

Thinking in Context 2.3

Compare and contrast reproductive options for a woman in her late 30s who wishes to conceive a child without a partner.

1. Identify options.
2. What are the pros and cons of each?
3. What considerations do you deem most important in choosing an option?

Prenatal Diagnosis

2.4 Describe methods of prenatal testing.

Prenatal testing is a routine procedure that allows physicians to examine a fetus and assess its health. It is recommended when genetic counseling indicates a risk for genetic abnormalities, when the woman is over 35, when both parents belong to an ethnicity with an elevated risk for specific genetic conditions, or when there are signs of atypical fetal development (Krstić & Običan, 2020). Technology has advanced rapidly, equipping professionals with an array of tools to assess fetal health.

Methods of Prenatal Diagnosis



Ultrasound technology enables health care professionals to observe the fetus, measure fetal growth, detect physical abnormalities, and more.

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Ultrasound is the most common prenatal diagnostic procedure. It involves directing high-frequency sound waves at the mother's abdomen to provide clear images of the womb on a video monitor. Ultrasound enables physicians to observe the fetus, measure its growth, judge gestational age, determine

the sex of the fetus, detect multiple pregnancies (twins, triplets, etc.), and detect physical abnormalities. Many issues, such as heart defects, cleft palate, and microencephaly (small head size), can be detected through ultrasound. At least 80% of women in the United States receive at least one prenatal ultrasound scan (Sadler, 2023). Three to four screenings during the pregnancy are common to evaluate fetal development. Repeated ultrasound of the fetus does not appear to affect growth and development (Abramowicz, 2019; Stephenson, 2005).

Career: Diagnostic Medical Sonographer

A diagnostic medical sonographer, commonly known as an ultrasound technician, is a health care professional who uses ultrasound equipment to capture images of internal organs, tissues, and blood vessels, including those of a developing embryo or fetus, which assist physicians in diagnosing medical conditions. In addition to operating equipment, sonographers analyze and record images to identify normal and abnormal findings, documenting results that support accurate diagnoses and treatment decisions. Becoming a diagnostic medical sonographer requires completing an accredited sonography program covering anatomy, physiology, physics, medical terminology, and the principles of sonography, along with supervised clinical practice. Training typically takes 2 years as part of an associate's or bachelor's degree, or 1 year through a certificate program offered by hospitals and colleges. Certification, usually obtained through the American Registry for Diagnostic Medical Sonography (ARDMS), is recommended and often required by employers. For more information, visit ARDMS: www.ardms.org.

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 obtain 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 when they are well informed about what to expect (Mojahed et al., 2021).



During amniocentesis, ultrasound is used to guide the insertion of a long, hollow needle into the mother's abdomen in order to extract a sample of the amniotic fluid that surrounds the fetus. The amniotic fluid contains fetal cells, which are grown in a laboratory dish and tested for genetic and chromosomal anomalies and defects.

Saturn Stills/Science Source

Amniocentesis is typically 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, 2018). Usually, amniocentesis is conducted between the 15th and 18th weeks 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 10 and 13 weeks of pregnancy (Maines & Montero, 2025). CVS involves 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 before 10 weeks of gestation as some studies suggest an increased risk of limb defects and miscarriages (Maines & Montero, 2025).

Fetal MRI uses magnetic resonance imaging technology to create images of the fetus, helping to 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 issues, including those affecting the central nervous system (Masselli et al., 2020). MRI is safe for the mother and fetus in the second and third trimesters but is expensive and is not widely available in some areas (Patenaude et al., 2014).

Noninvasive prenatal testing (NIPT) involves screening the mother's blood for cell-free fetal DNA, which are chromosome fragments from the breakdown of fetal cells. Cell-free fetal DNA circulates in maternal blood in small amounts that can be detected through a blood sample (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 it is less effective at detecting a wide range of chromosomal abnormalities compared to more invasive techniques such as amniocentesis or CVS 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., 2023). However, researchers have identified the entire genome sequence using NIPT, suggesting that its accuracy may improve over time (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.	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's 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, 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's 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.

