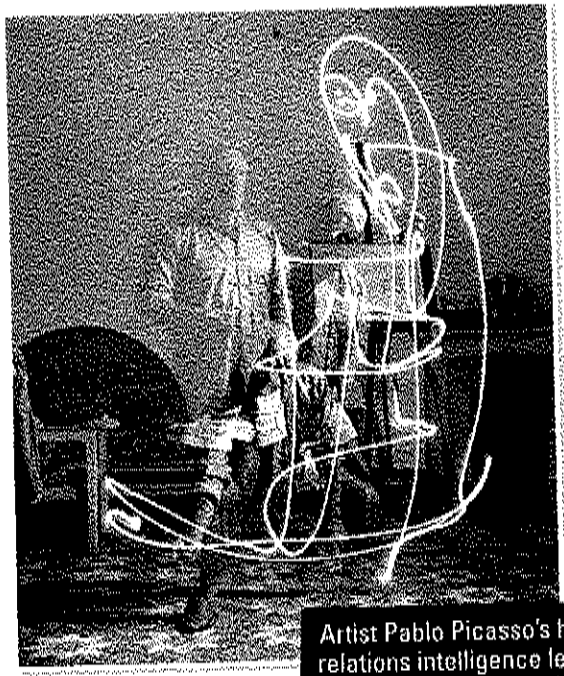
CHAPTER 9

INTELLIGENCE

Most of the famous creators Gardner studied had to struggle to win acceptance for their ideas. When acceptance came too easily, some even made a special effort to be unconventional because they felt it made them more creative.

Gardner points out that each and every characteristic will not be true for all creative individuals. However, as a general profile, quite a few of the details should hold true. As you will learn in this chapter, creativity is not the same as intelligence. But the seven major figures Gardner profiled possessed both exceptional creativity and exceptional intelligence.



Artist Pablo Picasso's high spatial-relations intelligence led him to invent new styles and helped him to create masterpieces of visual art.

What do you think?

1. What seven types of intelligence did Gardner's Exceptional Creators demonstrate?
2. What living person do you consider an Exceptional Creator? How does he or she exhibit the common characteristics of creators?

Chapter at a Glance

SECTION 1: What Is Intelligence?

- Intelligence is different from achievement.
- Psychologists have developed several different theories of intelligence.

SECTION 2: Measurement of Intelligence

- Psychologists use tests to measure a person's intelligence.
- Intelligence tests must be both reliable and valid.
- Problems with the use and design of intelligence tests have led to some controversies.

SECTION 3: Differences in Intelligence

- Most people have average intelligence.
- There are several levels of mental retardation.
- The gifted have high intelligence and special talent.
- Creativity is independent of intelligence.

SECTION 4: What Influences Intelligence?

- Genetic factors have a strong influence on intelligence.
- A nurturing environment promotes intellectual development in children.
- Advanced age limits some aspects of intelligence.

SECTION 1

What Is Intelligence?

Before You Read

Main Idea
Psychologists have many different theories of intelligence.

Reading Focus
1. How is human intelligence a puzzle?
2. What are some of the leading theories of intelligence?

Vocabulary
achievement
intelligence

TAKING NOTES Use a graphic organizer like this one to take notes on intelligence.

Theory	Description

Kasparov vs. the Computer

PSYCHOLOGY CLOSE UP

Can a computer be a Grand Master?

Garry Kasparov reigned as world chess champion from 1985 to 2000. One of his rare defeats during this period came in a 1997 match against an IBM supercomputer known as Deep Blue. In a 1996 match, Kasparov had beaten Deep Blue handily: three wins, two draws, and one loss. But through five games of the rematch, Deep Blue held Kasparov to one win, three draws, and one loss. In the sixth game, a tired Kasparov accidentally reversed two steps in a well-known defensive maneuver. Deep Blue immediately took advantage by taking Kasparov's queen. Kasparov soon admitted defeat.

Deep Blue was an example of artificial intelligence (AI), a broad field that involves the creation of "thinking machines." Recent innovations in artificial intelligence have produced even more powerful machines, such as IBM's "Watson." Unlike Deep Blue, which was designed only to play chess, Watson analyzes natural language to find patterns in unstructured data. This substantially broadens the scope of what Watson can learn and do in comparison to its predecessors. These machines include everything from industrial robots to speech-recognition devices to game-playing computers. A computer designed specifically for one particular intellectual task, as Deep Blue was, is called an expert system.

Although it could be an expert, can any computer be truly intelligent? Some computers do one particular task better than humans. But no computer can perform as many different tasks as the human brain. After retiring from competitive chess in 2005, Kasparov turned his attention to Russian politics. Deep Blue was built only to beat Kasparov. After its victory, IBM disassembled the machine.

The Intelligence Puzzle

Intelligence is one characteristic that sets humans apart from other forms of life. Although other animals display intelligence, humans' capacity to adapt to changing conditions sets them apart from other animals.

The human ability to think about abstract ideas, such as space and time, also sets us apart from all other species. Intelligence has even expanded our senses, enabling us to invent microscopes and telescopes to see things too small or distant for the naked eye to detect. This chapter examines how intelligence is defined and measured. It also discusses differences in intelligence and considers the factors that influence intelligence.

The nature of intelligence varies. People can be very intelligent and not know many facts about academic subjects because they have not studied. People can also know a great deal because they have worked hard, even if their intelligence is not particularly high. But what exactly is intelligence?

Understanding Achievement According to psychologists, one thing intelligence is *not* is **achievement,** which refers to knowledge and skills gained from experience. In other words, achievement focuses on the things that you know and can do. Thus, achievement involves specific content, such as Spanish, calculus, history, psychology, biology, art, or music.

The relationship between achievement and experience is obvious. If you have spent many hours reading about the Civil War, for example, then you will probably do well on a test about that period in U.S. history. You will have gained knowledge on the subject of the Civil War. But if you were tested on the Revolutionary War instead, you might not do as well.

Although intelligence is not the same as achievement, intelligence can provide the *basis* for achievement. Intelligence makes achievement possible by giving people the ability to learn.

For example, consider two students who are both fascinated by mathematics. Suppose that they both take exactly the same math classes and spend the same amount of time studying the subject. The only difference between the two is that student A is more intelligent than student B. Despite the equality of opportunity and effort, student A will gain more knowledge and skills from the mathematics classes than student B. Intelligence helps student A achieve more than student B.

Understanding Intelligence Now we know what intelligence is *not*. But what is it? **Intelligence** can be defined as the abilities to learn from experience, to think rationally, and to deal effectively with others. Within that definition, psychologists have differing theories about what exactly makes up intelligence.

Reading Check **Analyze** What is the difference between achievement and intelligence?

