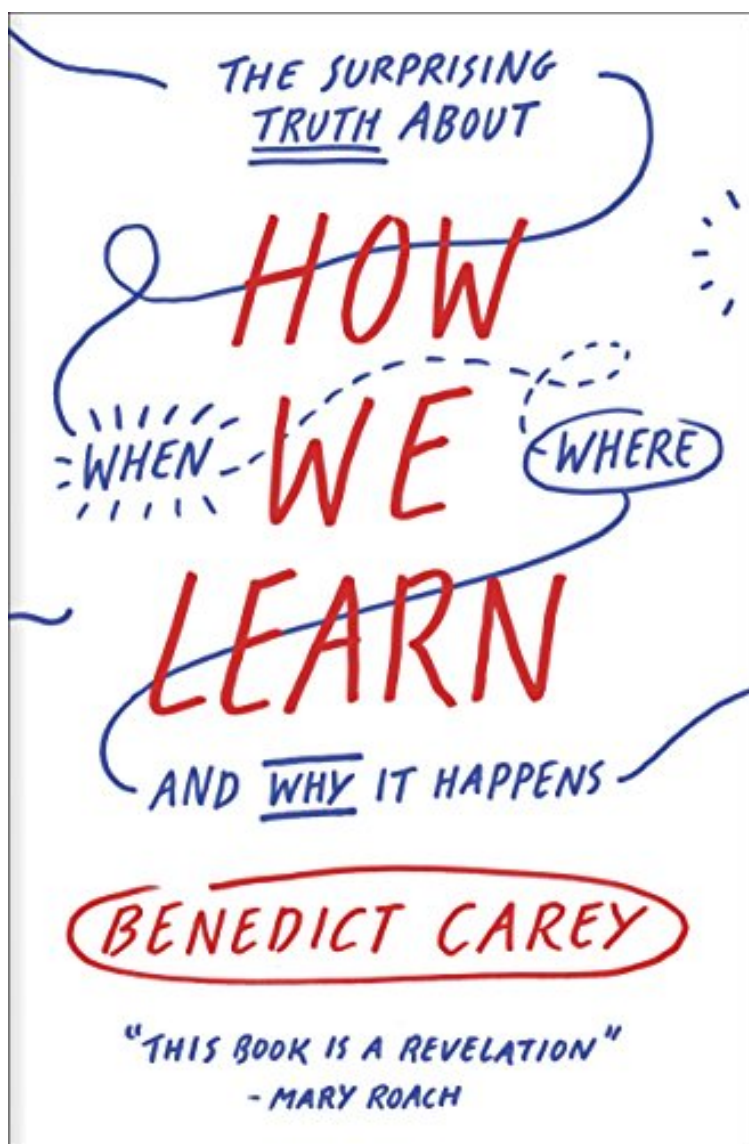


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# How We Learn: The Surprising Truth About When, Where, and Why It Happens



Par Benedict Carey  
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## Description :

Presentation de l'diteurIn the tradition of The Power of Habit and Thinking, Fast and Slow comes a practical, playful, and endlessly fascinating guide to what we really know about learning and memory todayand how we can apply it to our own lives. From an early age, it is drilled into our heads: Restlessness, distraction, and ignorance are the enemies of success. Were told that learning is all self-discipline, that we must confine ourselves to designated study areas, turn off the music, and maintain a strict ritual if we want to ace that test, memorize that presentation, or nail that piano recital. But what if almost everything we were told about

