information. His capacity to remember nonverbal material was even more impaired. With or without distractions, he forgot even simple figures, such as circles, squares, and triangles.

Despite his severe memory loss, H.M. retained a limited capacity to learn, although the learning process was very slow and difficult. For example, H.M. had to exert great effort and undergo 155 trials to learn to navigate a very short visual maze, one which most people mastered after only a couple of trials. Surprisingly, a week later H.M. remembered what he had painstakingly learned. Two years later he still retained some of what he had learned: It took him only 39 trials to relearn his way through the maze—116 fewer than he had needed originally.

H.M. showed learning ability in other situations as well. When asked to trace a drawing of a star by looking at its reflection in a mirror, he completed the task successfully. In addition, he retained what he had learned. For example, on the second and third days, he performed as well on the first trial of the day as he had on the last trial of the day before. That was evidence that there was no memory loss from day to day. Apparently, H.M.'s short-term memory was intact, but he was unable to save items from short-term memory into long-term memory. His motor skills were unimpaired.

From cases such as that of H.M., psychologists have begun to shed light on the mysteries of memory. They have learned that memory is a complex set of functions performed by specific areas of the brain.

What do you think?

1. Of the many abilities that make up what we know as memory, which did H.M. lose and which did he retain?
2. Do you think the surgery that cured H.M. of seizures made his life better?

CHAPTER 7

MEMORY

Chapter at a Glance

SECTION 1: Memory Classifications and Processes

- Memory can be classed as explicit or implicit. Two main types of explicit memory are episodic and semantic.
- Memory of sensory input involves three distinct functions: encoding, storage, and retrieval.

SECTION 2: Three Stages of Memory

- In sensory memory, each of the senses records its input in a distinct register.
- Sense data that receive attention are retained in short-term memory.
- Information from short-term memory can be stored in long-term memory if it is encoded and linked to other stored information.
- Information can be quickly retrieved from long-term memory because long-term memory is structured, or organized.

SECTION 3: Forgetting and Memory Improvement

- The three basic remembering tasks are recognition, recall, and relearning.
- Much of what we think of as remembering actually involves reconstructing ideas based on associations.
- Forgetting, or memory failure, can be caused by a malfunction in encoding, storage, or retrieval.
- Forgetting can occur at any stage of memory.
- Knowledge of how remembering and forgetting occur has led to practical techniques for improving memory.

SECTION 1

Memory Classifications and Processes

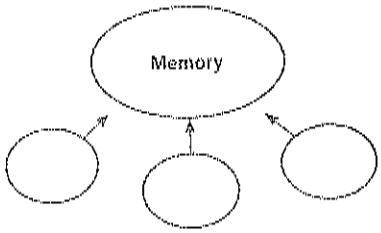
Before You Read

Main Idea
Memory is the process of encoding, storing, and retrieving information. Memory includes factual and general information, experiences of events, and skills.

Reading Focus
1. What are the three kinds of memory?
2. How does encoding of memories work?
3. What are the processes of memory storage?
4. What factors affect memory retrieval?

Vocabulary
memory
episodic memory
semantic memory
explicit memory
implicit memory
encoding
storage
maintenance rehearsal
elaborative rehearsal
retrieval
context-dependent memories
state-dependent memories

TAKING NOTES Use a graphic organizer like this one to take notes on the types and processes of memory.



Memories of Tea AND Cakes

PSYCHOLOGY CLOSE UP ***How did a small cake and a cup of tea elicit memories of a garden?*** Marcel Proust was a French writer obsessed with memories. Proust's genius was his ability to detail the thoughts and emotions he experienced as he remembered people, scenes, and events from his childhood. In his multi-volume book *Remembrance of Things Past*, Proust spends many pages telling about dunking a madeleine—a cake-like cookie—in a cup of tea and the cascade of feelings and images that passed through his mind as a result.

> ***Once I had recognized the taste of the crumb of madeleine soaked in her decoction of lime-flowers which my aunt used to give me . . . immediately the old grey house upon the street, where her room was, rose up like the scenery of a theatre to attach itself to the little pavilion, opening on to the garden, which had been built out behind it for my parents.***

The mysteries of memory have fascinated people throughout history. How is it that we can have vivid memories of events that occurred many years ago, but we sometimes cannot remember what happened yesterday? How can we feel certain that we remember events that never actually happened? Why can two people experience the same event but remember it completely differently? In this section you will learn some of what researchers have discovered about what memory is and how it works.

Three Kinds of Memory

What is memory? **Memory** is the process by which we recollect prior experiences and information and skills learned in the past. There are different kinds of memory. One way to classify memory is according to the different kinds of information it contains: events, general knowledge, and skills.

Episodic Memory **Episodic memory** is memory of a specific event. The event took place in the person's presence, and the person experienced the event. Your memories of what you ate for dinner last night and of your last quiz are examples of episodic memory.

Some events are so important that it seems as if a flash goes off and we photograph the scene in every detail. These are called flashbulb memories. For instance, you will probably never forget the first time you felt like you were in love. Maybe you can recall how the sky and the trees looked that day. Maybe you were a bit kinder to everyone. Maybe you laugh now when you recall that you were convinced that all of life's problems suddenly seemed solved.

On the other hand, you will probably never laugh when you recall the events of September 11, 2001. You may remember exactly where you were and what you were doing when you heard that one tower of the World Trade Center in New York City was in flames. Most people who witnessed the events of that day remember turning on their TV and watching in horror as the second tower was struck by an airplane, and it became clear that terrorism was at work. Our minds can still see the lower part of Manhattan covered with black smoke and ashen debris after the towers collapsed, and the bewildered people rushing away from the horrible scene.

There are several reasons why certain memories become etched in our minds when the "flashbulb" goes off. One reason is the distinctness of the memories. We pay more attention to events that have special meaning for us. Such events usually arouse powerful feelings. Also, we tend to think about flashbulb memories often, especially if they are positive ones—a first love, the birth of a child, or a special accomplishment.

Sometimes places or events make an impression on us—and thus become flashbulb memories—because they are connected to other events that were important at the time, such as a major disaster or tragedy. When we think of the important event later, it triggers memories of things that were connected to it. For example, many older Americans have flashbulb memories of the 1963 assassination of President John F. Kennedy.

Semantic Memory Your memory of facts, words, concepts, and so on—most of what you would say you know—is **semantic memory.** The word *semantic* means having to do with meaning and language. Much of what you learn in your classes at school becomes part of your semantic memory. For example, you probably learned and remember that George Washington was the first president of the United States.

Unlike with episodic memory, we usually do not remember when we acquired the information in our semantic memory. We probably cannot remember precisely when we first learned about George Washington, for instance. So, too, you remember the alphabet and that human beings breathe oxygen, but you probably do not remember where, when, or how you learned those things.

Episodic and semantic memories are both examples of **explicit memory.** Things that are explicit are clear, or clearly stated or explained. An explicit memory is memory of specific information. That information may be autobiographical (episodic), or it may refer to general knowledge (semantic).

Implicit Memory The opposite of *explicit* is *implicit,* and another kind of memory is **implicit memory.** Things that are implicit are implied, or not clearly stated. Implicit memories include practiced skills and learned habits. Knowing how to throw a ball, for example, is learned implicitly: you know how to throw, but you could not list out every step in the throwing motion, nor could you describe exactly how you change your motion to throw near or far. Other skills learned implicitly include riding a bicycle, skipping rope, typing, and playing a musical instrument. Once such a skill has been learned, it usually stays with you for many years, perhaps even a lifetime—even if you do not use it very often.

Reading Check **Summarize** What are the three main types of memory?

Encoding

You have just read about three different types of memory. There are also three major processes of memory. The first is encoding.

Imagine writing an essay or a story on a computer. You use the keyboard to type information in the form of letters. The information is stored on a hard drive. But if you were to look at the hard drive under a microscope, you would not be able to see the letters you typed. This is because the computer translates the information into a form in which it can be used. The translation of information into a form in which it can be used is called **encoding.** For both computers and humans, encoding is the first stage of processing information.

Initially, we receive information through our senses physically—such as when sound waves cause the eardrum to vibrate. In encoding we convert the stimulus into psychological formats that can be represented mentally. To do so, we use different types of codes. To see what kind of code you use, write this string of letters on a piece of paper:

OTTFFSSENT

Look at the string for 30 seconds and memorize as much of it as you can. Then continue reading this section to find out which type of code—visual, acoustic, or semantic—you used to remember the letters.