Theories of Intelligence

Some people have very strong science or math skills. Others are talented in music or art. Still others have the ability to get along well with other people. Are all of these abilities signs of intelligence? Is any of them? How many factors are involved in intelligence?

Throughout human history, many philosophers and scientists have speculated about the answers to these questions. The Greek philosopher Plato devoted much of his writing to examining the nature of intelligence and the human mind. French philosopher Blaise Pascal suggested that there were two types of intelligence: mathematical and intuitive. In the 1800s, the rise of psychology as a science led to new theories of intelligence.

Spearman's Two-factor Theory Around 1900, psychologist Charles Spearman observed that people who do well on one type of intelligence test tend to do well on others, too. He suggested that general intelligence, which he labeled *g*, underlies all of our intellectual abilities. The *g* factor represents the abilities to reason and to solve problems.

The SATs, which break intellectual skills into verbal, quantitative, and writing subtests, reflect a more or less unified factor, which some psychologists refer to as *g*. At the same time, all people are better at some things than others—such as math, music, or writing. For this reason, Spearman suggested that specific, or *s*, factors account for people's specific abilities. Taken together, *g* and *s* explained Spearman's observations.

Thurstone's Theory of Primary Mental Abilities Many psychologists accepted Spearman's two-factor theory of intelligence. One who took exception was L. L. Thurstone, a specialist in psychological testing. In the 1930s Thurstone argued that Spearman's tests were flawed. Thurstone's own tests showed that instead of one general intelligence, there were seven "primary mental abilities": word fluency, verbal comprehension, spatial visualization, facility with numbers, memory, reasoning, and perceptual speed. Further testing led him to include something similar to Spearman's *g* in his theory.

ACADEMIC VOCABULARY
facility ability or aptitude

Gardner's Theory of Multiple Intelligences Later psychologists began to wonder whether all forms of intelligence could be measured through testing. Psychologist Howard Gardner considered a wide variety of studies and cultures to develop a new theory. In 1983 Gardner proposed a set of seven intelligences, which he later expanded to nine.

- verbal, or linguistic, intelligence
- logical-mathematical intelligence
- visual-spatial intelligence
- bodily-kinesthetic intelligence (such as dancers and athletes have)
- musical-rhythmic intelligence
- interpersonal intelligence (sensitivity to other people's feelings)
- intrapersonal intelligence (insight into one's own inner feelings)
- naturalist intelligence (understanding of nature and the laws that govern natural behavior)
- existential intelligence (insight into the larger philosophical issues of life)

Gardner refers to these talents or abilities as intelligences because they can be quite different from one another. In addition, he proposes that the different intelligences are independent of each other.

For example, one student might have strong scientific ability but little talent at music. Another student might have special musical-rhythmic ability but few athletic skills. A student athlete might have highly developed bodily-kinesthetic skills but limited scientific abilities.

Critics of Gardner's theory of multiple intelligences state that exceptional abilities in the musical or bodily-kinesthetic areas are not really what is meant by intelligence. His critics argue that those skills are special talents and that being talented is not the same thing as being intelligent.

Sternberg's Triarchic Theory In 1985 psychologist Robert Sternberg published his triarchic theory of intelligence. This theory breaks intelligence into the following three factors:

- analytical intelligence (the type of intelligence we use in academic courses)
- creative intelligence
- practical intelligence

Some people might excel in their schoolwork, while other people might be more creative or have more practical intelligence, or "street smarts." Practical intelligence includes abilities such as knowing how to discuss a grade with a teacher or what to do if you discover that you have lost your wallet.

Sternberg's Triarchic Model

Sternberg divided intelligence according to the way people process information. Everyone is capable of using the three types of intelligence to some degree. But each person tends to excel at one type. This chart shows some tasks performed by each type of intelligence.

Analytical Intelligence
- calculating expenses and profits
- diagramming a sentence
- measuring the results of a chemistry experiment

Creative Intelligence
- painting a portrait
- writing a song
- cooking a meal with the ingredients on hand

Practical Intelligence
- changing a tire
- negotiating with an employer
- leading a group on a tour of your school

Skills Focus **INTERPRETING CHARTS** What kind of intelligence are you using when you answer test questions? Explain.

Some students with limited analytical skills do very well in school—and afterward—because they are creative or have street smarts.

We often use more than one of Sternberg's three factors at the same time. If you were doing an experiment for an upcoming science fair, you might use practical intelligence to plan your time and to obtain the materials you need. You would use your analytical intelligence to interpret the results of your experiment. In addition, you would use your creative intelligence to design the display for your project.

Emotional Intelligence Psychologists Peter Salovey and John Mayer became interested in why smart people are not always as successful as might be expected. In 1990 they proposed yet another kind of intelligence: emotional intelligence. The theory gained popularity in 1995 with the publication of the book *Emotional Intelligence* by psychologist Daniel Goleman. Emotional intelligence, said Goleman, consists of five factors that are involved in success in school or on the job:

- **Self-awareness**: the ability to recognize our own feelings. If we know how we feel, we can better cope with our feelings.
- **Mood management**: the ability to distract oneself from an uncomfortable feeling. Although we may not be able to prevent feelings of anger or sadness, we do have some control over how long the feelings last. Rather than dwell on bad feelings, we can distract ourselves or make changes to improve our situation.
- **Self-motivation**: the ability to move ahead with confidence and enthusiasm. People who are self-motivators sometimes accomplish more than less motivated people who obtain higher scores on intelligence tests.
- **Impulse control**: the ability to delay pleasure until the task at hand has been accomplished. A student who resists the temptation to watch television until her or his homework is done may do better in school than a student who puts off homework until later.
- **People skills**: the ability to empathize, understand, communicate, and cooperate with others. People skills help us get along with others, and getting along with others helps us in school and on the job.

A "class clown" may have exceptional people skills. According to the new theory, such people could be considered emotionally intelligent. Emotional intelligence captured the interest of many psychologists and led to new research on the subject.

Reading Check **Summarize** Name and describe the theory of intelligence that suggested that there was a single, basic intelligence.

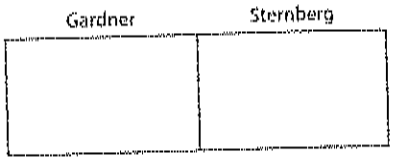
SECTION 1 Assessment

Reviewing Main Ideas and Vocabulary

1. **Define** What is intelligence?
2. **Identify** What seven forms of intelligence did Thurstone propose?

Thinking Critically

3. **Summarize** How did Spearman use *g* and *s* to explain intelligence?
4. **Explain** What did Spearman and Thurstone's theories of intelligence have in common that later psychologists began to question?
5. **Support a Position** Do you agree that all nine of Gardner's intelligences are really forms of intelligence? If so, choose one of the non-academic intelligences and explain why it qualifies as a form of intelligence. If not, choose one and explain why you think it is not a form of intelligence.
6. **Compare** Using your notes and a graphic organizer like the one below, align Gardner's nine intelligences with Sternberg's triarchic model.