learning is wrong? And what if there was a way to achieve more with less effort? In *How We Learn*, award-winning science reporter Benedict Carey sifts through decades of education research and landmark studies to uncover the truth about how our brains absorb and retain information. What he discovers is that, from the moment we are born, we are all learning quickly, efficiently, and automatically; but in our zeal to systematize the process we have ignored valuable, naturally enjoyable learning tools like forgetting, sleeping, and daydreaming. Is a dedicated desk in a quiet room really the best way to study? Can altering your routine improve your recall? Are there times when distraction is good? Is repetition necessary? Carey's search for answers to these questions yields a wealth of strategies that make learning more a part of our everyday lives and less of a chore. By road testing many of the counterintuitive techniques described in this book, Carey shows how we can flex the neural muscles that make deep learning possible. Along the way he reveals why teachers should give final exams on the first day of class, why it's wise to interleave subjects and concepts when learning any new skill, and when it's smarter to stay up late prepping for that presentation than to rise early for one last cram session. And if this requires some suspension of disbelief, that's because the research defies what we've been told, throughout our lives, about how best to learn. The brain is not like a muscle, at least not in any straightforward sense. It is something else altogether, sensitive to mood, to timing, to circadian rhythms, as well as to location and environment. It doesn't take orders well, to put it mildly. If the brain is a learning machine, then it is an eccentric one. In *How We Learn*, Benedict Carey shows us how to exploit its quirks to our advantage. Praise for *How We Learn*

This book is a revelation. I feel as if I've owned a brain for fifty-four years and only now discovered the operating manual. Mary Roach, bestselling author of *Stiff* and *Gulp*

A welcome rejoinder to the faddish notion that learning is all about the hours put in. *The New York Times Book Review*

A valuable, entertaining tool for educators, students and parents. *Shelf Awareness*

*How We Learn* is more than a new approach to learning; it is a guide to making the most out of life. Who wouldn't be interested in that? *Scientific American*

I know of no other source that pulls together so much of what we know about the science of memory and couples it with practical, practicable advice. Daniel T. Willingham, professor of psychology at the University of Virginia

From the Hardcover edition.

Chapter One: The Story Maker

The Biology of Memory

The science of learning is, at bottom, a study of the mental muscle doing the work: the living brain and how it manages the streaming sights, sounds, and scents of daily life. That it does so at all is miracle enough. That it does so routinely is beyond extraordinary. Think of the waves of information rushing in every waking moment, the hiss of the kettle, the flicker of movement in the hall, the twinge of back pain, the tang of smoke. Then add the demands of a typical layer of multitasking: say, preparing a meal while monitoring a preschooler, periodically returning work emails, and picking up the phone to catch up with a friend. Insane. The machine that can do all that at once is more than merely complex. It's a cauldron of activity. It's churning like a kicked beehive. Consider several numbers. The average human brain contains 100 billion neurons, the cells that make up its gray matter. Most of these cells link to thousands of other neurons, forming a universe of intertwining networks that communicate in a ceaseless, silent electrical storm with a storage capacity, in digital terms, of a million gigabytes. That's enough to hold three million TV shows. This biological machine hums along even when it's at rest, staring blankly at the bird feeder or some island daydream, using about 90 percent of the energy it burns while doing a crossword puzzle. Parts of the brain are highly active during sleep, too. The brain is a dark, mostly featureless planet, and it helps to have a map. A simple one will do, to start. The sketch below shows several areas that are central to learning: the entorhinal cortex, which acts as a kind of filter for incoming information; the hippocampus, where memory formation begins; and the neocortex, where conscious memories are stored once they're flagged as keepers. This diagram is more than a snapshot. It hints at how the brain operates. The brain has modules, specialized components that divide the labor. The entorhinal cortex does one thing, and the hippocampus does another. The right hemisphere performs different functions from the left one. There are dedicated sensory areas, too, processing what you see, hear, and feel. Each does its own job and together they generate a coherent whole, a continually updating record of past, present, and possible future. In a way, the brain's modules are like specialists in a movie production crew. The cinematographer is framing shots, zooming in tight, dropping back, stockpiling footage. The sound engineer is recording, fiddling with volume, filtering background noise. There are editors and writers, a graphics person, a prop stylist, a composer working to supply tone, feeling the emotional content as well as someone keeping the books, tracking invoices, the facts and figures. And there's a director, deciding which pieces go where, braiding all these elements together to tell a story that holds up. Not just any story, of course, but the one that best explains the material pouring through the senses. The brain interprets scenes in