(Continued)

Table 2.6 ■ Methods of Prenatal Diagnosis (*Continued*)

	Explanation	Advantages	Disadvantages
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.

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

Lives in Context

Prenatal Sex Selection

Many parents prefer to have a girl or boy for a variety of reasons, including cultural or religious traditions, “family balancing” based on their other children, or a simple personal preference. Scientific advances have now made it possible to reliably choose the chromosomal sex of an unborn child.

Chromosomal sex selection is generally performed using two methods: preconception sperm sorting and preimplantation genetic diagnosis (PGD) (Bhatia, 2018). In preconception sperm sorting, a centrifuge separates sperm based on whether they carry an X or a Y chromosome because X-bearing sperm are denser than Y-bearing sperm. The sperm with the desired chromosome are then used to fertilize the ovum. In PGD, ova are removed from the woman and fertilized with sperm in the laboratory via IVF. After about 3 days, a cell is sampled, and its chromosomes are examined to determine the embryo’s sex. Then, embryos of the desired sex are implanted into the woman’s uterus.

Although effective with success rates of 75% for sperm sorting and 99% for PGD, sex selection is controversial. Critics argue that it can lead down a slippery slope of genetic engineering for nonmedical traits, such as appearance or intelligence. It can also contribute to imbalances in societal sex ratios, as seen in cultures that favor males, where practices such as female infanticide and gender-selective embryo termination have occurred. For instance, India and China have outlawed prenatal sex determination to curb these practices, but enforcement remains difficult, and selective termination of embryos is still common (Bowman-Smart et al., 2020).

Regulation of sex selection varies widely. Canada, the United Kingdom, and many European countries restrict the use of PGD for nonmedical reasons, whereas the United States does not have a formal policy regarding sex selection (Ethics Committee of the American Society for Reproductive Medicine, 2022). Although sex selection technology can help couples carrying genetically transmitted diseases carried on the sex chromosomes to ensure the birth of a baby of the unaffected sex, its nonmedical use remains a pressing ethical issue.

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, lung, urinary tract, and other areas prior to birth (Ahmad et al., 2023; Peiro & Scorletti, 2019).

Gene editing can be used to modify fetal cells by adding or repairing sections of genetic material that are missing or atypical. 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 2.4

What information would you give to a person who is pregnant or considering becoming pregnant about prenatal diagnosis?

1. How would you explain the various options, including their advantages and disadvantages?
2. Would you recommend the same tests to everyone? Why or why not?

Heredity and Environment Interactions

2.5 Examine the interactions between heredity and environment, including behavioral genetics, gene–environment correlations and interactions, and the epigenetic framework.

Our genetic makeup, which we inherit from our biological parents, influences all of our traits, everything from hair and eye color to personality, health, and behavior. However, genes do not work alone. The characteristics we show, our phenotype, result from interactions among our genotype and our unique life experiences. **Behavioral genetics** examines how genetic and environmental variations shape the phenotypes people show, including traits, characteristics, abilities, and behavior (Harden, 2021). All traits, even those with a strong genetic basis, like height, are influenced by the environment (Jelenkovic et al., 2016; Plomin, 2019). For example, good nutrition supports height growth, while malnutrition can stunt it.

Behavioral Genetics Research Methods

Behavioral geneticists work to tease apart the role of biology and environment in development. They estimate the *heritability* of traits—that is, how much of the variation in a trait across people is due to genetic differences. The rest is assumed to be the result of environmental influences and experiences. Heritability research examines how both genotype and experience shape phenotypes, the traits that people show (Barry et al., 2023; Fowler-Finn & Boutwell, 2019). Common methods include selective breeding, twin studies, and adoption studies.

