2 | Study Efficiency

The words in your study guide blur as both eyes decide to stop cooperating with each other. Trying to focus again, you make an earnest effort to understand the sentence you've read over and over for the past five minutes. The word *polyhydramnios* won't sit still under your drowsy vision. One word has turned into two, and they are slowly drifting away from each other. You can't remember the last time you felt this tired.

You gently massage your eyes in hopes that they will wake up again. Alas, it's no use. Their lack of cooperation is a sign that your brain is calling it quits. But the test is tomorrow and you still have lectures to review. *I must keep working, I must focus!* you think. This sentiment used to be a powerful motivating factor, but it is no longer strong enough to overcome the urge to sleep. The sandman beckons—your eyes finally close, having felt as if they were supporting the weight of the world. Your head drops toward the desk. Sleep seems inevitable, but suddenly your legs wake and you stand up. You look like a reanimated corpse, and that's not far from the truth. You feel the rising panic about tomorrow's test, and you know exactly what you need to do. You're lucky you loaded up your wallet with coins and singles this morning as that's the only form of money your drug dealer accepts.

Not surprisingly, the vending machine in the lobby of the medical library has fewer drinks in it than it had at the beginning of the day. You don't really like the taste of energy drinks, but the coffee pot broke a long time ago and no one has since made any effort

to replace it. You gulp down the massive drink in just forty-five seconds, and in precisely three minutes you're back in the study room, staring at lecture slides. "All right, let's do this," you mutter as you plug back into your work station. The clock reads 2:17 a.m., and at the sight of it, your stomach wrenches as if you were just punched. The test is in just five hours and forty-three minutes, and the caffeine you just imbibed is barely working.

You struggle through those last few lectures, knowing you won't absorb all the detail you would like to. Of course, looking at the lectures even once is better than not looking at them at all. You hope the test won't have any questions from those lectures, but your inner pessimist raises an anxiety-producing question, "What if there are lots of questions on the test from those lectures?" The last hour of studying is best described as brief moments of anxiety layered upon a background of somnolence.

At 3:26 a.m. you decide the time to sleep has finally come. You've pushed and pushed and you can't possibly push anymore. The last few days of near-constant studying have been brutal on your sleep cycle and general state of well-being. Your brain is like a fully soaked sponge; it has absorbed as much knowledge as it can, and adding more will simply cause other knowledge to leak out. You rise from your desk amid the graveyard of empty coffee cups, energy drinks, and lecture printouts, and like a zombie, you make your way out of the building, muttering something about brains—not because you want to eat them but because yours hurts. You shouldn't drive—you're probably as dangerous as a drunk. But your stubborn nature easily overrides your moral compass as you get behind the wheel. Again, your eyes struggle to stay open as the view of the outside world begins to fade away. Not wanting to die, you panic, and your body offers up a quick surge of adrenaline. You make it home in one tired piece, and one minute later you're in bed. As you stretch out, you make the regrettable decision to look at your alarm clock: 3:54 a.m.

The thought that you have to get up in two and a half hours is disturbing, but you're glad to get any sleep at all. Still, your dreams are plagued by thoughts of the test and all the minutiae you've already forgotten.

Bzzzzz. Bzzzzz. Bzzzzz. You wake up disoriented in the dark, and it takes you thirty seconds to understand that your alarm is going off and you have a test to take. You bound out of bed, pound an energy drink, brush your teeth, and hop in the car. When you reach school, you realize you're almost as tired as you were the night before. Any more studying will be impossible, but a final surge of anxiety-generated adrenaline kicks in, and still sitting in your car, you look over a few study-guide pages one final time. When you step into the building, you hear chattering in the distance. As you move closer to your study room, the din grows louder. It's 7:30 a.m. on Tuesday and the study room sounds like a noisy bar with people trying to talk over one another. You hear angry yelling, but instead of being drunk on alcohol, your fellow medical students are delirious with sleep deprivation. You take a deep breath as your hand rests on the doorknob. You know that as soon as the door opens, you will be bombarded with questions about the minutest of minutiae.