the instants after they happen, inserting judgments, meaning, and context on the fly. It also reconstructs them later on what exactly did the boss mean by that comment? scrutinizing the original footage to see how and where it fits into the larger movie. It's a story of a life our own private documentary and the film crew serves as an animating metaphor for what's happening behind the scenes. How a memory forms. How it's retrieved. Why it seems to fade, change, or grow more lucid over time. And how we might manipulate each step, to make the details richer, more vivid, clearer. Remember, the director of this documentary is not some film school graduate, or a Hollywood prince with an entourage. It's you. Before wading into brain biology, I want to say a word about metaphors. They are imprecise, practically by definition. They obscure as much as they reveal. And they're often self-serving, crafted to serve some pet purpose in the way that the chemical imbalance theory of depression supports the use of antidepressant medication. (No one knows what causes depression or why the drugs have the effects they do.) Fair enough, all around. Our film crew metaphor is a loose one, to be sure but then so is scientists' understanding of the biology of memory, to put it mildly. The best we can do is dramatize what matters most to learning, and the film crew does that just fine. To see how, let's track down a specific memory in our own brain. Let's make it an interesting one, too, not the capital of Ohio or a friend's phone number or the name of the actor who played Frodo. No, let's make it the first day of high school. Those tentative steps into the main hallway, the leering presence of the older kids, the gunmetal thump of slamming lockers. Everyone over age fourteen remembers some detail from that day, and usually an entire video clip. That memory exists in the brain as a network of linked cells. Those cells activate or fire together, like a net of lights in a department store Christmas display. When the blue lights blink on, the image of a sleigh appears; when the reds come on, it's a snowflake. In much the same way, our neural networks produce patterns that the brain reads as images, thoughts, and feelings. The cells that link to form these networks are called neurons. A neuron is essentially a biological switch. It receives signals from one side and when it flips or fires sends a signal out the other, to the neurons to which it's linked. The neuron network that forms a specific memory is not a random collection. It includes many of the same cells that fired when a specific memory was first formed when we first heard that gunmetal thump of lockers. It's as if these cells are bound in collective witness of that experience. The connections between the cells, called synapses, thicken with repeated use, facilitating faster transmission of signals. Intuitively, this makes some sense; many remembered experiences feel like mental reenactments. But not until 2008 did scientists capture memory formation and retrieval directly, in individual human brain cells. In an experiment, doctors at the University of California, Los Angeles, threaded filament-like electrodes deep into the brains of thirteen people with epilepsy who were awaiting surgery. This is routine practice. Epilepsy is not well understood; the tiny hurricanes of electrical activity that cause seizures seem to come out of the blue. These squalls often originate in the same neighborhood of the brain for any one individual, yet the location varies from person to person. Surgeons can remove these small epicenters of activity but first they have to find them, by witnessing and recording a seizure. That's what the electrodes are for, pinpointing location. And it takes time. Patients may lie in the hospital with electrode implants for days on end before a seizure strikes. The UCLA team took advantage of this waiting period to answer a fundamental question. Each patient watched a series of five- to ten-second video clips of well-known shows like *Seinfeld* and *The Simpsons*, celebrities like Elvis, or familiar landmarks. After a short break, the researchers asked each person to freely recall as many of the videos as possible, calling them out as they came to mind. During the initial viewing of the videos, a computer had recorded the firing of about one hundred neurons. The firing pattern was different for each clip; some neurons fired furiously and others were quiet. When a patient later recalled one of the clips, say of Homer Simpson, the brain showed exactly the same pattern as it had originally, as if replaying the experience. It's astounding to see this in a single trial; the phenomenon is strong, and we knew we were listening in the right place, the senior author of the study, Itzhak Fried, a professor of neurosurgery at UCLA and Tel Aviv University, told me. There the experiment ended, and it's not clear what happened to the memory of those brief clips over time. If a person had seen hundreds of *Simpsons* episodes, then this five-second clip of Homer might not stand out for long. But it could. If some element of participating in the experiment was especially striking for example, the sight of a man in a white coat fiddling with wires coming out of your exposed brain as Homer belly-laughed then that memory could leap to mind easily, for life. My first day of high school was in September 1974. I can still see the face of the teacher I approached in the hallway when the bell rang for the first class. I was lost, the hallway was swarmed, my head racing with the idea that I might be late, might miss something. I can still see streams of dusty morning light in that hallway, the ugly teal walls, an older kid at his locker, stashing a pack of Winstons. I swerved beside the teacher and

