When did the sun begin? When people began living. Who made it? God. How did God do this? He put a real lot of lightbulbs in it. Are these lightbulbs still in the sun? No. What happened to them? They burnt out. No, they stay good a long time. So are the lightbulbs still in it? No. I think he made it out of gold. And he lit it with fire. (Siegler, conversation with son, 1985)

The child in the vignette above answered these questions one week before his fifth birthday. What do his answers tell us about how he viewed the world at that time? Do they reflect a simple lack of knowledge about astronomy and physics? Or do they indicate a fundamental difference between young children’s reasoning and that of older children and adults? An adult who did not know the origins of the sun would never ascribe its origins to God putting lightbulbs in it. Nor would an adult link the origins of the sun to the fact that people began to be alive. Do these differences mean that children generally reason in more literal and self-centered ways than adults? Or do they just reflect a child’s grasping at straws when faced with a question for which he cannot even generate a plausible answer?

For hundreds of years, people have wondered about these and related questions. Do infants see the world in the same way as adults? Why do societies throughout the world first send children to school between ages 5 and 7? Why are
TABLE 1.1 Chapter Outline

I. What Is Children’s Thinking?
II. Key Questions about Children’s Thinking
   A. Are Some Capabilities Innate?
   B. Does Development Progress through Stages?
   C. How Does Change Occur?
   D. How Do Individuals Differ?
   E. How Do Changes in the Brain Contribute to Cognitive Development?
   F. How Does the Social World Contribute to Cognitive Development?

III. The Book’s Organization
    A. The Chapter-by-Chapter Organization
    B. The Central Themes

IV. Summary

adolescents so much more likely than 10-year-olds to fervently believe in causes such as vegetarianism or environmentalism? A century ago, people could only speculate about these issues. Now, however, we have concepts and methods that magnify our ability to observe, describe, and explain the process of development. As a result, our understanding of children’s thinking is growing rapidly.

The goal of this chapter is to introduce some basic issues and ideas regarding children’s thinking. The first section focuses on what children’s thinking involves. The next section introduces some of the enduring questions that motivate people to study cognitive development. Finally, the last section provides an overview of the book’s organization. An outline of the chapter is provided in Table 1.1.

What Is Children’s Thinking?

Children’s thinking refers to the thinking that takes place from the moment of birth through the end of adolescence. Defining what thinking is turns out to be quite difficult, because no sharp boundary divides activities that involve thinking from ones that do not. Thinking obviously involves the higher mental processes: problem solving, reasoning, creating, conceptualizing, remembering, classifying, symbolizing, planning, and so on. Other examples of thinking involve more basic processes, processes at which even young children are skilled: using language, and perceiving objects and events in the external environment, to name two. Still other activities might or might not be viewed as types of thinking. These include being socially skillful, having a keen moral sense, feeling appropriate emotions, and so on. The capabilities in this last group involve thought processes, but they also involve many other, nonintellectual qualities. In this book, we give these boundary areas some attention, but the spotlight is on problem solving, conceptual understanding, reasoning, remembering, producing and comprehending language, and the other, more purely intellectual activities.
A particularly important characteristic of children's thinking is that it is constantly changing. How children think at particular points in development is interesting in and of itself, but even more central for understanding cognitive development are the questions of what changes occur and how the changes occur. Comparing an infant, a 2-year-old, a 6-year-old, and an adolescent, it is easy to appreciate the magnitude of these changes. But what processes could transform the mind of a newborn baby into the mind of an adolescent? This is the central mystery of cognitive development.

Consider an example of the dramatic changes that occur with development. DeVries (1969) was interested in 3- to 6-year-olds' understanding of the difference between appearance and reality. She presented children of these ages with an unusually sweet-tempered cat named Maynard and allowed them to pet him. When the experimenter asked what Maynard was, all of the children knew that he was a cat. Then, as the children watched, the experimenter put a mask of a fierce dog on Maynard's face. The experimenter asked, "Look, it has a face like a dog. What is this animal now?"

Many of the 3-year-olds thought that Maynard had become a dog. They refused to pet him and said that under his skin he had a dog's bones and a dog's stomach. In contrast, most 6-year-olds knew that a cat could not turn into a dog, and that the mask did not change the animal's identity.