FOCUS ON WRITING

7. **Descriptive** Decide which of Sternberg's three types of intelligence is your strongest. Write a paragraph describing a situation in which you displayed this form of intelligence.

SECTION 2

Measurement of Intelligence

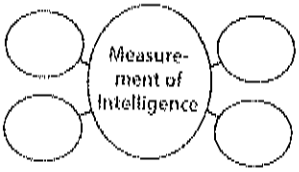
Before You Read

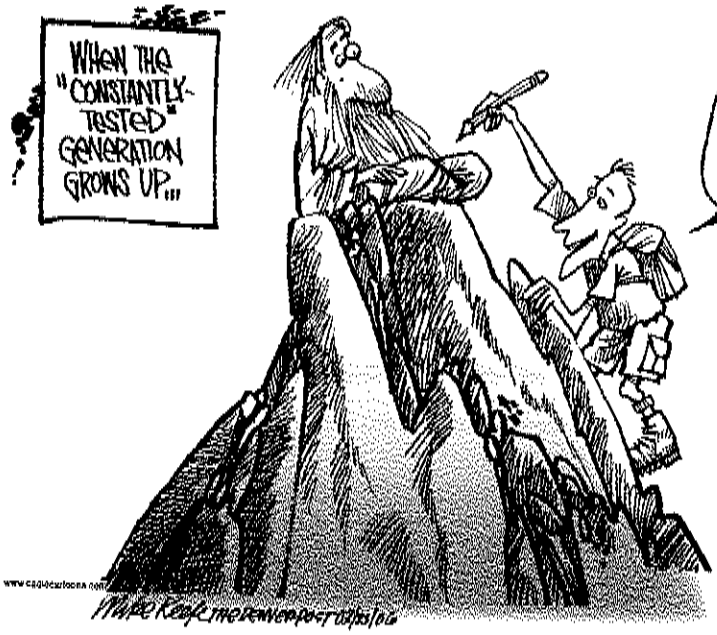
Main Idea
Psychologists have developed different kinds of intelligence tests. To be useful, the tests must be reliable and valid.

Reading Focus
1. What are the two most widely used intelligence tests?
2. How are test reliability and validity measured?
3. What are some controversies and problems associated with intelligence tests?

Vocabulary
mental age
intelligence quotient
transformed score
reliability
test-retest reliability
validity

TAKING NOTES Use a graphic organizer like this one to take notes on intelligence testing.





People Just Keep Getting SMARTER

PSYCHOLOGY CLOSE UP

Why do scores keep rising on intelligence tests? Educators, politicians, and the media frequently worry over declining academic standards and students who don't care. But psychologist James Flynn discovered something that might brighten the worriers' mood: people actually seem to be getting smarter, not dumber.

While researching intelligence tests used by the U.S. military, Flynn discovered something odd. Each time the tests were updated, some recruits would take both the old and the new version. And each time, their average score was higher on the old test than on the new test. Since IQ scores reflect the intelligence of the general population, the recruits compared more favorably against people from several years before than against people today. In other words, average intelligence was rising.

To confirm his findings, Flynn looked at results from several types of intelligence tests and many different cultures. Regardless of the type of test or the nationality of the test taker, he found that people seemed to be getting smarter. After publishing his results, the trend became known as the Flynn Effect.

Why is this happening? Flynn considered and ruled out several theories. Better nutrition doesn't seem to be the answer; neither does better schooling. One of the sturdiest hypotheses is that as our society becomes more complex and more technological, our brains are faced with more challenges from an early age. This rich environment may help us make the most of our mental capabilities.

Two Intelligence Tests

You have probably taken many tests throughout your school career. Some of the tests you have taken or will take are achievement tests—they show what you have learned. Other tests are aptitude tests, which are intended to predict your ability to learn new skills. There are also tests that are designed to measure intelligence. The most widely used intelligence tests are the Stanford-Binet Intelligence Scale and the Wechsler scales.

The Stanford-Binet Scale In the early 1900s, leaders of the French public school system were interested in finding a test that could identify children who were likely to need special educational attention. In response, French psychologist Alfred Binet devised the first modern intelligence test. The original version of the test was first used in 1905.

Binet assumed that intelligence increased with age, so his test contained questions for children of different age levels. Older children were expected to answer more difficult questions. Children earned "months" of credit for correct answers.

Binet's test yielded a score called a mental age. A child's mental age is not the same thing as his or her chronological age. **Mental age** (MA) shows the intellectual level at which a child is functioning. For example, a child with an MA of six is functioning, intellectually, like the typical six-year-old, even if the child is not six years old. An MA of nine is above average for a seven-year-old. The same MA of nine is below average for an 11-year-old.

In 1916 Binet's test was brought to the United States and revised by Louis Terman of Stanford University. For this reason, the test became known as the Stanford-Binet Intelligence Scale (SBIS).

The version of the Stanford-Binet test used today provides an intelligence quotient, not an MA. An **intelligence quotient** (IQ) is a number that reflects the relationship between a child's mental age and his or her actual, or chronological, age (CA). The IQ is a *quotient* because we use division to obtain the number. The IQ was initially computed using the formula IQ = (mental age divided by chronological age) × 100, or

$$IQ = \frac{\text{Mental Age (MA)}}{\text{Chronological Age (CA)}} \times 100$$

For example, a child with an MA of nine and a CA of nine would have an IQ of 100.

STANFORD–BINET INTELLIGENCE SCALE

These items are similar to those that appear on the Stanford-Binet Intelligence Scale. That test includes tasks for age levels from two to adult. The Stanford-Binet test produces an intelligence quotient, or IQ, that compares mental age to chronological age.

Age Level	Sample Item 1	Sample Item 2
2 years	Children know basic vocabulary words. When the examiner says, "Show me the hands" (or other part), they can point to the proper parts of a doll.	Children can match a model by building a tower made up of four blocks.
4 years	Children show language and classifying ability by filling in a missing word: "Father is a man; mother is a _____."	Children show general understanding by answering questions such as: "Why do people have cars?"
9 years	Children can point out absurdities. "Sally has a bicycle with square wheels. What is silly about that?"	Children show language ability by responding to queries such as: "What number rhymes with *sea*?"
Adult	Adults show vocabulary knowledge and conceptual thinking by explaining the differences between word pairs such as "honor" and "glory."	Adults show spatial skills by answering questions such as: "If a car turned to the left to head south, in what direction was it heading before it turned?"