said, Excuse me in a voice that was louder than I wanted. He stopped, looked down at my schedule: a kind face, wire-rimmed glasses, wispy red hair. You can follow me, he said, with a half smile. You're in my class. Saved. I have not thought about that for more than thirty-five years, and yet there it is. Not only does it come back but it does so in rich detail, and it keeps filling itself out the longer I inhabit the moment: here's the sensation of my backpack slipping off my shoulder as I held out my schedule; now the hesitation in my step, not wanting to walk with a teacher. I trailed a few steps behind. This kind of time travel is what scientists call episodic, or autobiographical memory, for obvious reasons. It has some of the same sensual texture as the original experience, the same narrative structure. Not so with the capital of Ohio, or a friend's phone number: We don't remember exactly when or where we learned those things. Those are what researchers call semantic memories, embedded not in narrative scenes but in a web of associations. The capital of Ohio, Columbus, may bring to mind images from a visit there, the face of a friend who moved to Ohio, or the grade school riddle, What's round on both sides and high in the middle? This network is factual, not scenic. Yet it, too, fills in as the brain retrieves Columbus from memory. In a universe full of wonders, this has to be on the short list: Some molecular bookmark keeps those neuron networks available for life and gives us nothing less than our history, our identity. Scientists do not yet know how such a bookmark could work. It's nothing like a digital link on a computer screen. Neural networks are continually in flux, and the one that formed back in 1974 is far different from the one I have now. I've lost some detail and color, and I have undoubtedly done a little editing in retrospect, maybe a lot. It's like writing about a terrifying summer camp adventure in eighth grade, the morning after it happened, and then writing about it again, six years later, in college. The second essay is much different. You have changed, so has your brain, and the biology of this change is shrouded in mystery and colored by personal experience. Still, the scene itself—the plot—is fundamentally intact, and researchers do have an idea of where that memory must live and why. It's strangely reassuring, too. If that first day of high school feels like it's right there on the top of your head, it's a nice coincidence of language. Because, in a sense, that's exactly where it is. For much of the twentieth century scientists believed that memories were diffuse, distributed through the areas of the brain that support thinking, like pulp in an orange. Any two neurons look more or less the same, for one thing; and they either fire or they don't. No single brain area looked essential for memory formation. Scientists had known since the nineteenth century that some skills, like language, are concentrated in specific brain regions. Yet those seemed to be exceptions. In the 1940s, the neuroscientist Karl Lashley showed that rats that learned to navigate a maze were largely unfazed when given surgical injuries in a variety of brain areas. If there was some single memory center, then at least one of those incisions should have caused severe deficits. Lashley concluded that virtually any area of the thinking brain was capable of supporting memory; if one area was injured, another could pick up the slack. In the 1950s, however, this theory began to fall apart. Brain scientists began to discover, first, that developing nerve cells—baby neurons, so to speak—are coded to congregate in specific locations in the brain, as if preassigned a job. You're a visual cell, go to the back of the brain. You, over there, you're a motor neuron, go straight to the motor area. This discovery undermined the interchangeable parts hypothesis. The knockout punch fell when an English psychologist named Brenda Milner met a Hartford, Connecticut, man named Henry Molaison. Molaison was a tinkerer and machine repairman who had trouble keeping a job because he suffered devastating seizures, as many as two or three a day, which came with little warning and often knocked him down, out cold. Life had become impossible to manage, a daily minefield. In 1953, at the age of twenty-seven, he arrived at the office of William Beecher Scoville, a neurosurgeon at Hartford Hospital, hoping for relief. Molaison probably had a form of epilepsy, but he did not do well on antiseizure drugs, the only standard treatment available at the time. Scoville, a well-known and highly skilled surgeon, suspected that whatever their cause the seizures originated in the medial temporal lobes. Each of these lobes has one in each hemisphere, mirroring one another, like the core of a split apple contains a structure called the hippocampus, which was implicated in many seizure disorders. Scoville decided that the best option was to surgically remove from Molaison's brain two finger-shaped slivers of tissue, each including the hippocampus. It was a gamble; it was also an era when many doctors, Scoville prominent among them, considered brain surgery a promising treatment for a wide variety of mental disorders, including schizophrenia and severe depression. And sure enough, postop, Molaison had far fewer seizures. He also lost his ability to form new memories. Every time he had breakfast, every time he met a friend, every time he walked the dog in the park, it was as if he was doing so for the first time. He still had some memories from before the surgery, of his parents, his childhood home, of hikes in the woods as a kid. He had excellent short-term memory, the ability to keep a phone number or name in mind for thirty