How can a human being, even a very young one, believe that a cat can turn into a dog? And how does the 3-year-old who has this belief turn into the 6-year-old who scoffs at such a silly notion? We know that the change happens, the issue is how it happens.

Key Questions about Children's Thinking

What are the most important questions in the study of children's thinking? Many answers are possible, but there is widespread agreement that the following six questions are among the most important:

Are some capabilities innate?
Does children's thinking progress through qualitatively different stages?
How do changes in children's thinking occur?
Why do individual children differ so much from each other in their thinking?
How does development of the brain contribute to cognitive development?
How does the social world contribute to cognitive development?

Of course, these questions are interrelated in many ways. For example, understanding the roles of the brain and the social world in cognitive development is crucial to understanding how change occurs. Likewise, understanding mechanisms of change may shed light on why individual children differ from one another.

Researchers from different theoretical perspectives and different content areas have focused on different questions to varying degrees. For example, as
described later, researchers who take an information-processing perspective on cognitive development tend to emphasize the issue of how change occurs, whereas researchers who take a sociocultural perspective focus on how the social world contributes to cognitive development. However, despite these differences in emphasis, each of the major theories of cognitive development has something to say about each of these main questions.

These key questions are introduced in the following sections. The emphases in this chapter are on fundamental concepts relevant to each question and on major themes that will recur repeatedly throughout the book.

**ARE SOME CAPABILITIES INNATE?**

When infants are born, how do they experience the world? When they see a chair, or people talking to each other, or a dog barking, what exactly do they see? What do they know, what don’t they know, and what learning capabilities do they possess? If we assume that infants come into the world poorly endowed with knowledge and learning capabilities, the question becomes, “How can they develop as rapidly as they do?” If we assume that infants come into the world richly endowed, the question becomes, “Why does development take so long?”

The question of infants’ initial endowment has elicited many speculations. Three of the most prominent come from the associationist perspective, the constructivist perspective, and the competent-infant perspective.

The associationist perspective was developed by English philosophers of the 1700s and 1800s, including John Locke, David Hume, and John Stuart Mill. They suggested that infants come into the world with only minimal capabilities, primarily the ability to associate experiences with each other. Therefore, infants must acquire virtually all capacities and concepts through learning.

The constructivist perspective, developed by Jean Piaget between the 1920s and the 1970s, suggests that infants are born possessing not only these associative capabilities but also several important perceptual and motor capabilities. Although few in number and limited in scope, these capabilities allow infants to explore their environment and to construct increasingly sophisticated concepts and understandings. For example, infants in their first 6 months are said not to be able to form mental representations of objects and events, but through actively manipulating and investigating objects, they are said to become capable of forming such representations later in their first year.

The competent-infant perspective, based on more recent research (e.g., Spelke & Newport, 1998), suggests that both of the other approaches seriously underestimate infants’ capabilities. Within this view, even young infants have a much wider range of perceptual skills and conceptual understandings than had previously been suspected. These capacities allow infants, in a rudimentary way, to perceive the world and to classify their experiences along many of the same dimensions that older children and adults use.
The impressive capabilities that recent investigations have uncovered can be illustrated in the context of infants’ perception of distance. Philosophers have long speculated about how people can judge the distances of objects from themselves. Some, such as George Berkeley, an associationist philosopher of the eighteenth century, concluded that the only way in which infants could come to accurately perceive distance was by moving around the world and associating how objects looked with how much movement was required to reach them. Yet, the day after infants are born, they can already perceive which objects are closer and which are farther away (Granrud, 1987; Slater, Mattock, & Brown, 1990). Clearly, some degree of distance perception is present even before infants have experience crawling and walking around the environment.

Infants also possess surprising knowledge of the properties of objects. For example, by age 3 months, the earliest age at which such knowledge has been successfully measured, infants show some understanding that objects continue to exist even when they move behind other objects and cannot be seen; that without support, objects will fall; that objects move along spatially continuous paths; and that solid objects cannot move through one another (Baillargeon, 1994; Spelke, 1994, 2000). Such knowledge is not identical to the knowledge of adults; for example, 3-month-olds seem to believe that any contact between an object and a support is sufficient to hold the object up, even when, for example, only the right edge of a block on the bottom is under the left edge of a block on top of it. By 6 months, infants show the more advanced understanding that for a support to be effective, the block on the bottom must be under a substantial proportion of the block on the top (Baillargeon, 1994).