Selective Breeding Studies

In animal studies, researchers use selective breeding to modify the genetic makeup of animals in a laboratory setting, studying how heredity influences traits and behavior. For example, mice can be bred to be highly physically active or highly sedentary by mating highly active mice with other highly active mice or, similarly, by breeding mice with very low levels of activity with each other. Over generations, the differences grow, resulting in extremely active and extremely sedentary mice (N. L. Schwartz et al., 2018). Selective breeding in rats, mice, and other animals, such as chickens, has revealed genetic contributions to various traits and characteristics, including aggressiveness, emotionality, sex drive, and even maze learning (Bubac et al., 2020).

Because humans cannot be bred for research, behavioral geneticists rely on observing natural variations in genes and environments. Family members share different amounts of genes and often share the same environment as well as have unique experiences. Behavioral geneticists study siblings, especially twins and adopted siblings, to compare people who share varying degrees of relatedness and environmental experiences (Friedman et al., 2021; York, 2020).

Twin Studies

Twin studies compare identical and fraternal twins to estimate the heritability of a trait or behavior, determining how much of it is attributable to genes. Recall that identical (monozygotic, or MZ) twins share 100% of their genes because they originated from the same zygote. Like all nontwin siblings, fraternal (dizygotic, or 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 genes strongly influence a given trait, identical twins should be more similar to each other than fraternal twins.

Adoption Studies

Whereas twin studies examine biologically related individuals, adoption studies compare the degree of similarity between people who are not biologically related but share a common environment. Some studies compare adopted children to their biological parents, who share 50% of their genes but not their home 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 resemble their biological parents more, 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.

Heritability and Personal Characteristics

Twin and adoption studies show 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 tend to have more similar intelligence scores than fraternal twins (Plomin, 2019). In a classic study of intelligence in over 10,000 twin pairs, the correlation coefficient for identical twins was .86 compared to .60 for fraternal twins (Plomin & Spinath, 2004). Correlation coefficients indicate the strength of the relationship between two variables and range from 0 to 1, with higher values indicating stronger relationships. Table 2.7 summarizes the results of comparisons of intelligence scores among individuals with different genetic relationships. Notice that correlations increase with genetic relatedness, as well as when kin live together, supporting the role of environmental factors. Even identical twins who share 100% of their genes are not entirely alike. Those differences are attributable to environmental factors and experiences unique to each sibling.

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

	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 and child (50% shared genes)	.41	.22
Half-siblings (25% shared genes)	.31	—
Unrelated (adopted) siblings (0% shared genes)*	.34	—
Nonbiological parent and child (0% shared genes)*	.20	—

Adapted from Bouchard, T. J., Jr., & McGue, M. (1981). Familial studies of intelligence: A review. *Science*, 212(4498), 1055–1059. <https://doi.org/10.1126/science.7195071>; Devlin, B., Daniels, M., & Roeder, K. (1997). The heritability of IQ. *Nature*, 388(6641), 468–471. <https://doi.org/10.1038/41319>.

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

Nonshared Environment

Siblings raised in the same home by the same parents share many daily experiences, yet they often have very different personalities, interests, and abilities. Behavioral geneticists emphasize the role of the **nonshared environment**, experiences unique to each child, in accounting for differences among siblings (Hetherington et al., 2013).

Even in the same family, children are often treated differently. The oldest in a large family may have very different parenting and family experiences than the youngest child. With each child, parents gain experience and knowledge about child development and child-rearing, which can influence their confidence and parenting. Additionally, parents' interactions are influenced by their children's personalities, resulting in unique experiences for each child. A shy child might elicit different responses than an outgoing child. We will examine the ways that children evoke reactions in their environment later in this chapter.

Even twins who share the womb and a birthday experience nonshared environments, as they have different friends, activities, teachers, and interactions with parents that are influenced by their unique personalities and characteristics. These unique experiences, the nonshared environment, contribute to many of the differences we see among siblings and interact with genetics to influence children's development.