Skills Focus **INTERPRETING CHARTS** At what age are children expected to recognize absurdities?

Children who answer test items as competently as older children have IQs above 100. An 8-year-old who does as well as the average 10-year-old will attain an IQ of 125. Children who do not do as well as typical children their age attain IQ scores below 100.

The intelligence quotient is an example of a **transformed score**—any score that has been changed from a raw score in a systematic way. Psychologists transform raw scores so that test results can be more easily compared.

The Wechsler Scales The Stanford-Binet is the "classic" individual intelligence test. Today, however, David Wechsler's scales are more widely used. Wechsler developed intelligence tests for children and adults. The most widely used test is the revised Wechsler Adult Intelligence Scale (WAIS-R).

The Wechsler scales consist of several subtests. Each subtest measures a different intellectual skill. Some of Wechsler's subtests measure verbal skills. Others assess performance skills. In general, verbal subtests involve words and ideas; performance subtests focus on spatial relations. Both verbal and performance subtests require reasoning ability. The Wechsler scales reveal relative strengths and weaknesses as well as overall intellectual functioning.

ACADEMIC VOCABULARY
assess to judge or determine

The Wechsler scales differ from the Stanford-Binet test in several important ways. The Wechsler scales do not use the concept of mental age, although they still use the term IQ. The Stanford-Binet test measures verbal ability, whereas the Wechsler scales measure both verbal and nonverbal abilities. Because the Wechsler tests yield three scores (verbal, nonverbal, and combined), they can be used to identify particular learning disabilities. For example, if an individual's verbal score is significantly lower than his or her nonverbal score, this might indicate a reading disability.

Scores on the Wechsler tests are based on a comparison of a person's answers with the answers of others in the same age group. The average score for any age level is 100. About 50 percent of scores fall within a broad range of 90 to 110. About 2 percent of people who take the tests score above 130, and about 2 percent score below 70.

Reading Check **Identify** What is now the most widely used intelligence test?

Reliability and Validity

The results of intelligence tests affect people's lives, so psychologists hold the tests to high standards. Intelligence tests (and other types of psychological tests) must meet two criteria: they must be *reliable* and *valid*.

Test Reliability Imagine that every time you measured the width of your desk with a tape measure, it showed a different result. If this happened, we would say that the tape measure was an unreliable form of measurement. The **reliability** of a test refers to its consistency. A test or any other method of assessment is reliable if it gives a highly similar score every time it is used. A reliable intelligence test should obtain similar IQ scores for the same individual on different testing occasions.

There are different ways of showing a test's reliability. One of the most common is called **test-retest reliability.** Test-retest reliability is determined by comparing scores earned by the same person on the same test taken at different times. The Stanford-Binet and Wechsler tests are both highly reliable. For example, if you took the Stanford-Binet in your first year of high school and again in your senior year, your IQ score would probably be nearly the same both times.

Keep in mind that "nearly the same" does not mean "identical." Scores for the same person on different testing occasions may vary somewhat. A person may be more motivated or attentive one day than another. Also, scores may improve as subjects become familiar with the test format. In addition, intelligence is not fixed—it varies over time. Some intellectual skills may increase with education; some may decline with age, injury, or health problems.

Test Validity A test has **validity** if it measures what it is supposed to measure. To see whether a test is valid, test scores are compared with outside standards or norms. A proper standard for checking the validity of a musical aptitude test might be the ability to learn to play a musical instrument. Tests of musical aptitude therefore should predict ability to learn to play a musical instrument.

What standards might be used to check the validity of intelligence tests? Most people agree that intelligence plays a role in academic success. Intelligence test scores should

TYPICAL SUBTESTS FROM THE WECHSLER SCALES

The Wechsler scales consist of subtests that measure different skills. These are examples of items similar to those that appear on the various subtests.

Verbal Subtests

General Information

1. How many legs does a dog have?
2. How many nickels make a quarter?
3. What is ice made of?
4. Who wrote *Harry Potter*?
5. What is salt?

Similarities

1. How are a wolf and a fox alike?
2. How are a saw and a hammer alike?
3. How are a day and a week alike?
4. How are a circle and a square alike?

General Comprehension

1. What should you do if you see someone forget her coat when she leaves a restaurant?
2. Why does some food need to be stored in a refrigerator?
3. Why is copper often used in electrical wires?

Vocabulary

This test consists simply of asking "What is a _____?" or "What does _____ mean?" The words cover a wide range of difficulty.

Arithmetic

1. Sam had two pieces of fruit, and Joe gave him four more. How many pieces of fruit did Sam now have?
2. Four women divided 12 eggs equally among themselves. How many eggs did each person receive?
3. If two buttons cost 20 cents, how much would a dozen buttons cost?

Performance Subtests

Digit Symbol

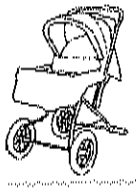
The subject is tested on the ability to associate meaningless figures with specific numbers.

Block Design

The subject is tested on the ability to recreate geometric designs using colored blocks.

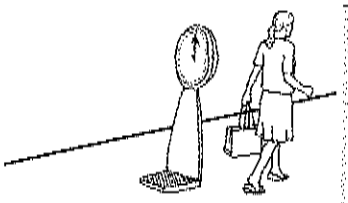
Picture Completion

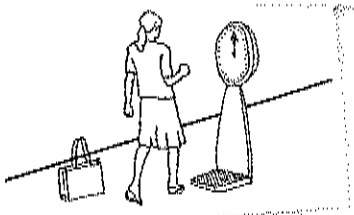
The subject is asked to identify what is missing from a picture like this.

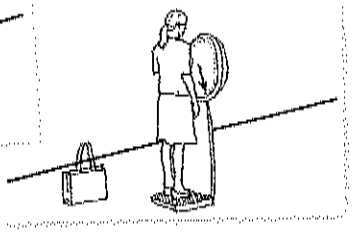


Picture Arrangement

The subject is tested on the ability to arrange pictures such as these in a sequence so that they tell a story.







therefore predict school grades. They do so moderately well. Intelligence is also thought to contribute, in part, to job success. Scores on intelligence tests have been shown to predict adult occupational status reasonably well. Thus, these intelligence tests seem to be reasonably valid. However, because there is considerable disagreement about what intelligence is, some psychologists believe that it is difficult to make definitive statements about the validity of IQ tests.