In the room, papers lie everywhere, and the garbage cans overflow with coffee cups. A group of medical students sit around a table squawking at each other. "Hey, do you know why hyperkalemia causes metabolic acidosis?" one of your peers asks you, without so much as a hello or a how are you doing. On test day, medical students have no time for such trivialities. You reach into the depths of your recently learned renal physiology knowledge and your answer makes logical sense. Your sense of self-worth blossoms. Maybe you do know your stuff. Maybe the test won't be that bad. But another peer interrupts and says, "Yeah, that's what I thought, too, but I asked the professor and he said something else, and the book says something different. I e-mailed the

professor at 10:00 p.m., but he still hasn't gotten back to me!" You wonder why this student offered up such a baited question. Maybe there is no known answer, and if there isn't, there's a low probability this question will be on the test. Your head feels as if it will explode, so you grab your laptop and leave the study room, heading toward the exam room.

Sitting in your assigned space, you realize that the moment is almost here. You desperately want this test to be over. At 7:50 a.m. the study room group makes their loud entrance. You're sitting beside a good friend, and you focus your conversation on posttest party plans.

Nine minutes pass, and the proctor says, "The test will begin in one minute." The room becomes eerily silent. The anxiety is palpable. A quick check of your carotid pulse causes you to become aware of your accelerated heartbeat. You wonder if it's due to anxiety, excessive caffeine intake, or both. Your stream of thoughts is interrupted as the proctor says, "You may begin your test now. You have two hours."

Okay, this is what I've been preparing for; I am ready for this, you think. You notice the first vignette is lengthy. "A 65-year-old man presents to the emergency department with dyspnea on exertion and complains of..." Oh, and there are so many lab values. Maybe you'll return to this question later. But the next question proves to be just as lengthy, as does the third question. Skimming, you finally find a two-sentence question, an easy one, and answering it generates some momentum. One hour passes and you are on pace to finish with only twenty-three lengthy questions left. You lean back in your chair, take a deep breath, and stretch out your arms. This causes you to become lightheaded, but you hold it together and refocus on the computer screen. Next question.

"A 45-year-old female presents with diffuse muscle pains and complains that...A 45-year-old female presents with diffuse muscle pains...A 45-year-old female...muscle pains." As hard

as you try, you can't read that first sentence. You stare harder at the words, but they blur, and you realize it's been a long time since your last caffeine fix. Your eyes start to close and your head begins to droop toward your computer. You can't tell if you're awake or dreaming. The next thing you know, fifteen minutes have somehow disappeared, and you have only forty-five minutes left to answer twenty-three questions. This thought and the catnap you just took create a jolt of energy that powers you through the remaining questions.

Finally it's over. Walking out of the exam room, you let out a sigh of relief. As you make your way toward the study room, the chatter becomes audible, even louder than it was before. As you step into the room, you enter a sea of commotion and questions, with one immediately directed toward you: "What did you get for the question with the woman who had the muscle pains?" Before you try to answer, three people give their answers, each one different. A commotion ensues—arguments, despair, more questions. You want to go home and sleep for three days straight. Lamentably, this afternoon's school activities are mandatory.

You slog from one activity to the next, looking and feeling like a zombie. By some miracle, you make it through the rest of the school day without falling asleep, though the afternoon lectures are a blur, the memory of each immediately erased the moment you leave the lecture hall. Luckily, all lectures are recorded, and you take solace in the fact that you will eventually watch them. Finally, the day is done and you can go home and sleep guilt free. You drink one last cup of coffee for safety's sake and hop in the driver's seat. You've been waiting for this moment for so long, you're ecstatic. Five peaceful hours later, you are staring squinty eyed at the ceiling, somewhat refreshed. Outside it's dark. *How long did I sleep?* Desperately, you shoot a glance at the clock, hoping you can return to a seminormal sleep schedule. When you notice it's only 9:30 p.m., you're relieved. You have

just enough time to eat dinner, relax for a couple of hours, and head back to bed.

At 11:00 p.m. you're slumped on the couch, contentedly catching up on all the TV you've missed. You love watching TV without the constantly interfering *I should be studying!* thought. At 11:45 p.m. the grip of sleep begins to take hold, and you decide to finish out the night by fooling around on the computer. You need to check tomorrow's schedule to see how early you need to wake up. You grunt. Class at 8:00 a.m. Looking closer, you see that tomorrow's lectures include multiple hours of relatively complicated topics, but you're almost too tired to care.