Gene–Environment Interactions

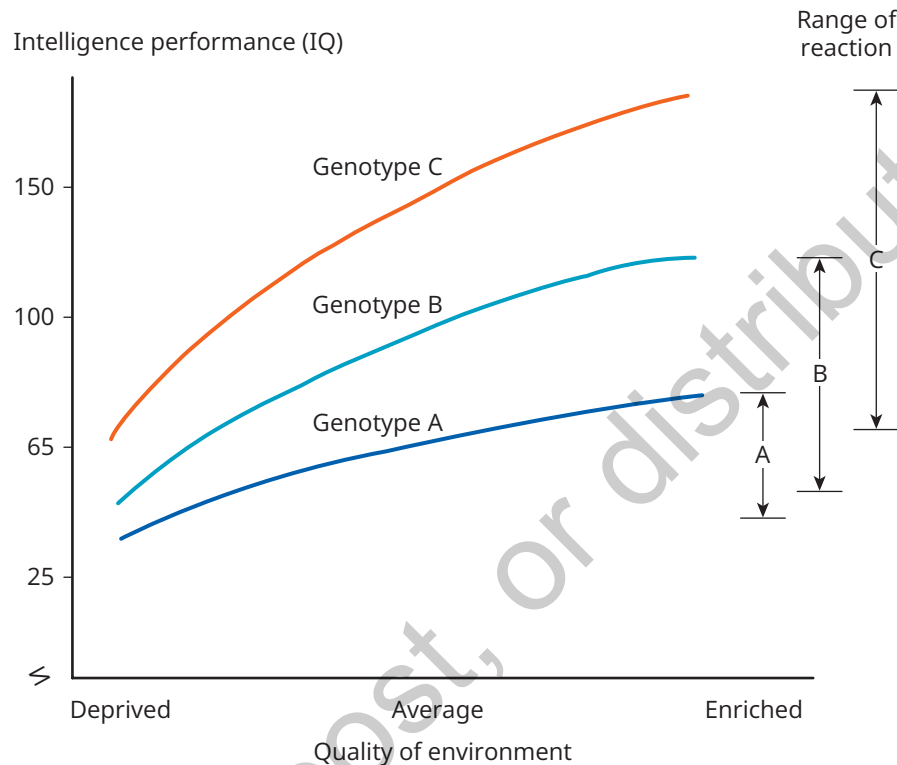
At 6 feet, 2 inches in height, 16-year-old Deondre towers over his 5-foot-tall mother and is considerably taller than his father, who is 5 feet, 11 inches. Why is Deondre so much taller than his biological parents? Shared genes account for only part of the story of development. Genes and the environment work together in complex ways to shape traits, 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 explain differences among family members.

Range of Reaction

The environment affects people differently depending on their genetic makeup (Briley et al., 2019). The same genotype can be expressed in a variety of phenotypes, depending on environmental conditions, its mix of opportunities, and its constraints. This is known as the **range of reaction** (see Figure

2.5)—specifically, a wide range of potential expressions of a genetic trait, depending on environmental opportunities and constraints (Gottlieb, 2007).

Figure 2.5 ■ Range of Reaction



Adapted from Gottlieb, G. (2007). Probabilistic epigenesis. *Developmental Science*, 10(1), 1–11. <https://doi.org/10.1111/j.1467-7687.2007.00556.x>

Consider height. It is largely genetic, yet an individual may show a range of sizes depending on environment and behavior (Jelenkovic et al., 2016; Thompson, 2021). Children born to very tall parents may inherit the genes that predispose them to be tall. However, unless they receive adequate nutrition, they will not reach their full genetic potential for height. In societies where nutrition has improved dramatically over the course of a generation, it is common for children to tower over their parents. Enhanced environmental opportunities—in this case, nutrition—enable the children to fulfill their genetic potential for height.

In short, genes set boundaries for the range of possible developmental outcomes; the environment influences where, within that range, the phenotype falls—the traits displayed (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 influences (Briley et al., 2019; Harden, 2021).

Some traits exhibit a narrow reaction range, characterized by very little variation in their outcomes, a phenomenon known as **canalization**. Canalized traits are strongly biologically programmed, and only very extreme environmental forces can alter their developmental path (Posadas & Carthew, 2014; Takahashi, 2019). For example, motor development in infants follows a predictable age-related sequence: first crawling, then walking, and eventually running. Around the world, most infants begin walking at around 12 months of age. Generally, only extreme circumstances, such as extreme deprivation, can disrupt this typical developmental path (Adolph & Franchak, 2017). We examine the role of experience in motor development in Chapter 4.