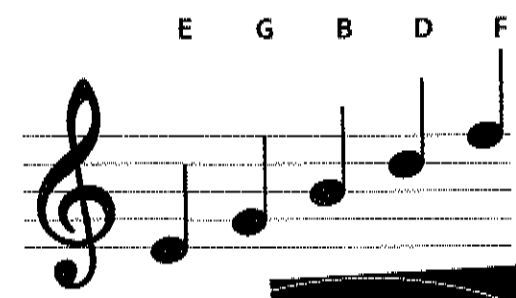
Visual and Acoustic Codes When you tried to memorize the letters, did you attempt to see them in your mind as a picture? If you did, you used a visual code. That is, you tried to form a mental picture of the letters in your mind.

Another way that you may have tried to remember the letters might have been to read the list to yourself and repeat it several times. That is, you may have said the letters (either out loud or silently) one after another: O, T, T, and so on. This way of trying to remember the letters uses an acoustic (or auditory) code. An acoustic code records the letters in your memory as a sequence of sounds.

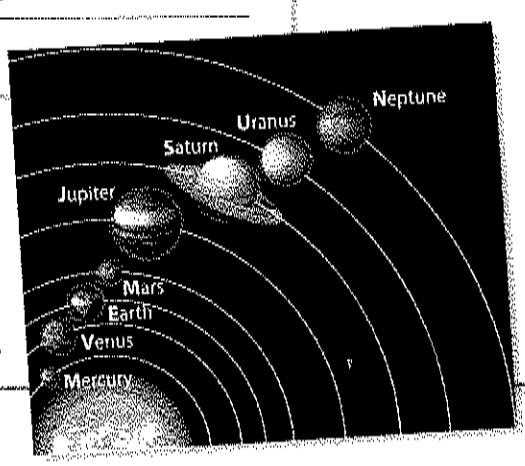
Semantic Codes Still another way that you may have tried to remember the list might have been to try making sense of the letters, that is, to figure out what they might mean. For example, you may have noticed that the last four letters spelled the word *sent*. You may then have tried to see if the letters made up a phrase or sentence with the word *sent* in it. The word *semantic* means "relating to meaning," so this type of code is called a semantic code. A semantic code represents information in terms of its meaning.

What you may not have realized when you examined the list is that the letters OTTFFSSENT stand for the first letter of the series of numbers from one (O) through ten

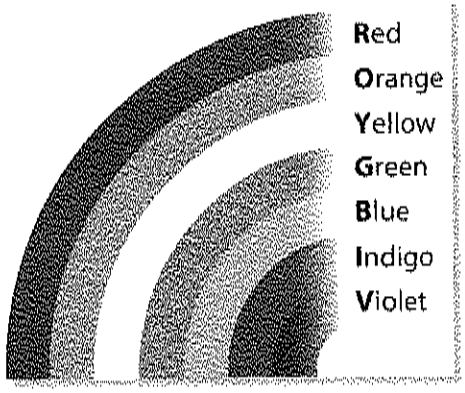
COMMON SEMANTIC CODES



Every
Good
Boy
Does
Fine



My Very Educated
Mother Just Served
Us Noodles



Red
Orange
Yellow
Green
Blue
Indigo
Violet

Roy G. Biv

Many memory techniques work by joining something that is hard to remember with something that is easier to remember.

(T)—that is, One, Two, Three, Four, Five, Six, Seven, Eight, Nine, Ten. Obviously, if you had known that in the first place, remembering the letters would have been much easier. By using semantic (meaningful) codes, you can memorize items more easily and will probably remember them for a longer amount of time than you would otherwise.

Reading Check **Identify** What different types of coding does the mind use?

Storage

After information is encoded, it must be stored. **Storage,** the second process of memory, is the maintenance of encoded information over a period of time. As with encoding, human storage of information is not all that different from a computer's storage of information. With a computer, however, the user must instruct the machine to save information in its memory. Otherwise, the information will be lost when the user shuts down the computer. People who want to store new information in their memory use a variety of strategies. These strategies are related closely to the strategies people use for encoding.

Maintenance Rehearsal Suppose you wanted to remember a name, address, or phone number. How would you do it? One way would be to keep repeating it to yourself to keep it alive in your memory. If a long time passed before you could find your address book and a pen, you might need to repeat it several times. Such mechanical or rote repetition of information in order to keep from forgetting it is called **maintenance rehearsal.** The more time spent on maintenance rehearsal, the longer the information will be remembered. Actors know this well. That is why they rehearse their lines until the lines are second nature.

Maintenance rehearsal requires only "surface processing"; in other words, it does not make information meaningful by connecting it to past learning. For that reason, it is actually a poor way to put information in permanent storage.

Elaborative Rehearsal A more effective way to remember new information is to make it meaningful through "deep processing," that is, by relating it to information you already know well. This method, called **elaborative rehearsal,** is widely used in education because it has proved to be a much more effective method than maintenance rehearsal. For example, language arts and foreign language teachers recommend elaborative rehearsal when they encourage students to use new vocabulary words in sentences instead of just repeating the individual words alone.

Organizational Systems Stored memories become organized and arranged in your mind for future use. If you are a fairly organized person, you probably have a particular place in your home for each of your possessions. When you bring items home, you probably do not just throw them on the floor or stick them haphazardly in a closet; instead, you sort them and put them in their places. That way you have a better chance of finding them when you need them. You have probably learned from experience that not knowing where your possessions are means that you end up spending a lot of time looking for them when you need them.

In some ways, your memory resembles a vast storehouse of files and file cabinets in which you store what you learn and need to remember. The more you learn, the more files you need and the more elaborate your filing system becomes. When you started attending school, for instance, the first facts you learned about American history may have been about Pocahontas, the Pilgrims, or George Washington. At first, your "American history" file probably had only a few pieces of information in it.

However, as you progressed and learned more about American history, you had to expand your filing system. As you learned about other presidents, you found new ways to file the information in your memory. You may have filed the presidents in chronological order, that is, in the order in which they held office. In that file you put Washington first, followed by others such as Jefferson, Lincoln, and Theodore Roosevelt. You may also have filed more recent presidents according to the events in American history with which they are associated, such as Franklin Roosevelt with the New Deal and World War II, Richard Nixon with Watergate, and George W. Bush with the war in Iraq.

As your memory develops, it organizes the information you learn into files and then into files within files. Your memory organizes the new information it receives into certain groups, or classes, according to common features. For example, all mammals share certain features. They are warmblooded, and they nurse their young. If you knew that whales are warmblooded and nurse their young, you probably filed them in your memory as mammals. If you did not know those facts, you might have filed them as fish because they swim and live in the water.

Classes can contain smaller classes and can also be part of a larger class. For example, the class mammals includes monkeys, rats, and other warmblooded, nursing creatures. At the same time, mammals are part of a larger class—animals. Much of our semantic memory that is stored as we get older and acquire more knowledge is organized into groups or classes.

Filing Errors Our ability to remember information—even when we are healthy and functioning well—is subject to error. Some memory errors occur because we "file" information incorrectly. Psychologists have discovered that when we classify pieces of information accurately—that is, when we place items in the correct files—we have a much better chance of recalling them accurately. Nevertheless, filing systems are not perfect. Have you ever misplaced a paper? For example, have you ever brought home a science paper and mistakenly filed it in your history folder? Our mental filing systems sometimes make similar errors.

Reading Check **Explain** How does elaborative rehearsal help your memory use organizational systems?

Retrieval

The third memory process is called retrieval. **Retrieval** consists of locating stored information and returning it to conscious thought. Retrieving information stored in our memory is like retrieving information stored in a computer. To retrieve information stored in a computer, we have to know the name of the file and the rules for retrieving it. Retrieval of information stored in our memory requires a similar knowledge of proper procedures.

Some information in our memory is so familiar that it is readily available and almost impossible to forget. Examples of this type of information include our own names and those of our friends and family members. But when it comes to trying to remember lines from a play or a mathematical formula, retrieval may be more difficult.

Do you remember the list of letters discussed earlier in the section? What were they? Write them down now. . . .

Now think about how you retrieved that string of letters from your memory. Notice that the method of retrieval you used depends on the way you encoded the string to begin with. For instance, if you used an auditory code, then, when you tried to recall the string of letters, you thought to yourself something like "ought-fissent," hearing the sounds in your mind, and then you tried to spell that string of sounds. But you might easily have made a mistake.

However, if you remember the semantic code that the letters stand for the numbers 1 through 10, you can accurately recall, or retrieve, the letters. Using this semantic code may be more complex than hearing the list in your mind, and it might take you a little longer to reconstruct the list of letters, but using the 1–10 device gives you a much better chance of remembering the letters—and of remembering them for a longer time.