seconds or so by rehearsing it, and he could make small talk. He was as alert and sensitive as any other young man, despite his loss. Yet he could not hold a job and lived, more so than any mystic, in the moment. From the Hardcover edition. *Revue de presse* This book is a revelation. I feel as if I've owned a brain for fifty-four years and only now discovered the operating manual. For two centuries, psychologists and neurologists have been quietly piecing together the mysteries of mind and memory as they relate to learning and knowing. Benedict Carey serves up their most fascinating, surprising, and valuable discoveries with clarity, wit, and heart. I wish I'd read this when I was seventeen. Mary Roach, bestselling author of *Stiff* and *Gulp* *How We Learn* makes for a welcome rejoinder to the faddish notion that learning is all about the hours put in. Learners, [Benedict] Carey reminds us, are not automatons. *The New York Times Book* The insights of *How We Learn* apply to far more than just academic situations. Anyone looking to learn a musical instrument would benefit from understanding what frequency and type of practice is most effective. Even readers with little practical use for Carey's information will likely find much of it fascinating, such as how intuition can be a teachable skill, or that giving practice exams at the very beginning of a semester improves grades. *How We Learn* is a valuable, entertaining tool for educators, students and parents. *Shelf Awareness* *How We Learn* is more than a new approach to learning; it is a guide to making the most out of life. Who wouldn't be interested in that? *Scientific American* Whether you struggle to remember a client's name, aspire to learn a new language, or are a student battling to prepare for the next test, this book is a must. I know of no other source that pulls together so much of what we know about the science of memory and couples it with practical, practicable advice. Daniel T. Willingham, professor of psychology at the University of Virginia and author of *Raising Readers in an Age of Distraction* *How We Learn* is as fun to read as it is important, and as much about how to live as it is about how to learn. Benedict Carey's skills as a writer, plus his willingness to mine his own history as a student, give the book a wonderful narrative quality that makes it all the more accessible and all the more effective as a tutorial. Robert A. Bjork, Distinguished Research Professor, Department of Psychology, University of California, Los Angeles **Fact #1: Your brain is a powerful and eccentric machine, capable of performing astonishing feats of memory and skill. Fact #2: Benedict Carey has written a book that will inspire and equip you to use your brain in a more effective way. Fact #3: You should use your brain right now to buy this book for yourself and for anyone who wants to learn faster and better.** Daniel Coyle, bestselling author of *The Talent Code* From the Hardcover edition.