In addition to possessing primitive versions of fundamental concepts, infants also possess general learning mechanisms that help them acquire a wide range of new knowledge. One such learning mechanism is imitation. When 2-day-olds see an adult move his head in a certain way, they tend to move theirs in a similar fashion; when 2-week-olds see an adult stick out his tongue, they tend to stick out their tongues in response (Meltzoff, 2002; Meltzoff & Moore, 1983). Such repetitions provide a way for infants to learn new behaviors and also to strengthen their bond with those they imitate, particularly their parents.

Another such learning mechanism is statistical learning, which involves extracting sequential patterns from input. In their first year of life, infants are capable of detecting such patterns both in auditory input, such as sequences of tones or linguistic sounds (Saffran, 2003b; Saffran, Aslin, & Newport, 1996), and in visual input, such as sequences of colored shapes (Kirkham, Slemmer, & Johnson, 2002). Statistical learning is a powerful mechanism by which infants can detect regularities in their environment.

Findings like these have given rise to the view that infants are quite cognitively competent. But like previous perspectives, the new view raises as many questions as it answers. If infants understand fundamental concepts, why do much older children experience such difficulty with the very same concepts? For example, if infants understand that a toy continues to exist even when a cover
is placed on it, why do 3-year-olds still not understand that a cat cannot be turned into a dog simply by putting a mask on it? Reconciling the strengths that are present early in development with the weaknesses that are also present then and for years thereafter is one of the greatest challenges in understanding children's thinking.

Another challenge is specifying how innate or early-developing abilities interact with experience to yield developmental change. One approach to addressing this issue is to examine the effects of variations in experience on the nature and path of development. For example, does perceptual development differ in typically developing infants and infants who are blind or deaf from birth? Does language acquisition depend on the nature of the linguistic input that children receive? The solutions to these puzzles highlight the complex interplay between biologically specified abilities and experience in the physical and social world.

**Does Development Progress through Stages?**

When a girl misbehaves, her parents might console each other by saying, "It's just a stage she's going through." When a boy fails utterly to learn something, his parents might lament, "I guess he just hasn't reached the stage where he can understand this." The idea that development, including cognitive development, occurs in stages is common among psychologists as well as parents. But what exactly does it mean to say that a child is in a stage, and do children in fact progress through qualitatively distinct stages of thinking? And why might development be stagelike, rather than continuous?

The view of development as stagelike was in part inspired by the ideas of Charles Darwin (1877). Darwin is not usually thought of as a developmental psychologist, but in many ways he was one. In his book *The Descent of Man*, Darwin discussed the development of reason, curiosity, imitation, attention, imagination, language, and self-consciousness. Not surprisingly, he was most interested in the evolutionary course of these competencies, that is, in how they emerged in the course of the evolution from earlier-appearing animals to humans. However, many of his ideas could be, and were, translated into concepts about the development that occurs in an individual human lifetime.

Perhaps Darwin's most influential observation was his most basic: that over the vast period of time that living things have populated the earth, they have evolved through a series of qualitatively distinct forms. This observation suggested to some that development within a given lifetime also progresses through distinct forms or stages. Unlike Darwin himself, however, developmental theorists who adopted an evolutionary perspective further hypothesized that children would make the transition from one stage to the next quite suddenly. This stage approach directly contradicted speculations by associationist philosophers,
such as John Locke, that children's thinking develops through the gradual accretion of innumerable particular experiences. Associationists compared the developmental process to a building being constructed brick by brick. Stage theorists compared it to the metamorphosis from caterpillar to butterfly.