Gene–Environment Correlation

Both genes and the environment contribute to development. Not only do they interact, but environmental factors often support and enhance genetic predispositions and traits (Briley et al., 2019; Scarr & McCartney, 1983). **Gene–environment correlation** refers to the finding that many traits influenced by genetics tend to be associated with environmental factors that further promote those traits (Saltz, 2019). That is, genetic predispositions 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 Parents naturally create home environments that reflect their own interests and preferences. Since children share genes with their parents, homes can inadvertently support the child’s genetic predispositions—an example of a *passive gene–environment correlation* (Wilkinson et al., 2013). For example, musically talented parents may pass on genes for musical ability and also create an environment filled with instruments, music, and opportunities to learn (Corrigall & Schellenberg, 2015) (Figure 2.6). This is a passive gene–environment correlation because the environment just happens to support the child’s abilities without the child’s direct influence. This type of gene–environment correlation tends to occur early in life when caregivers create rearing environments for their infants and young children.

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).



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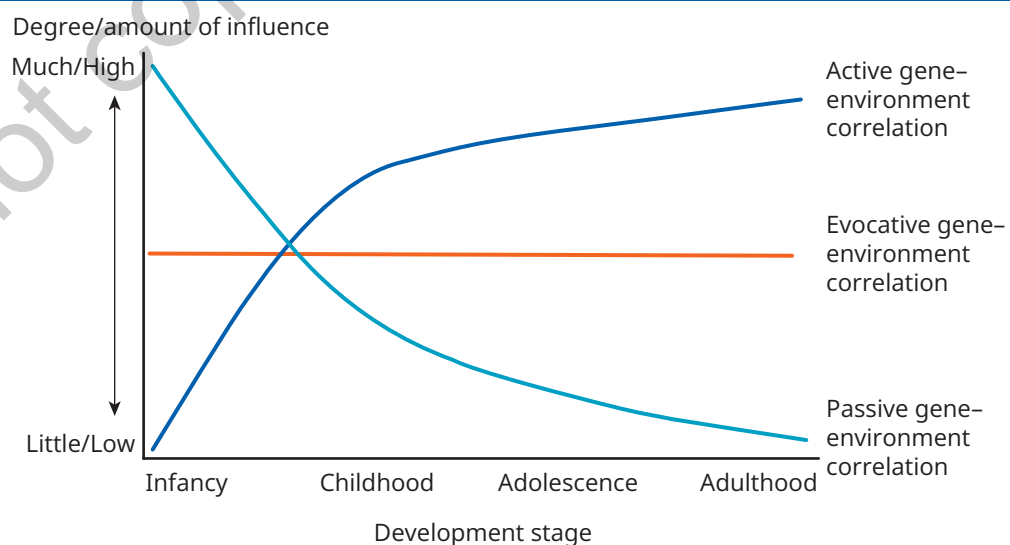
Evocative Gene–Environment Correlation Children naturally elicit responses from people and the environment, just as the environment and people’s actions elicit responses from them. In an *evocative gene–environment correlation*, a child’s genetic traits, such as personality characteristics like sociability, influence their social and physical environment—how others respond to them—which shapes development in ways that support the genetic trait (Pieters et al., 2015; Saltz, 2019).

For instance, active, happy infants tend to receive more positive attention than passive or moody infants (Deater-Deckard & O’Connor, 2000). Even among infant twins reared in the same family, the more outgoing twin tends to receive 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 reinforces their tendency to be cheerful (Klahr et al., 2013). In this way, the child’s genetic trait leads them to behave in ways that evoke responses from the physical and social environment that support their predisposition. To return to the music example, a child with a genetic predisposition for musical talent will elicit adult approval when they play music; this environmental support, in turn, encourages the further development of the child’s musical talent.