Before reading on, take this very brief spelling quiz: Which of the following words is spelled correctly—*retrieval* or *retreival*? Even if you know how the word is pronounced, saying the word to yourself (using an acoustic code) will not help you remember the correct spelling, which is retr*ie*val. How might you go about remembering the correct spelling? Repeating it over and over (maintenance rehearsal) is certainly one way. However, a much better way would be to remember a spelling rule, such as "*i* before *e* except after *c*," as a semantic code. That rule enables you to reconstruct the correct spelling without having to memorize the order of the letters.

Context-Dependent Memory Have you ever been to a place that brought back old memories? Perhaps you went back to your elementary school or to a neighborhood where you once lived. The memories that came back to

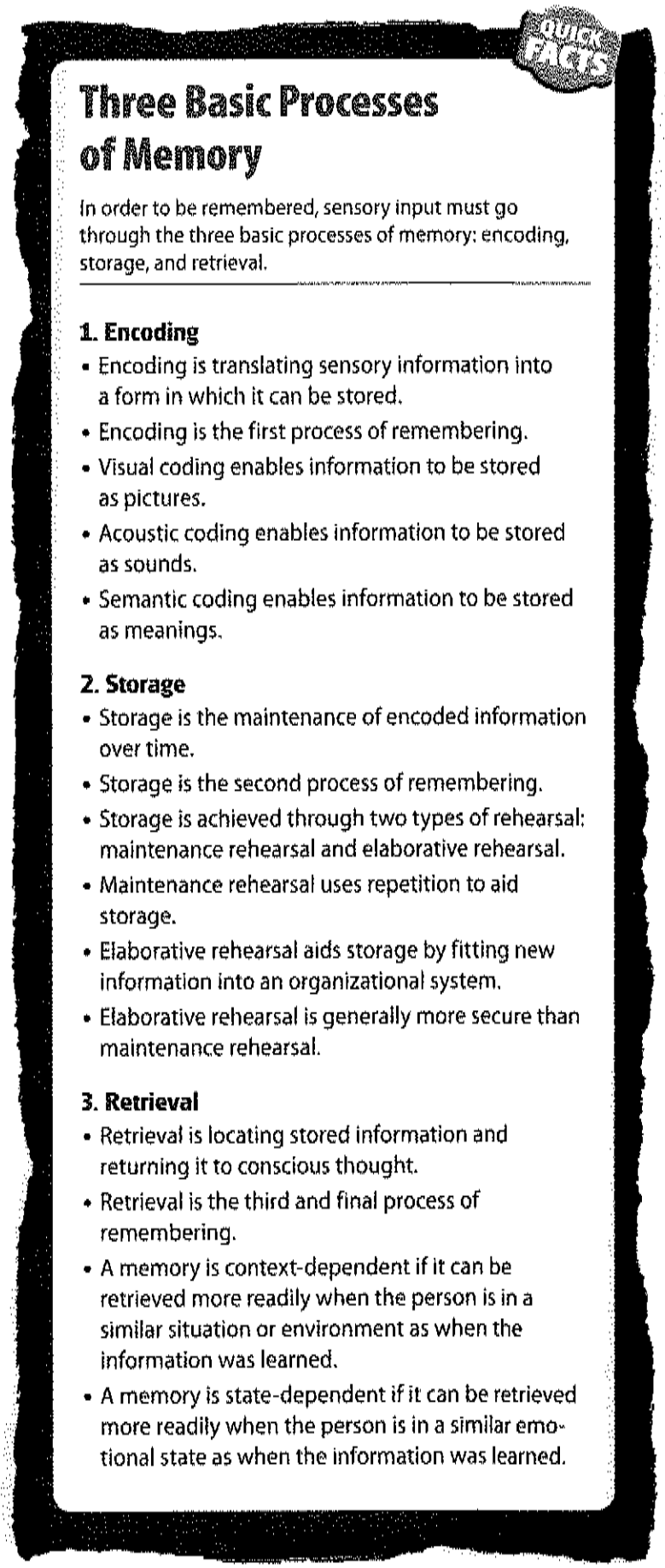
you in that place are called **context-dependent memories.** The context of a memory is the situation in which a person first had the experience being remembered. Such memories are dependent on the place where they were encoded and stored. If you had not returned to the place where your memories were encoded, you probably would not have retrieved them.

A fascinating experiment in context-dependent memory involved students who belonged to a swimming club. Some students were asked to memorize lists of words while they were in the swimming pool. Other students tried to memorize the lists while they were out of the water. Later, the students who had studied the lists in the water did a better job of remembering them when they were in the water again. Students who had studied out of the water, on the other hand, remembered more words when they were dry. These findings suggest that the ability to retrieve memories is greater when people are in the place or situation in which they stored the memories to begin with.

Another study of context-dependent memory found that students did better on tests when they studied in the room where the test was given. If possible, try to do some studying for your tests in the classrooms where you will take the tests. Of course, you should study in a variety of other settings as well to help you retain the material after the tests are over.

When police and lawyers ask witnesses to describe a crime, they ask the witnesses to describe the scene as clearly and with as much detail as possible. By doing this, witnesses are better able to recall details that they might otherwise have forgotten. Police sometimes take witnesses to the scene of the crime in the hope that such visits will improve their memories of what they witnessed.

You might remember going to a party at which you heard a song that suddenly brought back memories of being in the seventh grade. That is because seventh grade is when you heard the song (probably many times), encoded it, and stored it in your memory. Hearing the song again brought back context-dependent memories connected to that earlier period in your life. In fact, one reason some people like to hear familiar music is that it brings back old and happy memories.



Three Basic Processes of Memory

In order to be remembered, sensory input must go through the three basic processes of memory: encoding, storage, and retrieval.

1. Encoding

- Encoding is translating sensory information into a form in which it can be stored.
- Encoding is the first process of remembering.
- Visual coding enables information to be stored as pictures.
- Acoustic coding enables information to be stored as sounds.
- Semantic coding enables information to be stored as meanings.

2. Storage

- Storage is the maintenance of encoded information over time.
- Storage is the second process of remembering.
- Storage is achieved through two types of rehearsal: maintenance rehearsal and elaborative rehearsal.
- Maintenance rehearsal uses repetition to aid storage.
- Elaborative rehearsal aids storage by fitting new information into an organizational system.
- Elaborative rehearsal is generally more secure than maintenance rehearsal.

3. Retrieval

- Retrieval is locating stored information and returning it to conscious thought.
- Retrieval is the third and final process of remembering.
- A memory is context-dependent if it can be retrieved more readily when the person is in a similar situation or environment as when the information was learned.
- A memory is state-dependent if it can be retrieved more readily when the person is in a similar emotional state as when the information was learned.

State-Dependent Memory Not only do people tend to retrieve memories better when they are in the same place they were in when they first stored the memories, but people also retrieve memories better when they are in the same emotional state they were in when they first stored the memories. Memories that are retrieved because the mood in which they were originally encoded is re-created are called **state-dependent memories.** For example, feelings of happiness tend to bring back memories from other times when we were happy, while feelings of sadness can trigger memories from other sad times.

ACADEMIC VOCABULARY

phenomenon an observable event or occurrence

To demonstrate this phenomenon, psychologist Gordon Bower conducted experiments in which study participants were instructed, while in a hypnotic trance, to experience happy or sad moods. Then, while still in the trance, the participants tried to memorize a list of words. People who had studied the list while in a happy mood were better able to recall it when they were put into a happy state again. People who had studied the list while in a sad mood showed better recall when placed back in a sad mood. Bower's explanation of these results is that mood influences memory.

Not only is memory better when people are in the same mood as when the memory was acquired, it is also better when people are in the same state of consciousness. Drugs, for example, alter one's state of consciousness and thus result in state-dependent memories. Things that happen to a person while under the influence of a drug may be remembered most accurately when the person is again under the influence of that drug.

On the Tip of the Tongue Memories can sometimes be difficult to retrieve. Trying to retrieve memories that are not very well organized or are incomplete can be highly frustrating. Sometimes we come so close to retrieving information that it seems as though the information is on the "tip of the tongue." Psychologists call this the tip-of-the-tongue phenomenon or the feeling-of-knowing experience. You feel you know something. In fact, you are sure you know it. However, you just cannot seem to verbalize it.