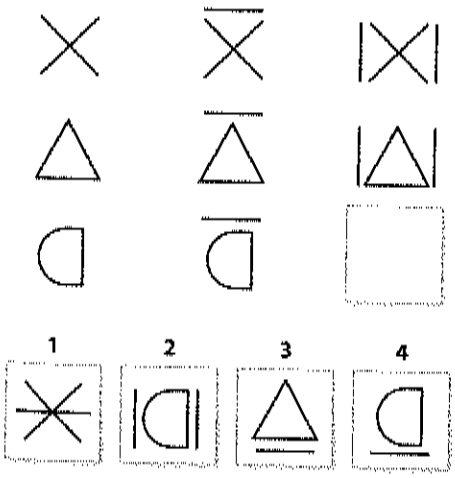
Reading Check **Infer** What scores would you expect if a person took an unreliable test several different times?

Controversies and Problems

Intelligence testing has become an accepted part of our culture. But the history of intelligence testing is full of controversies, some of which have yet to be resolved. In addition, psychologists point to problems with intelligence tests that may affect results.

Controversies In the late 1800s many began to see intelligence testing as a way to improve society. Movements sought to elevate the most intelligent people to positions of importance. But they also wanted to reduce the numbers of the least intelligent people.

TESTS THAT MINIMIZE CULTURAL BIAS



Find the pattern in the first two rows. Identify the symbol that completes the third row.
Do math tests have cultural bias? Explain.

In the early 1900s the United States used intelligence tests to determine which immigrants would be allowed into the country. Those who did not score well were deported. During the same period, many states sterilized people who were found to be "mentally defective." The horrors perpetrated by Nazi Germany in the name of social purity brought an end to these misuses of intelligence tests.

Another controversy around intelligence testing is cultural bias. Critics charge that some tests give an advantage to a particular group because they are created by members of that group. People who are not members of that group would find such tests more difficult. For example, a question about building an igloo would be easier for Inuit, who live in the Arctic, but more difficult for most other people. In theory, tests that are free from cultural bias ought to be possible. The challenge is to develop questions that test a particular skill regardless of the test-taker's culture.

Problems Intelligence tests are not perfect. Some test takers do better than others, but not necessarily because they are more intelligent. Other factors—such as education or economic background—can make a difference.

Motivation to do well also contributes to performance on intelligence tests. Faced with frequent failure, a person may begin to expect to fail. Without the motivation to try his or her best, failure becomes more likely.

Expectations are especially important when test takers are members of a group with negative stereotypes. When people know about a negative stereotype that applies to them—regardless of the truth of the stereotype—the expectation can be self-confirming. This is called stereotype threat. Studies have shown that reminding subjects about a negative stereotype before they take a test can result in performance that does not match true abilities. Conversely, subjects who are reminded of positive stereotypes tend to perform better than expected.

Reading Check **Identify Supporting Details** What are two ways in which an intelligence test might show cultural bias?

SECTION 2 Assessment

Reviewing Main Ideas and Vocabulary

1. **Define** What is mental age?
2. **Explain** Why is IQ called a *quotient*?
3. **Recall** What two criteria must all intelligence tests meet?

Thinking Critically

4. **Evaluate** If a 10-year-old boy takes the Stanford-Binet test and scores as well as a 12-year-old, what would his IQ be?
5. **Explain** How is test-retest reliability determined?
6. **Interpret** How is the following question culturally biased? *Lawrence and Molly go to the opera once a month. About how many arias do they hear each year?*
7. **Compare and Contrast** Using your notes and a graphic organizer like the one below, compare the Stanford-Binet test to the Wechsler scales.

Similarities	Differences

FOCUS ON WRITING

8. **Persuasive** A politician proposes a new law to require voters to have an average score or higher on an intelligence test. Anyone with a below-average score cannot vote. Write a letter to the editor explaining the pitfalls of this proposal.

SECTION 3

Differences in Intelligence

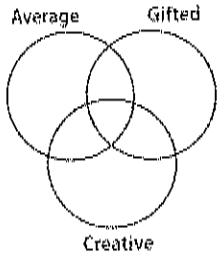
Before You Read

Main Idea
Most people have average intelligence. A few have either very high or very low intelligence.

Reading Focus
1. What is average intelligence?
2. How is mental retardation defined?
3. Does giftedness just mean being very smart?
4. What is creativity?

Vocabulary
mental retardation
gifted
prodigy
creativity

TAKING NOTES Use a graphic organizer like this one to take notes on differences in intelligence.



PSYCHOLOGY CLOSE UP

Intelligence AND Autism

Does autism help Temple Grandin understand animals?

Autism is a complex neurological disorder that affects millions of people. Generally, autistic people have difficulty interacting with others and may focus intensely on one object or subject. For many years, autism was treated as a kind of mental retardation. As the disorder has become better understood, psychologists have realized that some autistic people have normal intelligence. And a few people with autism display extraordinary gifts.

Temple Grandin, for example, has autism and a gift for understanding animals. She first realized this ability as a teenager. She felt more at ease among the animals at her aunt's ranch than among people. Grandin pursued her interest in animals and eventually earned advanced degrees in animal science.

While completing her degrees, Grandin began visiting a meat-packing plant, where she observed that the animals were in distress. She realized that the design of the chutes and pens was one of the chief causes of stress for the animals. The manager of the plant, who had gotten to know Grandin through her many visits, offered her the chance to redesign the layout to make it easier on the animals. Her design succeeded, and she began a career designing more animal-friendly environments.

Temple Grandin credits the support she received at every step of her life for helping her make the most of her talents. As more autistic people receive such support, their intelligence will shine through.

Average Intelligence

Despite the limits of intelligence tests, they do have some uses. One of the primary functions of intelligence tests is to help identify people whose intelligence is out of the ordinary—at either end of the scale. The education system best suits people of average intelligence. Those with extremely high or extremely low intelligence need special accommodations.

The average IQ score is 100. This is by design. Test-makers administer drafts of their tests to sample populations in order to confirm that the tests are reliable and valid. They use the results to calibrate how the tests are scored. The mean average score becomes the mid-point, or 100. When the general population takes the test, a person's score should reflect her or his intelligence in relation to all the other people taking the test.

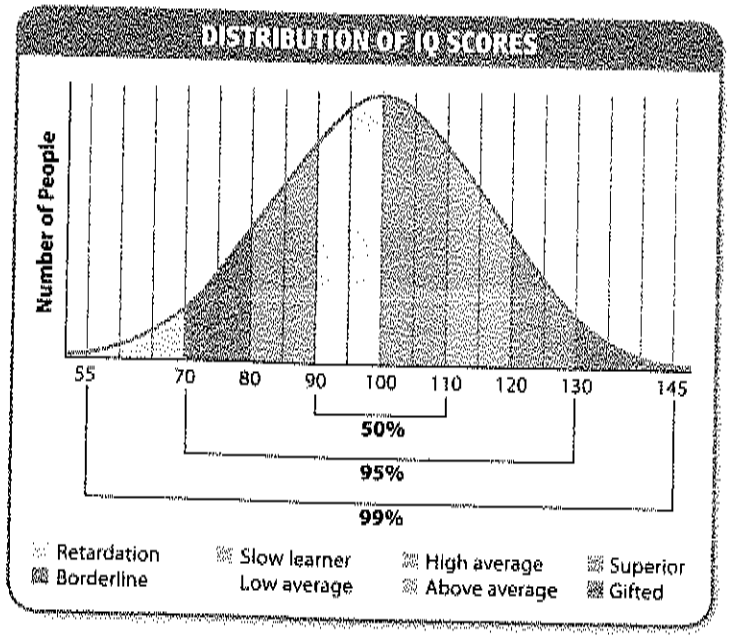
About half of the people in the United States attain scores in the broad average range from 90 to 110. Nearly 95 percent attain scores between 70 and 130.