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 seeks experiences and environments that align with 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–Environment 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 because caregivers, typically genetically similar parents, create the rearing environment and determine infants’ experiences (Armstrong-Carter et al., 2021). Evocative gene–environment correlations also occur from birth, as infants’ inborn traits naturally elicit responses from others that reinforce their genetic predispositions.

Figure 2.7 ■ Gene–Environment Correlations Over the Lifespan



In contrast, active gene–environment correlations become more pronounced as children grow older and more independent. As they become increasingly able to control parts of their environment, children engage in niche-picking by choosing interests and activities that align with their predispositions, shaping their development. Niche-picking contributes to the differences we observe in siblings, including fraternal twins, as they age. Interestingly, identical twins tend to become more similar over time, perhaps because they are increasingly able to select environments that best fit their genetic propensities, thereby 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 Interactions

Despite our growing understanding of genetic influences on behavior, the traits we ultimately show—our phenotypes—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).

In a classic longitudinal study, boys who experienced trauma and abuse were more likely to develop behavior problems, but their outcomes varied depending on the presence of a gene that controls monoamine oxidase A (MAOA), an enzyme that regulates brain chemicals (Caspi et al., 2002). Maltreated boys with the *low*-MAOA gene were about twice as likely to show aggression and be convicted of violent crimes. Boys who carried the high-MAOA gene were no more likely to become violent than their nonmaltreated peers. Importantly, the low-MAOA gene on its own was not associated with violence; it predicted violence only in boys who experienced abuse early in life. These findings have been replicated in another 30-year longitudinal study of boys (Fergusson et al., 2011) and a meta-analysis of 27 studies (Byrd & Manuck, 2014).

Similar findings of an MAOA gene–environment interaction in which low MAOA, but not high MAOA, predicts adverse outcomes in response to childhood adversity has been extended to include other outcomes, including antisocial personality disorder and depression (Dash et al., 2023; Manuck & McCaffery, 2014; Mariz et al., 2022). Most of these studies have focused on males. Females show a more mixed pattern, with some studies showing that girls display the MAOA gene–environment interaction on emotional reactivity and aggression but to a much lesser extent than boys, whereas other studies suggest no relationship (Byrd et al., 2019). 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 can increase our susceptibility to environmental risks, others may increase our sensitivity to, and the effectiveness of, environmental interventions (Bakermans-Kranenburg & van IJzendoorn, 2015; Chhangur et al., 2017). The effects of genes vary in response to environmental influences, and not all genotypes react to environmental influences in the same way (Fowler-Finn & Boutwell, 2019). Most traits, like intelligence, are polygenic—shaped by many genes, each with multiple variants that may interact with environmental conditions in different ways (Armstrong-Carter et al., 2021; Briley et al., 2019; Plomin et al., 2016). These interactions help explain why the same environment can produce different outcomes in different individuals and why similar individuals can develop differently depending on their context.

We have learned a great deal about how our genes and environments work together to influence our development. However, it is important to note that these conclusions pertain to populations, or large groups of people, rather than to specific individuals. Behavioral genetic research cannot predict individual behavior (Turkheimer, 2019). Also, many studies rely on samples that are not ethnically and socioeconomically diverse, limiting the conclusions that can be drawn (Sirugo et al., 2019). Despite advances, the genetics of most traits remain 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 more than just 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 molecular layer that stretches along the DNA and provides instructions to genes, determining whether they are turned on or off and guiding what each cell becomes, whether a heart, muscle, or brain cell (O'Donnell & Meaney, 2020).

At birth, each cell in our body turns on only a subset of its genes. The epigenome instructs genes to be turned on and off throughout development and also in response to the environment, shaping our phenotype, or the traits we display (Paro et al., 2021; Pinel et al., 2018). Environmental factors such as toxins, crowding, diet, injuries, and 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 comes from studies on agouti mice, which all carry the agouti gene. Typically, 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. However, a groundbreaking study showed that yellow agouti mice can produce offspring that look strikingly different despite carrying the same gene (Waterland & Jirtle, 2003).