Because the files in our memory have labels, so to speak, that include both the sounds and the meanings of words, we often try to retrieve memories that are on the tip of the tongue by using either acoustic or semantic cues. Sometimes we try to summon up words that are similar in sound or meaning to a word that is on the tip of the tongue. We might make a remark like: "I can't think of her name. It starts with an M. Mary? Maria? Something like that."

Reading Check **Contrast** What clues can help you remember a context-dependent memory? a state-dependent memory?

SECTION 1 Assessment

Reviewing Main Ideas and Vocabulary

1. **Summarize** What happens in each of the three main stages or processes of memory?
2. **Identify** What are the two types of explicit memory?
3. **Describe** How do organizational systems help the mind store memories? How do they help the mind retrieve memories?

Thinking Critically

4. **Contrast** What are the differences between maintenance rehearsal and elaborative rehearsal?
5. **Analyze** Explain why both episodic and semantic memories are classified as explicit.
6. **Compare and Contrast** In this section, human memory is likened to computer memory and to a filing system. In what ways might human memory be *unlike* these things?
7. **Analyze** Using your notes and a graphic organizer like the one here, identify the different memory tasks that the brain must perform. Give an example of each combination of memory stage and type of memory content.

	Types		
Processes	Episodic	Semantic	Implicit
1.			
2.			

FOCUS ON WRITING

8. **Expository** Think of a time you had a tip-of-the-tongue experience. Describe what you did to try to retrieve the memory, and explain why you think this worked or did not work.

Unreliable Memories, Unreliable Witnesses

Elizabeth Loftus has been studying the reliability of memory for over 30 years.

"Misleading details can be planted into a person's memory for an event that actually occurred. It also is possible to plant entirely false memories," according to Elizabeth Loftus and Daniel Bernstein (Bernstein et al., 2005). For example, they persuaded adults to avoid eating eggs by getting them to remember—falsely—that eggs had made them sick in childhood. False memories about eggs may seem trivial, but what if the false memories are of suffering child abuse or witnessing a murder?

Elizabeth Loftus's work has been key in showing how memories are constructed or reconstructed from a variety of sources. In one major study on false memory, Loftus found that about one-fifth of subjects could be influenced to "recall" false childhood memories of being lost in a shopping mall (Loftus, 1995). Loftus has shown not only that false memories exist but also that feeling sure about a memory does not prove that it is reliable.

One factor in false memory is source confusion—the inability to recall the source of a piece of information. If you cannot recall how you got an idea, you cannot know if the idea itself is reliable. Any idea in short-term memory, whether true or false, can be processed for storage in long-term memory and can be elaborated and modified to "make sense" alongside your other beliefs.

Researchers Valerie Reyna and Chuck Brainerd conceive two types of memory (Brainerd and Reyna, 2005). A "verbatim trace" is a precise representation of what you actually experienced. A "gist trace" represents the meaning of an experienced event and so is much more liable to error. Scans of brain activity during memory tasks showed that these two types of memory are recorded in two different parts of the brain. Further, children depend more heavily on the part of the brain that records verbatim traces. Since the capacity for gist trace develops over time, Reyna and Brainerd conclude that children's testimony can sometimes be more reliable than adults'.

Studies like these lead scientists to expect that brain scans may someday test the reliability of witnesses. We already know that different portions of the brain are activated depending on whether a person has seen the exact same thing before. If a person is shown an object unique to a crime scene, neuroimaging can (in theory) prove whether the person was there.

In the meantime, psychological research is helping train police investigators to avoid interviewing techniques that can mislead witnesses. One example is pressing for additional details when a witness has already expressed uncertainty.

Modern knowledge about the unreliability of memory means that even the testimony of the most honest witness must be carefully scrutinized.

Thinking Critically

1. **Explain** How can you tell if a "memory" is false or inaccurate?
2. **Discuss** According to Loftus, "Who we are may be shaped by our memories, but our memories are shaped by who we are and what we have been led to believe." What do you think she means?

SECTION 2

Three Stages of Memory

Before You Read

Main Idea
The three stages of memory storage are sensory input, short-term or working memory, and long-term memory.

Reading Focus
1. What are the three types of sensory memory?
2. How does short-term memory work?
3. How do schemas affect long-term memory?

Vocabulary
sensory memory
iconic memory
eidetic imagery
echoic memory
short-term memory
primacy effect
recency effect
chunking
interference
long-term memory
schemas

TAKING NOTES Use a graphic organizer like this one to note ideas about each stage of memory.

Stages of Memory		
Sensory	Short-Term	Long-Term

a rose to remember

PSYCHOLOGY CLOSE UP ***How could roses affect one's ability to remember facts?*** In an interesting study, research subjects played a game in which they had to remember the locations of pairs of cards. They were presented with a burst of rose scent each time they learned a pair correctly. One half hour after the game they were sent to sleep. While the subjects were in the deepest phase of sleep, researchers exposed some of them to more pulses of rose scent. The next day, the participants played the game again. Those who had smelled the roses while asleep averaged a 97 percent score, while those who had smelled nothing averaged 86.

The subjects were not wakened by the scent, and they did not remember smelling anything while asleep. The apparent explanation is that while they were sleeping, their brains were still processing memories of the game. Somehow, the scent helped in this process of creating long-term memories.

Using functional MRI, the researchers further discovered that smelling roses during other phases of sleep did not enhance memories of the game. In addition, if instead of card pairs, subjects were asked to remember a finger-tap sequence, the scent did not affect their memory. These results suggest that we process different types of memories during different phases of sleep. They also suggest that we process memories in multiple steps or stages, even when we are not aware of doing so.

Sensory Memory

Sensory memory is the first stage of information storage. It consists of the immediate, initial recording of data that enter through our senses. If we were to see a scene in a brief flash—if a strobe light flashed once in a dark room, for instance—the visual impression would decay within a fraction of a second. Such an impression is called a memory trace. Except when we are asleep, we receive a continuous and potentially overwhelming stream of memory traces. If we want to remember what we perceive, we have to do something with the information very quickly.

Psychologists believe that each of our five senses has a register. For example, the mental pictures we form of visual stimuli are called *icons*. Icons are held in a sensory register called **iconic memory.** Iconic memories are accurate, photographic images. However, these iconic memories are extremely brief—just a fraction of a second. The rare ability to remember visual stimuli over long periods of time (what most of us think of as photographic memory) is called **eidetic imagery.** About 5 percent of children have eidetic imagery. This keen ability usually declines with age, however. By adolescence, it is nearly gone.

Mental traces of sounds, called *echoes,* are held in a mental sensory register called **echoic memory.** While icons are held only for a fraction of a second, echoes can last for several seconds. For this reason, acoustic codes are easier to remember than visual codes. That is, it is easier to remember a spoken list of letters than to remember a mental picture of the letters.

Reading Check **Infer** Why do scientists believe there are five sensory memory registers?

Short-Term Memory

If you pay attention to iconic and echoic memories held ever so briefly in a sensory register, you can transfer that information into your **short-term memory** (STM). The information will remain there after the sensory memory trace has faded away. Short-term memory is also called working memory.

We use our short-term memory a great deal of the time. Whatever you are thinking about is in your short-term memory. When you are trying to solve a math problem, the elements of the problem are in your short-term memory. When you meet someone new, you put the person's name in your short-term memory, perhaps by using the name or by repeating it to yourself several times. When a teacher changes the date on which a paper is due, you place that information in your short-term memory until you can write it down or store it in long-term memory. If you look up a number in the phone book, you need to keep it in your short-term memory until you dial it. If you have to walk across the room to reach the phone, you might repeat or rehearse the number on your way. If the number is busy, you need to keep it in your short-term memory even longer as you wait a few minutes before dialing again.

Information in short-term memory begins to fade rapidly after several seconds. If you want to remember it longer, you need to keep rehearsing the information or take other steps to prevent it from fading. People can sometimes keep visual images in short-term memory, but it is usually better to encode information as sounds that can be rehearsed or repeated.

The Primacy and Recency Effects When we try to remember a series of letters or numbers, our memories of the first and last items tend to be sharper than our memories of the middle items. The tendency to recall the initial items in a series is called the **primacy effect.** (The root *prim–* means "first.") No one has proven a definitive explanation of the primacy effect. Perhaps we remember the first items better because being first is itself a distinctive feature that attracts our attention, or perhaps it is because there is less competition or interference from surrounding items.

The tendency to recall the last items in a series is called the **recency effect.** The recency effect has not been explained definitively, either. Possible explanations are similar to those for the recency effect: being last would appear to be a distinctive feature that draws attention, and the last item in a list is not surrounded by other items that compete with it for attention. Additionally, earlier items in the list cannot interfere with later items, so the last item has less opportunity to become displaced.