In the early part of the twentieth century, James Mark Baldwin hypothesized a set of plausible stages of intellectual development. He suggested that children progressed from a sensorimotor stage, in which sensory observations and motor interactions with the physical environment were the dominant form of thought, to a quasilogical, a logical, and finally a hyperlogical stage. The idea that children progress through these stages receives a certain amount of support in everyday observations of children. Infants' interactions with the world do seem, at least at first impression, to emphasize sensory input and motor actions. And not until adolescence do children spend much time thinking about purely logical issues, such as whether laws that apply to them, including those regarding driving, voting, and drinking, are logically consistent with each other. Baldwin's stage theory was ignored by most of his contemporaries, but it exerted a strong influence on at least one later thinker: Jean Piaget.

Piaget, without question, added more than any other individual to our understanding of children's thinking. He made a huge number of fascinating observations about the ways in which children think at different ages. For example, the reason that Siegler asked his son about the origins of the sun (the anecdote at the beginning of this chapter) was because he was fascinated by Piaget's descriptions of the answers given by children in the 1920s, and Siegler was curious whether children in the 1980s would respond similarly (they do). Among Piaget's other contributions were developing the stage notion to a much greater extent than Baldwin had, and popularizing the idea of viewing intellectual development in terms of stages.

What exactly do we mean when we say that children's thinking progresses through certain stages? Flavell (1971) noted four key implications of the stage concept. First, stages imply qualitative changes. We do not say that a boy is in a new stage of understanding of arithmetic when he progresses from knowing 50 percent of the multiplication facts to knowing all of them. Instead, we reserve the term for situations in which the child's thinking seems not only better but different in kind. For example, when a girl makes up her first genuinely amusing joke after several years of telling stories that she may call jokes, but that do not even make sense to adults, it seems like a qualitative change. Note the ambiguity of the term seems like, though. Perhaps the girl's efforts had been improving slowly for a long time but had not quite reached the threshold for what an adult recognizes as a joke. To some degree, what constitutes a qualitative change is in the eyes of the beholder.

A second implication of stage theories, which Flavell labeled the concurrence assumption, is that children make the transition from one stage to another on many concepts simultaneously. When they are in Stage 1, they show
Stage 1 reasoning on all of these concepts; when they are in Stage 2, they show Stage 2 reasoning on all of them. As a result of these concurrent changes, children's thinking shows abstract similarities across many domains. When the parent in the above example said, "He's just not in a stage where he can understand this," the implication was that a general deficiency would keep the child from understanding not just the particular concept but also other concepts of comparable complexity.

Viewing children's thinking as progressing through a series of stages also has two additional implications. One, which Flavell called the abruptness assumption, is that children move from one stage to the next suddenly rather than gradually. Children are in Stage 1 for a prolonged period of time, enter briefly into a transition period, then are in Stage 2 for a prolonged period, and so on. The fourth assumption of stage theories is coherent organization. The child's understanding is viewed as being organized into a sensible whole, rather than being composed of many independent pieces of knowledge.

Thus, stage theories depict development as involving qualitative change, occurring simultaneously for many concepts, occurring suddenly, and involving a transition from one coherent way of thinking to a different coherent way of thinking. Without question, this is an elegant and appealing description. But how well does it fit the realities of children's thinking? This issue will be considered in greater depth in Chapter 2.

**How Does Change Occur?**

To develop is to change. Several types of change that occur during the course of development are illustrated in Figure 1.1. The depiction originally was formulated to describe changes in perceptual development (Aslin & Dumais, 1980), but the categories apply to all types of changes in children's thinking.

The left side of the figure illustrates three patterns of change that can occur in the prenatal period (before birth): a particular capability can develop fully, partially, or not at all. The right-hand side depicts changes occurring after birth. An already-developed ability can either be maintained or decline; a partially developed ability can grow, stay the same, or decline; and an undeveloped ability can grow or stay undeveloped.

The variety of possible patterns expands further when we realize that any given ability involves many components that may follow quite different developmental courses. For example, regardless of where infants are born, they can produce all of the sounds that are used in any of the world's languages. Over the course of childhood, however, they lose the ability to produce many sounds that are not part of their native language. On the other hand, they gain increasing facility in producing at will the sounds that are part of their own language. Thus, after infancy, the ability to produce speech sounds both declines and grows, depending on which sounds we are talking about.
FIGURE 1.1 Illustration of several paths of developmental change (after Aslin & Dumais, 1980). Reprinted from Aslin, R.N. & Dumais, S.T., Binocular vision in human infants: A review and a theoretical framework, in L.P. Lipsitt & H.W. Reese (Eds.), Advances in Child Development and Behavior, Copyright 1980, with permission from Elsevier.