What about the other 5 percent? People who attain IQ scores of 70 or below are defined by psychologists as having mental retardation. People who attain scores of 130 or above are regarded as gifted. In both cases, special help is needed.

Reading Check **Find the Main Idea** What is the average score on an intelligence test?

Statistically Speaking...

IQ Scores Psychologists refer to this bell-shaped graph as a "normal distribution." Many traits, including intelligence, are distributed along normal curves.



50% Percentage of people whose intelligence scores range from 90 to 110

2 to 6 Estimate of how many points intelligence scores rise every 10 years

120 million Approximate number of standardized tests given to U.S. students each year

Skills Focus **INTERPRETING GRAPHS** Why is the bell curve tallest at the center?

Mental Retardation

While having an IQ score at or below 70 is the technical definition of **mental retardation,** there are other indicators as well. Mental retardation is also associated with problems in communication, taking care of oneself, social skills, self-direction, travel in the community, and vocational training. There are several levels of mental retardation.

Mild Retardation About 80 percent of people with retardation are classified as mildly retarded, with IQs ranging from 50 to 70. Such people often are not obviously retarded, but as children they have more difficulty than most other children in learning to walk, in feeding themselves, and in learning to talk. Most children with mild retardation are able to learn to read and do arithmetic. As adults, they often are able to take care of themselves and hold jobs. They may, however, need occasional guidance and support.

Moderate Retardation People with IQ scores from 35 to 49 have moderate retardation. They can learn to speak, to feed and dress themselves, and to work under supportive conditions. They usually do not learn to read or to solve math problems. Children with Down syndrome are most likely to be classified in the moderately retarded range.

Although adults with moderate retardation are usually not capable of self-maintenance, they can participate in simple recreation and travel alone in familiar places.

Severe Retardation People with severe mental retardation—IQs of 20 to 34—usually require constant supervision. They may have some understanding of speech and be able to respond. Although they can perform daily routines and repetitive activities, they need continuing direction in a protective environment. Some children in this category can learn some basic self-help tasks, such as self-feeding.

Profound Retardation People with profound retardation—IQs below 20—barely communicate. They may show basic emotional responses, but they cannot feed or dress themselves and are dependent on other people for their care throughout their lives.

Causes of Retardation Retardation can be caused by any of several factors. Accidents that result in brain damage and difficulties during childbirth can cause retardation. Pregnant women who abuse alcohol or drugs, are malnourished, or who have other health problems may give birth to children who are mentally retarded. Retardation also can be caused by genetic disorders or abnormalities, such as Down syndrome.

Reading Check **Identify** What are the four levels of mental retardation?

Giftedness

Technically speaking, people who are gifted have IQ scores of 130 or above. However, giftedness (like retardation) may be more than just a matter of IQ. In general, to be **gifted** is to possess outstanding talent or to show the potential for performing at remarkably high levels of accomplishment when compared with other people of the same age, experience, or environment.

The most gifted children are sometimes called child prodigies. A **prodigy** develops special skill in a particular talent or discipline in childhood. Prodigies perform at a level comparable to, or above, most adults in that field. Many prodigies benefit from parents who encourage and help develop their child's talent. Some famous prodigies are listed here.

Famous Prodigies

Visual Arts

Gian Lorenzo Bernini Bernini first learned to sculpt in the workshop of his father, a sculptor. By the age of 14, Bernini was crafting portrait busts for wealthy patrons. He created his first masterpieces in his early 20s. As a sculptor, architect, and painter, Bernini established the baroque style.

Music

Wolfgang Amadeus Mozart Mozart's father, Leopold, trained him as a musician from an early age. Mozart wrote his first composition at age 5 and gave his first public performance when he was 6. He had written 8 symphonies by the time he was 12. Mozart composed some of the world's greatest music.

Sports

Venus and Serena Williams The Williams sisters' father, Richard, raised them to be tennis stars. They each began winning amateur tournaments at the age of 10 and turned professional at age 14. Venus, the older sister, ranked 25th in the world by age 17. Serena ranked 21st in the world by age 16. They have both won many Grand Slam tournaments.

Math

Ruth Lawrence After being tutored at home by her father, Ruth Lawrence entered Oxford University at age 11. Two years later, she graduated with honors with a degree in mathematics. The next year, she had earned a second degree in physics. By the time Lawrence was 17, she had earned a doctorate in math.

Some researchers believe that motivation and creativity contribute to giftedness. Others emphasize the importance of insight. And many educators consider children with outstanding abilities to be gifted. The abilities can be in specific areas such as music, language arts, mathematics, or science. Children may be gifted in terms of leadership abilities or creativity, or they may exhibit excellence in the visual or performing arts.

ACADEMIC VOCABULARY
diminished reduced or weakened

On the basis of research and experience, educators generally recognize the importance of identifying gifted children early and providing them with rich, varied learning opportunities. Special schooling helps gifted children to develop their potential.

Reading Check **Summarize** What does it mean to be gifted?

Creativity

Giftedness is often linked with creativity. **Creativity** is the ability to invent new solutions to problems or to create original or ingenious materials. For example, some of Albert Einstein's best work grew out of his ability to visualize difficult problems. He developed the theory of special relativity by imagining what light would look like if an observer could move at the speed of light. Einstein himself recognized the value of creativity. He once said, "The true sign of intelligence is not knowledge but imagination."

CASE STUDY CONNECTION
Creative Genius Albert Einstein was both very intelligent and very creative.

Although creativity may be a part of giftedness, a person can be highly creative without being gifted. In fact, a person can even be substantially below average in intelligence and yet have very high creativity.

English psychiatrist Lorna Selfe identified one such person, a girl named Nadia. Nadia had diminished mental skills and could not speak. However, she had a remarkable talent for drawing, and her creative ability was indisputable. Nadia exemplified savant syndrome—a person who has autism or mental retardation yet exhibits extraordinary skill, even brilliance, in a particular field. About 10 percent of people with autism display special skills, but fewer than 1 percent of people with other mental disabilities do.