Chunking When we try to keep something in our short-term memory by rehearsing it, it usually helps to organize the information into manageable units that are easy to remember. The organization of items into familiar or manageable units is known as **chunking.** Return for a moment to OTTFFSSENT. If you tried to remember it letter by letter, there were 10 distinct pieces, or chunks, of information to retain in your short-term memory. When you tried to repeat the list as consisting of 10 meaningless chunks, you probably had a difficult time. It is not easy to repeat 10 meaningless letters, let alone remember them.

If you tried to encode OTTFFSSENT as sounds—something like "ought-fissent"—you reduced the number of chunks you needed to remember from 10 to one or two. (Of course, you also needed to remember the variations in spelling.) Psychologist George Miller found that the average person's short-term memory can hold a list of seven items—the number of digits in a local telephone number. Nearly everyone can remember a ZIP code, which is five numbers long. Some people can remember a list of nine items, but very few people can remember more than nine.

Businesses try to obtain telephone numbers with as many zeros or repeated digits as possible because such numbers are easier to remember. Numbers with zeros and repeated digits contain fewer chunks of information. Alternatively, a business may try to get a telephone number that can be spelled out as a word or phrase. Thus, people need only remember the word or phrase, not the seven numbers. For instance, a clinic that helped people quit smoking was able to get a telephone number that spelled out the phrase NO SMOKE. This phrase worked well as a semantic code.

You may be wondering how people remember long-distance telephone numbers—since with area codes included, such phone numbers are 10 digits long. Actually, most people do not try to remember the numbers as a series of 10 separate items. Rather, they try to remember the area code as a single, separate chunk of information. They become familiar with the area codes of surrounding areas and of places where their long-distance friends and relatives live. When they know where someone lives, they sometimes already know and remember the area code.

If you had known that OTTFFSSENT stood for the first letters of the numbers 1 through 10, you could have reduced the number of chunks of information you needed to hold in short-term memory from 10 down to 1. That one chunk would have been a single rule: make a list of letters in which each letter is the first letter of the numbers 1 through 10.

Interference Short-term memory is like a shelf that can hold only so much. Once a shelf is full, if you try to squeeze something else onto it, you will end up shoving something else off. Only a limited amount of information can be retained in short-term memory at a time. **Interference** occurs when new information appears in short-term memory and takes the place of what was already there.

A classic experiment by Lloyd and Margaret Peterson showed how new information can cause problems with what is stored in short-term memory. The Petersons asked college students to remember three-letter combinations, such as ZBT. Because most students can remember seven chunks of information, this task was fairly easy. Nearly 100 percent of the students could recall the three-letter sequences when asked to repeat them immediately. But then the Petersons asked the students to count backward from a number such as 142 by threes (142, 139, 136, 133, and so on). After a certain amount of time passed, the students were then asked to stop counting backward and to report the letters they had been asked to remember. After only three seconds of this interference, the percentage of students who could recall their letters dropped by about half. After 18 seconds had elapsed, practically nobody could recall the letters. The numbers that entered the students' short-term memory while they were counting backward had displaced the letters in nearly all cases.

Short-term memory is very useful, but it is only a temporary solution to the problem of remembering information. It allows us just enough time to find a way to store chunks of information more permanently. Short-term memory is the bridge between sensory memory and long-term memory.

Reading Check **Find the Main Idea** Why is short-term memory also called working memory?

Quick Lab

What Can You Remember?

You can take this short memory test by yourself or work with a partner. You will need a watch or clock with a second hand.

PROCEDURE

1. Before you begin, use your hand or another book to hide the photograph on the right.
2. Expose the photograph for five seconds and look at it; then hide it again.
3. List as many objects from the photograph as you can, and describe everything you remember about each.

ANALYSIS

1. How many items in the picture were you able to identify? Could you describe them in accurate detail?
2. What exactly did you think about as you tried to remember? For instance, did you ask yourself questions? Did you use spatial cues?
3. Did you "remember" any objects or people that were not in the picture? How do you think this happened?

Long-Term Memory

Long-term memory (LTM) is the third, and final, stage of information storage. If you want to remember something more than just briefly, you have to take certain steps to store it in your long-term memory. Mechanical or rote repetition (maintenance rehearsal) is one way of transferring information from short-term memory to long-term memory. Relating new information to information that you already know (elaborative rehearsal) is another technique.

New information is constantly being transferred into your long-term memory. In fact, your long-term memory already contains far more information than an encyclopedia or a computer's hard drive. It holds names, dates, places, the memory of how you kidded around with the student in front of you in second grade, and the expression on your mother's face when you gave her the picture you drew of her in fourth grade. Your long-term memory contains more words, pictures, sounds, smells, tastes, and touches than you could ever possibly count.

Memory as Reconstruction Some psychologists once thought that nearly all the perceptions and ideas people had were stored permanently in their memory. Supporters of this view often pointed to the work of Wilder Penfield, a brain surgeon. Many of Penfield's patients reported that they had experienced images that felt like memories when, during surgery, parts of their brain were stimulated electrically. From this information, some observers inferred that experiences become a physical part of the brain and that proper stimulation can cause people to remember them. Today, psychologists recognize that electrical stimulation of the brain does not necessarily bring about the accurate replay of memories. Memory expert Elizabeth Loftus, for example, notes that the memories evoked by Penfield's instruments had little in the way of detail and were often factually incorrect.

We now know that memories are not recorded and played back like videos or movies. Rather, they are reconstructed from the bits and pieces of our experience. When we reconstruct our memories, we shape them according to the personal and individual ways in which we view and understand the world. Thus, we tend to remember things in accordance with our beliefs and needs. In this way, we put our own personal stamp on our memories. We may even censor some details that make us uncomfortable. This is one of the reasons brothers and sisters can have differing memories of the same family events: each sibling has interpreted the information differently.

Schemas The mental representations that we form of the world by organizing bits of information into knowledge are known as **schemas.** Elizabeth Loftus and J. C. Palmer conducted a classic experiment on the role of schemas in memory. They showed people a film of a car crash. Then they asked them to complete questionnaires about the film. One question asked for an estimate of how fast the cars were going when they collided. However, the researchers varied how they phrased the question for different participants. Some participants were asked how fast the cars were going when they "hit" each other. Other participants were asked how fast the cars were going when they "smashed" into each other.

The participants who had been asked how fast the cars were going when they "hit" each other estimated an average speed of 34 miles per hour. Those who responded to the word "smashed," on the other hand, estimated an average speed of 41 miles per hour. In other words, which schema people used—"hit" or "smashed"—influenced how they mentally reconstructed the crash.

The participants were questioned again a week later. They were asked if they had seen any broken glass. The correct answer was "no"; there was no broken glass in the film. Of participants who had been told that the cars had "hit" each other, 14 percent incorrectly said yes, there was broken glass. Of those who had been told that the cars had "smashed" into each other, however, 32 percent incorrectly reported seeing broken glass. Schemas influence both the ways we perceive things and the ways our memories store what we perceive.

Capacity of Memory Our long-term memory holds the equivalent of vast numbers of videos and films of our lifetime of experience. All of them are in color (as long as we can perceive color). They also come with stereo sound (as long as we can hear), with smells, tastes, and touches thrown in. This light-and-sound show would never fit on any stage. But all of it is contained comfortably within our long-term memory. And there is room for more, much more. How much more? Psychologists have yet to discover a limit to how much can be stored in a person's long-term memory.

Although there is apparently no limit to how much we can remember, we do not store all of our experiences permanently. Not everything that reaches our short-term memory is transferred to our long-term memory. Our memory is limited by the amount of attention we pay to things. We are more likely to remember the things that capture our attention. The memories we store in our long-term memory are the incidents and experiences that have the greatest impact on us.

Reading Check **Summarize** How do schemas help us remember?

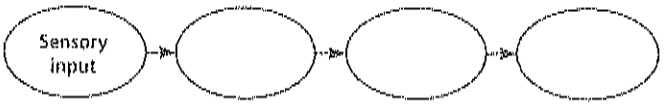
SECTION 2 Assessment

Reviewing Main Ideas and Vocabulary

1. **Summarize** How does attention affect what goes into short-term and long-term memory?
2. **Recall** What experimental evidence supports the existence of interference?
3. **Analyze** Why is short-term memory also referred to as working memory?
4. **Define** What is chunking?