How can changes in children’s thinking be explained? Two of the most influential efforts to answer this question are the Piagetian and the information-processing perspectives. Piaget suggested that the basic mechanisms that produce all cognitive changes are assimilation and accommodation. Assimilation is the process through which people represent experiences in terms of their existing understanding. A 1-year-old girl who saw a round candle might think of it as a ball if she knew about balls but not candles. Accommodation is the opposite process; in it, people’s existing understanding is altered by new knowledge. The 1-year-old who saw the round candle might notice that this “ball” was different from others in having a thin object (the wick) protruding from it. This discovery might lay the groundwork for later learning that the world includes round candles.

Researchers who adopt the information-processing approach to children’s thinking have been particularly interested in the process of change. They have focused on four change mechanisms that seem to play large roles in cognitive development: automatization, encoding, generalization, and strategy construction.

Automatization involves executing mental processes increasingly efficiently so that they require less and less attention. With age and experience, processing becomes increasingly automatic on a great many tasks, allowing children to see connections among ideas and events that they otherwise would miss. For example, in the first few weeks of walking home from school, a 5-year-old girl
might need to completely focus her attention on the task of finding her way. Later, the activity would become automatized, and she would find her way home despite paying attention to what other people were saying and doing while she walked with them.

Encoding involves identifying the most informative features of objects and events and using those features to form internal representations of the objects and events. The importance of improved encoding in children's increasing understanding of the world is evident in the context of their learning to solve story problems in arithmetic and algebra. Often such stories include irrelevant as well as relevant information. The trick to solving the problems is to encode the relevant information and to ignore the irrelevant parts.

The third and the fourth change mechanisms are generalization and strategy construction. Generalization is the extension of knowledge acquired in one context to other contexts. Strategy construction is the generation or discovery of a new procedure for solving a problem. The workings of generalization and strategy construction can be illustrated through a single example. After repeated experience with suddenly nonfunctioning computers, lamps, toasters, and radios, a child might reach the generalization that when machines do not work, it often is due to their being unplugged. On drawing this generalization, the child might form a strategy of always checking the plug whenever pushing a machine's "on" button has no effect.

The child's construction of this strategy illustrates that change processes work together rather than in isolation. Constructing the check-the-plug strategy depended on automatizing the perception of the machines sufficiently to encode the plug as a separate part of each machine and on drawing the generalization that machines that have plugs usually do not work when the plug is disconnected. As will be evident throughout this book, these four change processes—automatization, encoding, generalization, and strategy construction—play crucial roles in improvements in children's thinking in everything from infants' statistical learning to adolescents' computer programming.

**HOW DO INDIVIDUALS DIFFER?**

Just as children of different ages vary, so do children of any given age. Individual differences are present in all aspects of development, from height and weight to personality and creativity. However, they have received especially intense examination in the study of intelligence. This scrutiny began in earnest in the 1890s, when France initiated a program of universal public education. Recognizing that not all children would benefit from the same instruction, the French Minister of Education commissioned Alfred Binet and Theophile Simon to develop a test to identify children who would have difficulty learning from standard classroom procedures and who therefore would need special education.
The first Binet-Simon test was released in 1905. It included questions that were intuitively related to many aspects of intelligence: language, memory, reasoning, and problem solving. In 1916, Lewis Terman, a professor at Stanford University, revised the test for use in the United States and labeled it the Stanford-Binet. Updated versions remain in wide use today.

The Stanford-Binet and other intelligence tests are based on the assumption that not all children of a given age think and reason at the same level. Some 7-year-olds reason as well as the average 9-year-old; others reason no better than the average 5-year-old. To capture these individual differences among children, intelligence tests distinguish between a child’s *chronological age* (CA) and the child’s *mental age* (MA). Chronological age reflects the time since the child was born; if a girl was born 60 months ago, her chronological age is 5 years. Mental age is a more complex idea in that it reflects the child’s performance on an intelligence test relative to that of other children. Specifically, a child’s mental age is defined as the age at which 50 percent of children answer correctly as many items on the test as the particular child did. For example, if the average 5-year-old correctly answers 20 questions on a test, then a child who answered 20 items correctly would have a mental age of 5 years, regardless of whether the child is a 4-year-old, a 5-year-old, or a 6-year-old.