Research suggests that highly intelligent people are more likely than the average person to be particularly creative. Yet just as a high level of creativity does not guarantee high intelligence, high intelligence does not guarantee high creativity. For example, a Canadian study of gifted children ages 9 to 11 found that they generally were more creative than children who were average in intelligence. However, this was only true for the group as a whole. Some of the gifted individuals were no more creative than the children who were average in intelligence.

Reading Check **Draw Conclusions** Are all creative people highly intelligent? Explain.

SECTION 3 Assessment

Reviewing Main Ideas and Vocabulary

1. **Define** What is a prodigy?
2. **Recall** What is the technical definition of mental retardation?

Thinking Critically

3. **Support a Position** Does it make sense for the education system to be tailored to the needs of people of average intelligence? Why or why not?
4. **Identify Cause and Effect** What are some of the possible causes of mental retardation?
5. **Elaborate** How could someone be highly intelligent without being considered gifted?
6. **Explain** How could someone be highly creative without being highly intelligent?
7. **Categorize** Using your notes and a graphic organizer like the one below, describe the four levels of mental retardation.

Level of Retardation	Characteristics

FOCUS ON WRITING

8. **Expository** Imagine that someone creating an intelligence test accidentally used only extremely smart people to calibrate the test. Explain what would happen when the test was administered to the general population.

SECTION 4

What Influences Intelligence?

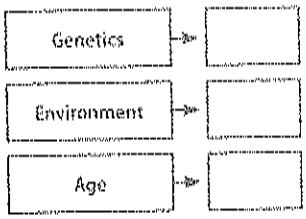
Before You Read

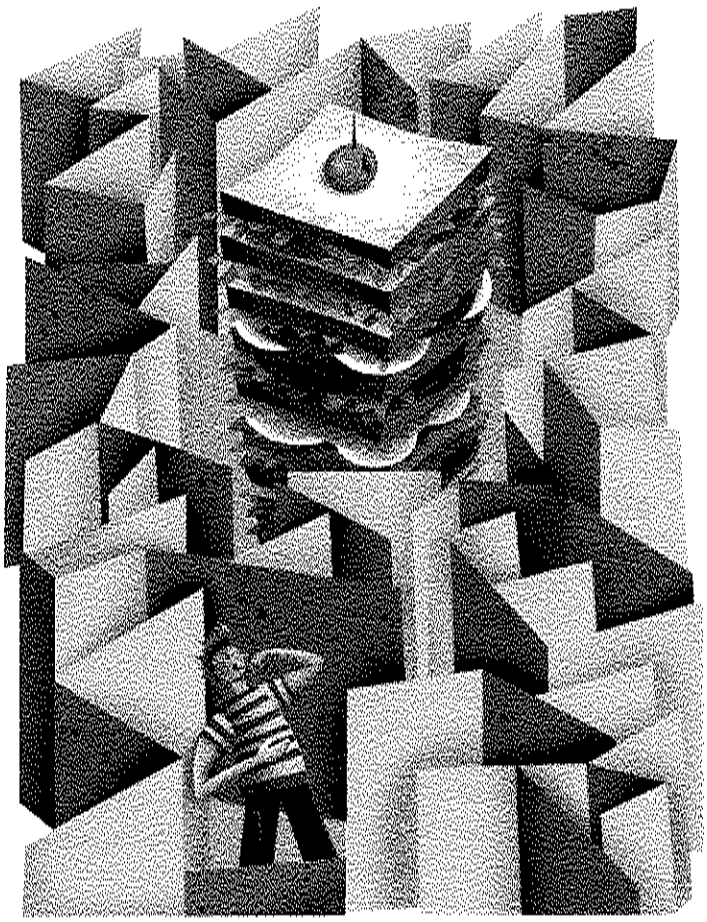
Main Idea
Both heredity and environment influence a person's intelligence.

Reading Focus
1. How does your genetic make-up influence your intelligence?
2. How does your environment influence your intelligence?
3. What are some of the connections between aging and intelligence?

Vocabulary
heritability
fluid intelligence
crystallized intelligence

TAKING NOTES Use a graphic organizer like this one to take notes on influences on intelligence.





Hungry to Learn

PSYCHOLOGY CLOSE UP

Can hunger make you smarter?

The brain is part of the body, so the state of your body affects your intelligence. One commonly-recognized example of this is the effect of overeating. Everyone knows you shouldn't eat a big meal before an important test—you'll be too sleepy to do your best.

Scientists have found that the opposite approach might help. When the stomach is empty, it produces ghrelin, a hormone that signals that it's time to eat. But ghrelin also boosts learning, memory, and spatial reasoning. Mice that were injected with ghrelin performed better than other mice when running mazes and performing other tests of their intelligence.

Does this mean you should starve yourself before your next big exam? Probably not. First of all, the scientists point out that more research needs to be done to establish whether hunger would help improve human intelligence. Secondly, the brain needs food to function. Too little nourishment might boost ghrelin levels, but it would also starve the brain of fuel. As with so many things, moderation is probably the best choice: take your test fed, but not full.

Genetic Influences on Intelligence

Through the 1900s, a great debate took place in the scientific world. Scientists wondered whether we are more influenced by our genetics or by our environment. The question applies to many human characteristics but few more so than intelligence. We will look first at the genetic side of the debate.

Are all people born with the same amount of intelligence? How do genetic factors affect the level of intelligence we have? Researchers who study the genetic factors in intelligence have used kinship studies and adoptee studies to explore questions such as these.

Kinship Studies If genetic factors are involved in intelligence, then closely related people should be more alike in terms of intelligence test scores than distantly related or unrelated people. For this reason, psychologists have studied intelligence test scores of related people. Identical twins have often been used in these studies. Because they have exactly the same genetic makeup, their test scores should be identical if intelligence is solely inherited. Any difference in scores would mean that other factors are also involved.

ACADEMIC VOCABULARY
colleagues co-workers or associates

Psychologist Thomas Bouchard and his colleagues compiled the results of more than 100 studies on the relationship between heredity and intelligence. They found that the intelligence test scores of identical twins are more similar than those of any other group of people. This finding holds true even when the twins are reared apart and grow up in different environments. Similarities in intelligence test scores between pairs of fraternal twins, other brothers or sisters, and parents and children are moderate. Similarities in intelligence between children and foster parents and between cousins are weak. What does all this mean? It means that genes do seem to play some role in intelligence. But how great a role does inheritance play?

Heritability is the extent to which variations in a trait from person to person can be explained by genetic factors. Most studies suggest that the heritability of intelligence ranges from 40 to 60 percent. That is, about half of the differences in intelligence test scores among people can be accounted for by heredity.