Thinking Critically

5. **Interpret** What do scientists mean when they say that memory is reconstructive?
6. **Infer** Recall the Psychology Close Up at the beginning of this section. What memory process was going on during deep sleep?
7. **Evaluate** What experimental evidence discussed in this section do you think best supports schema theory?
8. **Sequence** Using your notes and a graphic organizer like the one here, describe the processes that transform raw sensory input into remembered experiences and information.



FOCUS ON WRITING

9. **Narrative** Choose any simple fact. Describe how you think it went through the three stages of memory and became something you know.

SECTION 3

Forgetting and Memory Improvement

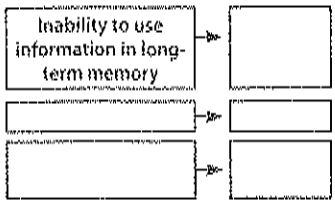
Before You Read

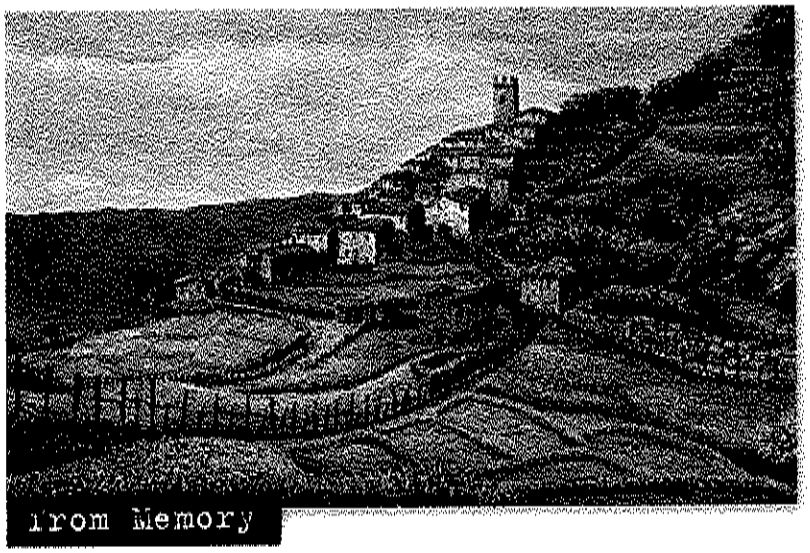
Main Idea
The three tasks of remembering are recognition, recall, and relearning. Failure of any of these results in forgetting.

Reading Focus
1. How does forgetting happen?
2. What are the three basic memory tasks?
3. How are the three ways of forgetting different?
4. What are some techniques for improving memory?

Vocabulary
recognition
recall
relearning
decay
retrograde amnesia
anterograde amnesia
infantile amnesia

TAKING NOTES Use a graphic organizer like this one to list different types of forgetting and note how each occurs.





PSYCHOLOGY CLOSE UP ***What memories make the greatest impression?***

Everyone has memories they say they will never forget. But Franco Magnani seems to have more of these than most people. When Magnani was in his thirties, he began painting extremely realistic pictures of his hometown of Pontito in the Tuscany region of Italy. This is remarkable because he left Pontito as an adolescent and has not been back since. Nor did he have any photographs or drawings of Pontito. His paintings are done entirely from his childhood memories, and the images reflect the perspective of a child.

The inspiration for Franco's "memory paintings" are his vivid, detailed, three-dimensional visual memories of his childhood home. When he is having these visions, he turns his head to "see" what is around the corner or behind him. Magnani's visions began as dreams during a serious illness and then increased in frequency. Eventually, Magnani was having daydreams while at his job as a chef—hallucinations, almost. At a certain point, he felt compelled to paint what he was seeing. "Like a flash," he says, "I'd see intricate details of my village. It was so acute, I'd want to leave the stove, go home, [and] start sketching." In this section you will read more about how and why people forget and remember.

Forgetting

Forgetting is the flip side of remembering. Forgetting may seem simple enough. If you do not think about something, you forget it, right? Not really; it is not that simple.

Forgetting can occur at any one of the three stages of memory—sensory, short-term, or long-term. Information encoded in sensory memory decays almost immediately unless you pay attention to it and transfer it into short-term memory. A memory trace in a visual sensory register decays in less than a second, and a sound recorded in echoic memory lasts no more than a few seconds.

Information in short-term memory does not last long, either. It will disappear after only 10 or 12 seconds unless you find a way to transfer it into your long-term memory. Information stored in short-term memory is lost when it is displaced, or crowded out, by new information.

ACADEMIC VOCABULARY

displace move from an original or natural place

The most familiar and significant cases of forgetting involve the inability to use information in long-term memory. If you think of the mind as a file cabinet, you can imagine how forgetting could be due, for instance, to a lost or damaged file or an initial filing error. Because long-term memory holds such vast amounts of material and the material is represented in an abstract form, forgetting and other memory errors (such as recalling information incorrectly) are not uncommon. Sometimes new information becomes mixed up with material you already know.

As well, old learning can interfere with new learning. For example, if you study a new foreign language, your knowledge of a language you already know or are studying at the same time can interfere with your new learning. This is more likely to happen if the languages are somewhat similar. Consider the French, Spanish, and Italian languages. The three have many similar word roots and spellings: for instance, *amour* (French), *amar* (Spanish), and *amore* (Italian) all mean "love." If you have ever tried to learn two or more of these languages, especially at the same time, you know how easy it is to confuse them.

Reading Check **Contrast** How does forgetting information in short-term memory differ from forgetting information in long-term memory?

Basic Memory Tasks

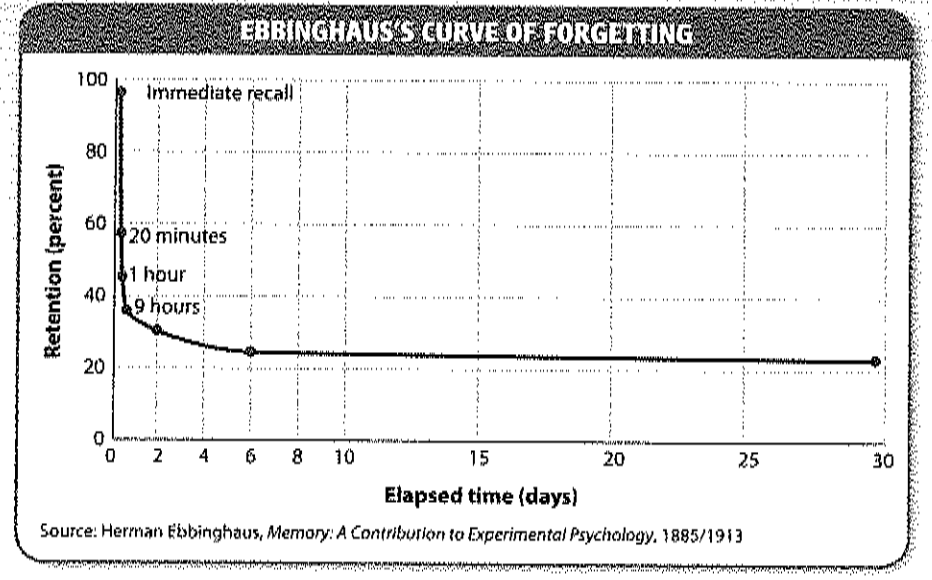
Do you know what DAL, RIK, and KAX are? They are nonsense syllables—meaningless sets of two consonants with a vowel in the middle. Nonsense syllables provide psychologists with a way to measure three basic memory tasks: recognition, recall, and relearning.

The first researcher to use nonsense syllables to study memory was German psychologist Hermann Ebbinghaus (1850–1909). His experiments are regarded as the first scientific study of forgetting, and psychologists today continue to use nonsense syllables in their studies. Because nonsense syllables are meaningless, remembering them depends on acoustic coding (saying them out loud or in one's mind) and rote repetition (maintenance rehearsal). These tasks play a part in recognition, recall, and relearning.

Recognition One of the three basic memory tasks is **recognition,** which involves identifying objects or events that have been encountered before. It is the easiest of the memory tasks. In some experiments on recognition, psychologists ask people to read a list of nonsense syllables. The participants then read a second list of nonsense syllables and are asked to identify any syllables in the second list that appeared in the first list. In this instance, forgetting is defined as failure to recognize a syllable that has been read before.