Terman saw that the implications of a 4-year-old, a 5-year-old, and a 6-year-old having a mental age of 5 years are quite different. For a 4-year-old, this level of performance is precocious; for a 5-year-old, it is average; for a 6-year-old, it is slow. To express these implications numerically, Terman borrowed an idea developed by Wilhelm Stern, a German psychologist, and combined the concepts of mental and chronological age to form an *Intelligence Quotient*, or IQ. A child’s IQ is the ratio between the child’s mental and chronological ages. This ratio is multiplied by 100, so that the IQ can be expressed as an integer, as shown below:

\[
IQ = \frac{\text{Mental Age}}{\text{Chronological Age}} \times 100
\]

Thus, in Terman’s example, the 6-year-old who had a mental age of 5 years would have an IQ of 83 (5/6 x 100), whereas the 4-year-old who had a mental age of 5 years would have an IQ of 125 (5/4 x 100). When we consider all children of a given chronological age, their average IQ score is 100, since the average mental age for any age group is, by definition, the same as that group’s chronological age. Whether the IQ score is above or below 100 (that is, whether the child’s mental age exceeds or falls below his or her chronological age) indicates whether the child scored above or below average for the age group; the distance of the score from 100 indicates how far above or below average the score was.

One reason that IQ scores have been used so widely is that they predict performance in school quite well. Another reason is their stability over long periods of time. For example, a 6-year-old’s IQ quite accurately predicts the child’s IQ at
age 16. The relation is not perfect; some children show large increases in IQ over time, and others show large decreases. There is also considerable controversy about what intelligence is and how well these or other tests measure it. Clearly, however, intelligence test scores tend to be quite stable from first grade to adulthood, and they allow quite accurate prediction of school achievement.

Until recently, no comparable predictive relation between early and later performance had been established for very young children. Scores on intelligence tests developed for children below 4 years were essentially unrelated to IQ scores of the same children when they were older. This suggested that individual differences in infant intelligence might be unrelated to individual differences in later intelligence.

Recently, however, a measure of infants’ information processing has revealed some continuity between intelligence in infancy and intelligence in later childhood. The measure is surprisingly simple. When infants are repeatedly shown a stimulus, such as an object or a picture, they lose interest in it and look at it less and less. That is, they habituate to it. Individual infants habituate at varying rates; some reduce their looking quite quickly, whereas others take much longer to do so. The key finding is that the more rapidly that 7-month-olds habituate (stop looking), and the greater their preference for a new picture after they have habituated (often called “novelty preference”), the higher their IQ scores tend to be 4 to 10 years later (Colombo, 1993; Fagan & Singer, 1983; Rose & Feldman, 1995, 1997; Sigman, Cohen, & Beckwith, 1997). The habituation rates also are related to later achievement test scores in reading and mathematics and to general language proficiency. Further, children whose habituation rates are slowest at 7 months have higher rates of learning disabilities when they are 6-year-olds (Rose, Feldman, & Wallace, 1992).

Why should rate of habituation at 7 months predict IQ and achievement test scores years later? One explanation is that both the early and the later performance reflect the effectiveness of the child’s encoding (Bornstein & Sigman, 1986; Colombo, 1993, 1995). In other words, more intelligent infants are quicker to encode everything of interest about the picture, leading them to be the first to lose interest in it. They perk up more when the new picture is shown because they more clearly encode the differences between it and the old one. Superior encoding has also been found to be related to the ability of gifted older children and adolescents to solve problems and learn quickly (Sternberg, 1999). Thus, quality of encoding may link early and later intellectual capabilities.

The large majority of research on intelligence and other areas of cognitive development focuses on individual children’s behavior. However, in trying to gain additional insights, researchers have recently been extending the search both inward and outward. The inward-looking efforts examine how development of the brain is related to changes in children’s thinking. The outward-looking efforts consider not only the individual child but also the formative influences of other people and of cultural institutions. Thus, the first approach builds on findings