Adoptee Studies Some studies have compared the intelligence test scores of adopted children to those of their biological parents and their adoptive parents. If children are separated from their biological parents at early ages but their intelligence test scores remain very similar to those of their biological parents, it is probably because of genetic influences.

On the other hand, if the intelligence test scores of adopted children are more like those of their adoptive parents, it is probably because of environmental influences. Most studies of adopted children have found that their intelligence test scores are more like those of the biological parents than those of the adoptive parents. Thus, there seems to be further evidence of heredity's role in intelligence.

Other psychologists, however, argue that an overemphasis on heredity can undermine parental and educational efforts to help children learn. Parents and educators are most effective when they believe their efforts will improve children's knowledge and skills. Because parents and educators cannot change children's genetic codes, it is useful for them to assume that effective parenting and teaching can make a difference.

Reading Check **Draw Conclusions** Whose intelligence test score will probably be closest to yours: a parent, a cousin, or a neighbor? Explain.

Environmental Influences on Intelligence

Bouchard and his colleagues found that for each type of kinship, from identical twins to parents and children, intelligence test scores are more alike for pairs of people who were reared together than for pairs who were reared apart. This result holds for identical twins, other brothers and sisters, and even people who are unrelated. These findings suggest that environmental factors also affect intelligence. A variety of studies have examined the influence of home environment, parenting style, schooling, and other environmental factors on intelligence.

Home and Parenting Studies have shown that home environment and styles of parenting influence the development of intelligence.

Quick Lab

Boosting Brainpower

Many factors influence how well our brains work. A quick survey may reveal how common behaviors affect your academic performance.

PROCEDURE

1. Take out a blank piece of paper but do not put your name on it. Answer the following questions about the past week:
   - **How many hours did you spend exercising?**
   - **How many hours of sleep did you get?**
   - **How many caffeinated beverages did you consume during or before school?**
   - **How many hours did you play a musical instrument?**
   - **What were your scores on quizzes and tests?**
2. Collect the answers, and order them by test scores.
3. Enter the results in a table with a column for each answer and a row for each student.

ANALYSIS

1. As a class, analyze the results, and see if you can correlate any of the four factors with higher test scores.
2. Now do the same with lower test scores.
3. If you find a clear link between behaviors and test scores, write a short press release describing your findings. If not, discuss whether any of these behaviors affect academic performance.

The following factors have been demonstrated to help improve intellectual functioning in children.

- The parents are emotionally and verbally responsive to their children's needs.
- The parents provide enjoyable and educational toys.
- The parents are involved in their children's activities.
- The parents provide varied daily experiences during the preschool years.
- The home environment is well-organized and safe.
- The children are encouraged to be independent—to make their own decisions and to solve their own problems whenever possible.

Preschool Programs Many preschool programs are designed to provide young children with enriched early experiences. These experiences are intended to develop intelligence and to prepare children for school. Many such programs exist, but one particularly well-known program is Head Start. Begun in 1965, Head Start was designed to give economically disadvantaged children a better start in school.

Communities across the United States operate Head Start centers under the guidance of the U.S. Department of Health and Human Services. Parental involvement is an important feature of Head Start. This program includes health, education, and social services for participating children and their families. In local Head Start centers, children become familiar with books. They also play word and number games; work with puzzles, drawing materials, toy animals, and dolls; and interact with teachers in a school-like setting.

Preschool programs, such as Head Start, have been shown to increase scores on certain academic outcome measures, such as reading achievement scores. However, research suggests that the Head Start program has little or no effect on math achievement scores or social-emotional development. Overall, Head Start and other early-education programs may have benefits that are not necessarily assessed by grades on standardized tests, such as a reduced likelihood of repeating a grade or being placed in a class for slow learners. Participants in such programs are more likely to finish high school, to attend college, and to earn high incomes. Participation in such programs even decreases the likelihood of juvenile delinquency and reliance on welfare programs.

Reading Check **Summarize** What did Bouchard find that demonstrates the importance of environment on intelligence?

Aging and Intelligence

Psychologists are also concerned about factors that affect intelligence among adults, especially older adults. Most older people show some drop-off in intelligence as measured by scores on intelligence tests. The decline is usually most notable in timed test questions—questions that must be answered within a certain amount of time. On the other hand, vocabulary skills can continue to expand for a lifetime.

Slowed response times are part of a decline in **fluid intelligence.** These mental capacities allow us to respond quickly to novel situations or problems. What remains more stable, though, is **crystallized intelligence**—the sum of our knowledge about the world. Crystallized intelligence can continue to grow throughout our lives.

Biological changes contribute to some of the decline in fluid intelligence. However, older people who retain their health have very high levels of intellectual functioning. One study, conducted in Seattle, has been following intellectual changes in adults since 1956. The Seattle study has found that intellectual functioning in older people is linked to several environmental factors:

- level of income
- level of education
- a history of stimulating jobs
- intact family life
- attendance at cultural events, travel, and reading
- marriage to a spouse with a high level of intellectual functioning
- a flexible personality

In general, the more of these factors that are present in people's lives and the higher and stronger the factors are, the higher the level of intellectual functioning.

All things considered, intellectual functioning in people of all ages appears to reflect many genetic, physical, personal, and social factors. The fact that a person's genetically determined intellectual potential cannot be predicted makes it difficult to resolve the debate about the roles that genetics and environment play in intelligence. However, no matter what genes a person may have inherited, that person's intelligence is not fixed or unchangeable. People can, depending on their education and other factors, improve their intellectual functioning. Genetic factors give each person a range of possibilities. The environment influences the expression of these possibilities. Intelligence remains a complex concept that challenges psychologists, educators, and many others.

Reading Check **Contrast** What is the difference between fluid and crystallized intelligence?

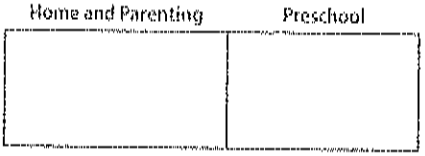
SECTION 4 Assessment

Reviewing Main Ideas and Vocabulary

1. **Define** What is heritability?
2. **Identify Main Ideas** What are the two broad categories of influences on intelligence?
3. **Recall** What type of intelligence tends to decline in older adults?

Thinking Critically

4. **Identify Cause and Effect** Why are the IQ scores of identical twins closer than the IQ scores of any other group of people?
5. **Explain** What effect do preschool programs such as Head Start have on intelligence scores?
6. **Summarize** Using your notes and a graphic organizer like the one below, summarize the effects of environmental influences on intelligence.



FOCUS ON WRITING

7. **Descriptive** Imagine that your local government has asked for your help in designing a new program for senior citizens. They want the program to help senior citizens maintain their mental acuity, and they suggest basing it on the Seattle study. Briefly describe how your program would work.