At 6:50 a.m. the wretched alarm wakes you. Despite all of yesterday's sleep, you're still in sleep debt, and you'd love to lie in bed a little longer. Somehow you convince yourself that more sleep isn't an option. You head to school, and all day, hour after hour, you're bombarded with medical knowledge. As the day wears on, you realize you're already behind, so later, driving home, you toy with the idea of studying the new material. But once you're home, the motivation isn't there. You want sleep. You get no studying done the rest of the week either. You'd like to study, but you're still drained from Tuesday's test.

Finally, the weekend arrives, and you are excited about taking part in fun activities to make up for the previous miserable all-study weekend. You tell yourself you'll study this weekend, if only for a few hours, but Saturday and Sunday pass and you get no studying done. You tell yourself it's fine. You're only a few days behind and this week you'll make up for that, and with every passing day you repeat the mantra, "I will study."

But studying for the last test took its toll, and even though the somnolence has worn off, the motivation to study isn't there. Three weeks after the test, you can count on one hand the number of hours you've studied. What's worse is that the next test is less than a week away. You begin to panic. You know you have to

> study and that many sleepless nights and energy drinks are in your near future. The cycle of cramming begins anew. It's as if you are sitting in the middle of a lake in a rowboat with a small hole in the bottom. And as the water flows in, you do nothing but watch it pool beneath you. At first it only coats the bottom of the boat. *Nothing to worry about*, you think. But as more water flows in and reaches your ankles, you think, *I'll take care of this later*. When the water is halfway up your calf and the boat is starting to sink, you yell, "I have to save my boat from sinking!" In a panic you start to bail as fast as you can, and after hurling the last bucket of water out of the boat, you collapse in exhaustion. The problem is, there's still a hole in the bottom of the boat and water is still flowing in. Exhausted, you remain content to watch it rise until once again the boat is sinking.

Most medical students recognize this cycle. Oftentimes they don't study until the last minute, at which point they begin to study excessively. Such students are affectionately known as crammers, and to understand them, let's examine their history.

Why Do Students Cram?

Although students face some tests in elementary school they seldom need to study for them. The first time they take a test that requires some studying is during middle school, and this is also the first time that smarter kids are placed in classes with other smart kids—the first time tests begin to be competitive. Although most of the emphasis in middle school is placed on homework and assignments, tests still count for something. However, most students can easily prepare by studying for an hour or two the night before a test. As a result, in middle school just about everyone is a crammer.

But an interesting change takes place in high school where tests begin to take on much more weight. In some classes, getting decent grades on tests and excellent grades on projects and homework will ensure a good

grade in the class, but just as tests rise in importance, so do grades. All high school students know that if they want to go to a good college, they have to get good grades, and in many cases that means doing well on tests. And doing well on tests means being prepared to take those tests. But how much studying does the average student need to do? The answer depends on the student, but two basic patterns of successful students exist: the bright student who tends to cram and the hardworking student.

Once students reach college, the days of waking up early to sit in class for seven hours straight are gone, and even attendance isn't mandatory. Still, college-level courses normally progress at two times the speed of an average high school course. As far as grades are concerned, some consist entirely of test scores, which means if students do well on the tests, they'll do well in the class. College classes also usually have only two or three tests a semester or quarter rather than the multitude of tests given in high school, and fewer tests means that each one covers a wider range of knowledge and therefore requires more preparation. In other words, students must study more than they did in high school to do well on the average college test.

In addition, the level of competition among students in college rises significantly compared to high school. As you well know, acceptance into medical school requires immense effort, particularly since many more premedical students graduate each year than the number of available medical school spots. A premedical student is not only competing with all the other premeds around the country but also with the nontraditional applicants who decide to change careers and have résumés bursting at the seams with fascinating experiences. As a result, premedical students need to consistently do well on hard tests and to take grades seriously. This normally equates to placing utmost importance on studying.

So for the purposes of understanding what leads to cramming, let's look at the two types of students.

The first is the bright student, the student who just "gets it." Bright students usually can get by on their intelligence alone and normally dislike homework and projects since these require "extra work." If it were up to

them, their grades would be based entirely on tests, and they usually don't need to work as hard as their peers, which often creates a tendency toward laziness. Through a combination of laziness and decreased study need, bright students usually cram for a few hours the night before the test.