The mice in Figure 2.8 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 yellow mouse, the agouti gene is continuously active, resulting in the characteristic yellow and obese appearance. In the brown mouse, however, the gene is effectively turned off.

Figure 2.8 ■ Mice With Agouti Gene

These two mice are genetically identical. Both carry the agouti gene, but it is expressed continuously in the yellow mouse and is silenced in the brown mouse.



Randy Jirtle and Dana Dolinoy, CC BY 3.0 <<https://creativecommons.org/licenses/by/3.0/>>, via Wikimedia Commons

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). Foods such as onions, garlic, beets, and soy, as well as the nutrients in prenatal vitamins, contain compounds that can attach to, or mark, the agouti gene. When

yellow agouti mothers are fed a diet high in these compounds, the epigenetic marks turn off the agouti gene in their offspring, leading to a brown, lean phenotype that is healthier overall.

Epigenetic Processes in People Like in animals, the human epigenome can be influenced by the prenatal environment. 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).

After birth, our experiences continue to shape our epigenome. Early exposure to trauma and adversity can reprogram children's development, sometimes 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 how children cope with stress (Mariani Wigley et al., 2022; Provenzi et al., 2020). Essentially, our experiences—both positive and negative—can add or remove epigenetic marks on our genes, influencing our physical, cognitive, and socioemotional abilities, including physical and mental health (Manczak et al., 2023; O'Donnell & Meaney, 2020; Raffington et al., 2023).

Although much epigenetics research focuses on adversity, these processes operate in all individuals, at all ages, and across 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 2.5

Suppose you wanted to determine the influence of genetics and environment on a characteristic, such as intelligence, body weight, or athletic ability.

1. What kind of study would you conduct? Consider twin and adoption study methods.
2. What would you measure? Choose one aspect (intelligence, body weight, or athletic ability) and explain how you would study it in groups of people.
3. Considering your design and measure, how would you determine the degree to which genes and environment influence the characteristic?
4. What are the challenges associated with conducting research of this nature?
5. Give a personal example of a passive gene–environment correlation, an evocative gene–environment correlation, and an 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 decides to pursue in vitro fertilization using a sperm donor. Soon Zinnia is delighted to learn that she is pregnant—with twins!

3. What types of prenatal screening tests might Zinnia experience? Discuss some of the advantages and disadvantages of each.
4. Do you expect Zinnia to carry identical or fraternal twins? Why?
5. 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 phenylketonuria (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, Jacobs 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 Identify reproductive technologies available to individuals and couples.

Intrauterine insemination, the simplest assisted reproductive technology (ART), involves inserting sperm into a woman's uterus. 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. Another option for prospective parents is adoption.

2.4 Describe methods of prenatal testing.

Ultrasound enables physicians to observe the fetus, measure fetal growth, judge gestational age, and determine physical abnormalities in the fetus. Fetal MRI applies magnetic resonance imaging technology to image the fetus's 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.

2.5 Examine the interactions between heredity and environment, including behavioral genetics, gene–environment correlations and interactions, and the epigenetic framework.

Behavioral 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, twin studies, and adoption studies. Genetics contributes 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	hemophilia
amniocentesis	in vitro fertilization (IVF)
assisted reproductive technology (ART)	incomplete dominance
behavioral genetics	intrauterine insemination; Jacobs syndrome
canalization	Klinefelter syndrome
chorionic villus sampling (CVS)	meiosis
chromosomes	mitosis
deoxyribonucleic acid (DNA)	monozygotic (MZ) twins
dizygotic (DZ) twins	mutations
dominant–recessive inheritance	niche-picking
Down syndrome	noninvasive prenatal testing (NIPT)
epigenetics	nonshared environment
fetal MRI	phenotype
fetoscopy	phenylketonuria (PKU)
fragile X syndrome	polygenic inheritance
gamete	range of reaction
gene–environment correlation	sickle cell anemia
gene–environment interactions	surrogacy
genes	triple X syndrome
genetic counseling	Turner syndrome
genetics	ultrasound
genomic imprinting	zygote
genotype	