A classic study by Harry Bahrick and his colleagues examined recognition using a different technique. Bahrick took pictures from the yearbooks of high school graduates and mixed them in with four times as many photos of strangers. Recent graduates correctly picked out their former classmates 90 percent of the time. Graduates who had been out of school for 40 years recognized their former schoolmates less often, but not by too much—75 percent of the time. Keep in mind that only one photo in five was actually of a former schoolmate. Thus, if the graduates had been guessing, they would have picked out former schoolmates only 20 percent of the time. The participants recognized the photos of their former classmates far more easily than they recalled their classmates' names. The study showed that the ability of people to recognize familiar faces remains strong and lasting.

Statistically Speaking...



The Speed of Forgetting

The ability to recall nonsense syllables drops sharply during the first hour of learning. After the first hour, memory loss becomes more gradual. Ebbinghaus measured the rate at which test subjects forgot a list of nonsense syllables. Subsequent research has shown that when the information to be learned is meaningful and significant—when there is a reason to learn and remember it—forgetting slows considerably.

Skills Focus **INTERPRETING GRAPHS** Given a list of nonsense syllables, what is the likelihood of remembering any particular syllable the next day?

Recall The second memory task is recall. To **recall** something means to bring it back to mind. In recall, you do not immediately recognize something you have come across before. Rather, you have to "search" for it and possibly try to reconstruct it in your mind.

Hermann Ebbinghaus sometimes studied his own recall ability by reading aloud to himself with a metronome (an instrument that marks out exact time by ticking) a list of nonsense syllables. He would then test how many of the syllables he could recall. Typically, Ebbinghaus could recall seven of the syllables after reading a list one time. As noted earlier, this is the number of items most people can keep in short-term memory.

If a person memorizes a list of nonsense syllables and is asked to repeat back the list immediately, there is generally no memory loss. But the ability to recall drops off quickly: about half of the items are forgotten within the first hour. After that first hour, memory loss becomes more gradual. For instance, the amount of material a person remembers is cut in half again in about a month. The person continues to forget as time goes on, but the rate of forgetting slows down considerably.

Psychologists also use paired associates to measure recall. Paired associates are lists of two nonsense syllables. In this method, people read a list pair by pair. Later, they are given the first member in each pair and are asked to recall the second one. That is, the people try to retrieve one syllable with the other serving as the cue.

Learning the vocabulary of a foreign language is something like learning paired associates. For example, a student studying Spanish might try to remember a Spanish word by pairing it with an English word that has a similar meaning. The student might remember that the Spanish word *mano* means "hand" by creating a meaningful link between the words. She or he could do that by remembering that the English word *manually* means "by hand." Otherwise, the only way to remember the foreign word is by mechanical repetition (maintenance rehearsal).

Relearning The third basic memory task is **relearning.** Sometimes we do not remember things we once knew. For example, people who have been out of school for 25 years might not remember any algebraic formulas. However, they could probably relearn them very quickly if they studied them again. Often, with some effort, we can fairly rapidly relearn things we once knew but have forgotten. You may have experienced this yourself when reviewing math facts or grammar rules after a long summer vacation. Ebbinghaus's experiments with nonsense syllables validated this as a general idea about relearning. First, Ebbinghaus recorded how many repetitions a particular person needed to memorize a list of nonsense syllables. Then, after a few months had passed, he checked on the person again. Typically, the person could not recall or even recognize the original list of nonsense syllables. However, Ebbinghaus found that the person was able to relearn the list more quickly than she or he had learned it the first time.

Reading Check **Analyze** What do experiments with nonsense syllables prove about recognition, recall, and relearning?

Repressed Memories

"First, we'll look for repressed memories of malpractice suits."

Skills Focus INTERPRETING CARTOONS

Why would a psychotherapist be interested in a patient's repressed memories?

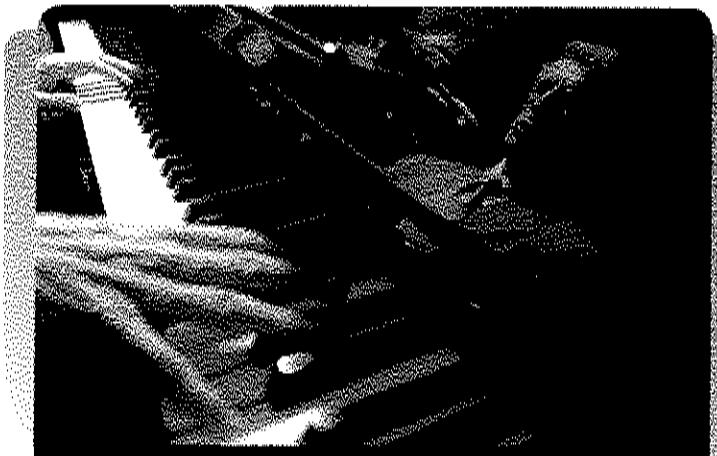
Different Kinds of Forgetting

Much forgetting is due to interference or decay. As you have already learned, interference occurs when new information shoves aside or disrupts what has been placed in memory. **Decay** is the fading away of a memory over time. Both decay and interference are part of normal forgetting that occur when memory traces fade from sensory or short-term memory (although some researchers have questioned whether decay is an actual, distinct phenomenon). Memory loss also occurs in long-term memory when something that has been stored there cannot be retrieved. However, there are more extreme kinds of forgetting.

Repression According to Sigmund Freud, the founder of psychoanalytic theory, we sometimes forget things on purpose without even knowing we are doing it. Some memories may be so painful and unpleasant that they make us feel anxiety, guilt, or shame. To protect ourselves from such disturbing memories, said Freud, we forget them by pushing them out of our consciousness. Freud called this kind of forgetting repression. For example, a person might forget to go to a dentist appointment because he or she expects the experience to be unpleasant. Non-Freudians usually explain repression in terms of interference.

Amnesia Amnesia is severe memory loss. It is often caused by trauma to the brain—such as from a fall or a blow to the head, electric shock, brain surgery, stroke, shock, fatigue, or illness. There are several types of amnesia, but all of them are extremely rare. Nonetheless, study of people suffering from amnesia has been very important in developing an understanding of how memory works.

People afflicted by **retrograde amnesia** forget the period leading up to a traumatic event. For example, athletes knocked unconscious during a game often have no memory of what happened before the play in which they were injured. Some cannot even remember starting



"His talk might be a jumble no one could understand, but his brain was still capable of music."
—Deborah Wearing

Memorable Melodies

An infection in pianist Clive Wearing's brain disabled his episodic and autobiographical memory. He suffered near-total retrograde amnesia—he lost virtually all memory of his life before the infection—and total anterograde amnesia, losing the ability to store new long-term memories. Yet Wearing's skills, such as his abilities to read music and to play the piano, remained intact. ***How does Clive Wearing's memory loss compare to H.M.'s?***

the game. In the most severe cases of retrograde amnesia, the person cannot remember a period of several years prior to the traumatic incident. One man suffered retrograde amnesia after receiving a head injury in a motorcycle accident. When he woke up after the accident, he had no memory of anything that had happened since he was 11 years old.

More commonly, trauma to the brain causes memory loss of events that take place after the trauma. This type of memory loss, in which the person loses the ability to store new memories, is called **anterograde amnesia.** Certain kinds of brain damage, such as damage to the hippocampus, have been linked to anterograde amnesia. Transient global amnesia is profound anterograde amnesia that begins abruptly and usually lasts less than a day.

Infantile Amnesia Unlike these extreme and rare forms of forgetting, there is one type of amnesia that we all experience. Some people think that they can remember events that took place in their infancy, but actually they cannot.

After many years of hearing his patients talk about their childhoods, Freud found that they could not remember things that had happened to them before the age of three. This forgetting of early events he called **infantile amnesia.**

People who think that they can remember their birth have probably constructed the memory from other memories. For example, they may remember being told about their birth by a parent or another family member. Or they may remember the birth of a younger sibling and then use that information to create a memory of their own birth.

The reason for infantile amnesia is not that the events happened a long time ago. People in their 80s have many precise memories of their life between the ages of 6 and 10, even though the events they remember occurred 70 years earlier. College freshmen, meanwhile, have difficulty remembering events that occurred before the age of 6, even though these events occurred only 13 or 14 years earlier. Therefore, failure to recall events from infancy or early childhood is not simply a matter of decay.

Freud explained infantile amnesia in terms of repression. He believed that young children often have aggressive and sexual feelings toward their parents but that they forget these feelings as they get older. The fact that people also tend to forget boring and bland events from their early childhoods is seen by some as casting doubt on Freud's theory.

Infantile amnesia reflects biological and cognitive factors. One biological factor is the development of the hippocampus, which does not become mature until about the age of two.

CASE STUDY CONNECTION

Anterograde Amnesia H.M.'s memory problems began after part of his hippocampus was surgically removed.

TYPES OF FORGETTING

QUICK FACTS

Forgetting is the inability to remember. Because memory is such a complicated process, there are many ways in which it can go wrong, and there are many possible causes and types of forgetting.

Type	Description
Decay	Fading away of a memory over time
Interference	Displacement, disruption, or distortion of previously existing memories by new memories
Repression	Subconscious forgetting to ease anxiety, guilt, shame, or other emotional trouble
Amnesia	Severe memory loss
Retrograde amnesia	Loss of memory of events that occurred prior to the trauma
Anterograde amnesia	Loss of the ability to store new long-term memories

Another biological factor is that memory formation is somewhat inefficient for a few years until myelination of nerve cells is complete.

There are also cognitive reasons for infantile amnesia:

- Infants are not particularly interested in remembering the past year.
- Infants, unlike older children and adults, tend not to weave together episodes of their lives into meaningful stories. Information about specific episodes thus tends to be lost.
- Infants do not make reliable use of language to symbolize or classify events. Their ability to encode sensory input is therefore limited.

Note that infantile amnesia refers to episodic memory—memory of specific events. We certainly learn and remember many other things during infancy and early childhood using semantic and implicit memory. For example, we learn who our parents are and to have strong feelings for them. We learn and remember the language spoken at home. We learn how to encourage other people to care for us. We learn how to get from one part of the home to another. We remember such information and skills quite well.

Reading Check **Recall** What are the five types of forgetting discussed in this section?

Improving Memory

Memory can be improved. As a result of studies of memory and forgetting, psychologists have been able to identify different strategies people can use to improve their memory.

Drill and Practice One basic way to remember information is by going over it again and again, that is, by repetition, or drill and practice. Repetition is one fairly effective way to transfer information from sensory memory to short-term memory and from short-term memory to long-term memory. You can remember facts in psychology and other courses by pairing different pieces of information with each other and then drilling yourself on the connections between the items.

A trick for remembering the names of people you meet is to use the names right away. This will help you remember them later. If you are introduced to a new person, for example, say his or her name aloud when you are introduced. You might find it even more helpful to write the name down, if you can, at the end of the conversation.

Relate to Existing Knowledge Elaborative rehearsal—relating new information to what you already know—requires you to think more deeply about the new information. If new information becomes connected in a variety of ways to what is already stored in your long-term memory, your brain will have more ways of finding it later. As a result, you may remember the new information better.

Elaborative rehearsal can be helpful in many situations. For example, if you were trying to remember the spelling of the word *retrieve*, you would probably do it by recalling the rule "*i* before *e* except after *c*." But how would you remember the spelling of the word *weird*, which does not follow the rule? You could use elaborative rehearsal on the word by recalling that it does not follow the "*i* before *e*" rule because it's a "weird" word.

Constructing links between items is another way elaborative rehearsal can help improve memory. You may find it easier to remember vocabulary words from a foreign language if you construct a meaningful link between each foreign word and its English equivalent. One way to create such a link is to find part of the foreign word and construct

a sentence or phrase that includes that part of the word in English. For example, suppose that you are trying to remember that a *peso* (PAY-soh) is a unit of Mexican money. You might note that *peso* contains the letters *pe*, and then construct the following sentence: "*Pe*ople pay with money." Then, when you come across the word *peso*, you recognize the *pe* and retrieve the sentence that serves as the link. From that sentence, you can then reconstruct the meaning of the word *peso*.

Form Unusual Associations It is sometimes easier to remember a piece of information if you can make an unusual or even humorous association between that piece of information and something else. For example, suppose that you wanted to memorize the symbol for the chemical element tin. You could remember that *Sn* is the symbol for tin by thinking of a *sn*ake in a *tin* can.

Sometimes people can enhance memory by forming a group of unusual associations. Suppose that you need to buy groceries but do not have time to write out a shopping list. How will you remember what items to buy? First, think of a group of related images, such as the parts of your body. Then, picture each dish you plan to cook as hanging from a different body part. For example, you might envision lasagna hanging off your left shoulder. When you are at the supermarket, mentally go through the body parts you have designated and see what is connected to each. When you get to the left shoulder and envision the lasagna, tick off the items you need to buy in order to make the lasagna: noodles, tomato paste, and so on.

Use Mnemonic Devices Methods for improving memory are called mnemonics (nee-MAHN-iks) or mnemonic devices. Many mnemonic devices combine chunks of information into a catchy or easily recognizable format, such as an acronym, phrase, or jingle. Others involve clever ways of combining different types of information, such as joining a mental picture with a mental caption, or pairing data from two different senses.

In biology, for example, you can remember that dromedary camels have one hump, and Bactrian camels have two humps. How? Just turn the uppercase letters D and B on their sides and count the "humps" in each one.

If you meet a lot of people you may benefit from using mnemonic devices to remember names. For instance, if you meet someone named Ben, you could imagine his face attached to a body like a rubber toy that wiggles and *ben*-ds from side to side. If his name is Ben Hamilton, you might imagine this figure being buried by a *ton* of *ham* falling from the sky.

Reading Check **Make Generalizations** How can you make new information easier to remember?

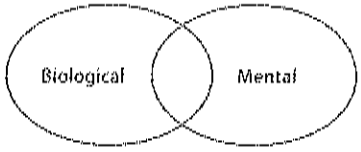
SECTION 3 Assessment

Reviewing Main Ideas and Vocabulary

1. **Define** What is a sensory register?
2. **Describe** How do memories decay?
3. **Interpret** Explain Freud's concept of repression.
4. **Identify** What are three methods for improving memory?

Thinking Critically

5. **Identify Cause and Effect** Why is elaborative rehearsal generally a more effective memory strategy than maintenance rehearsal?
6. **Explain** Why do you think relearning something you have forgotten would be easier than learning it for the first time?
7. **Contrast** How is remembering a list of nonsense syllables different from remembering a list of your classmates?
8. **Predict** How could you tell if a patient suffering from anterograde amnesia was having failures of encoding, storage, or retrieval?
9. **Categorize** Using your notes and a graphic organizer like this one, classify the different types of amnesia and forgetting as due to biological or mental causes.



FOCUS ON WRITING

10. **Narrative** Imagine the thoughts of someone who suffers from some form of amnesia. Write a journal or diary entry from this person's point of view.

Experiment

Applying What You've Learned

Effective Memory Improvement

Reading and Activity Workbook

Use the workbook to complete this experiment.

Which method of memorization is most effective?

1. Introduction

In this experiment, you and your classmates will evaluate the methods of memory improvement discussed in this chapter by using those methods and comparing their effectiveness. To complete this experiment, follow the steps below.

- You will work in small groups to collect data; then, all the groups will combine their data. To ensure that all the tests are run in the same way, you will first work as a class to outline the main steps of the experiment.
- To prepare for this planning discussion, review what you learned earlier about the steps of scientific research. Make a list of each of the main steps and the purpose of each step.
- Following your teacher's instructions, you will organize into smaller student groups to write memory tests, conduct your experiments, and analyze your data. Your teacher will assign each group one or more of the three memorization strategies described in Section 3: (1) drill and practice, (2) relate to existing knowledge, and (3) form unusual associations.
- After completing the group work, you will rejoin the rest of the class, compile everyone's data, and discuss the results.

2. Planning Your Experiments

Here are some suggestions to help you plan the experiments.

❶ **Frame a Research Question** To start forming a research question, begin by brainstorming. It might be helpful to create web diagrams on the board or screen. In the center oval, list one of the memorization techniques discussed in the chapter, and then add branches for ideas about when that technique would be useful. Here's an example:

❷ **Form a Hypothesis** If you have difficulty forming a hypothesis, start making statements based on your research question that start with "I guess . . ." or "I think . . . ," such as, "I think elaborative rehearsal would be effective for remembering Civil War battles." After you have formed this statement, remove the starting "I think" statement and you have written yourself a hypothesis.

❸ **Plan How to Test the Hypothesis** You will use the testing method of observation. It is important to have a clear, detailed list of experimental steps before you begin. It is also important that all the groups use the same format for recording data so everyone's results can be combined and analyzed at the conclusion of the experiment. As you plan your experiment, consider these issues.

- Determine your dependent and independent variables.
- Will you be looking for a causal explanation or a correlation?
- For what factors do you need to control? How will you control for them?
- Decide how you will sample participants—your subjects. Following your teacher's guidance, you may perform the experiments using the individuals in your group, another group in the class, or another class in the building as your participants.