The second type is the hardworking student. Hardworking students may not be as smart as the bright students, but what they lack in intelligence they make up for in hard work. They tend to like projects and homework, where they can spend as much time as they need to obtain superior results. Although they may not "get the material" right away, they will work tirelessly until they do. Usually, hardworking students do just as well as their brighter counterparts, but since they need to work harder to achieve the same results, they learn the value of hard work and have less of a tendency to cram. It's important to note that if you're a smart student, you're not necessarily lazy, and if you're hardworking, you're not necessarily less bright than your peers. Most students fall somewhere between these two extremes on a spectrum. And there are pros and cons to being each type. But the apt question to ask as far as medical school goes is this: Is it better to be smart and lazy or hardworking and less intelligent?

How do our two different types handle the increased pressure to succeed? Bright students are much more at home in the college atmosphere, knowing they can perform above average on any given test. And since most college courses place so much emphasis on tests, bright students have an immediate advantage. They love studying on their own, skipping classes, acing tests, and getting As. On the other hand, since college tests are generally much harder than tests in high school, even bright students have to buckle down and study at some point. This may be the first time in their entire lives that they actually have to study for any significant period of time. A semblance of study habits will begin to develop. Bright students may decide to spread their studying out over time, thus converting from crammers into noncrammers. But some bright students may wait to study until a few days before a test.

In college, hardworking students end up working even harder than they did in high school, making the library a second home. They often

talk about how much studying they have to do and how little time there is to do it. The increased pace of class and difficulty of college tests are a strain on hardworking students, and to succeed, they must pour countless hours into studying.

Which type of student makes it into medical school? Acceptance is by no means a linear process, but since competition is fierce, no medical school accepts students who don't have a record of good grades, a good MCAT score, and plenty of extracurricular activities. Thus, premedical students must not only ace every class but also do well on the MCAT and find enough time to participate in other activities.

Doing well in premed classes and on the MCAT generally requires a high level of intelligence, but intelligence alone rarely ensures success—with the exception of the geniuses among us, to succeed in these endeavors, we have to do the hard work. The fact that the premedical student also has to find time to partake in extracurricular activities creates even greater strain, and thus the student who gets into medical school is usually both bright and hardworking.

Figure 2.1 depicts a randomized, even distribution of premedical students with varying levels of intelligence and work ethic. Smarter students are on the right, while those with less intelligence are on the left. Hardworking students are represented at the top of the graph, while lazier students are near the bottom. A smart, hardworking student will end up in the upper right corner, and a smart lazy student in the lower right.

Figure 2.2 illustrates the types of students who normally get accepted into medical school.

As the two figures make vividly clear, far fewer students are accepted into medical school than apply. Usually, only the most competitive make it in. Let's examine the upper right-hand quadrant of figure 2.2. These students have the brain power to give them an advantage on tests and the work ethic to make sure that they are maximally prepared. They always manage to earn As and engage in many extracurricular activities. Note that a large chunk of dots is missing from this quadrant; the missing dots represent students who were smarter and harder working than the average

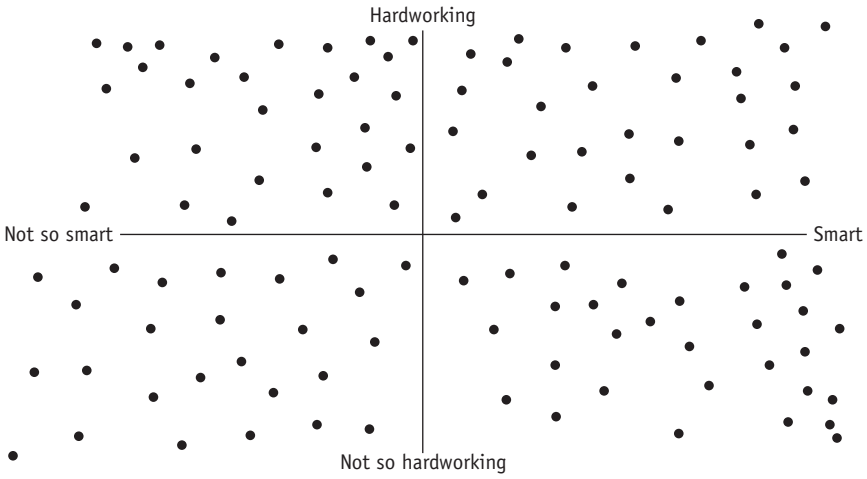

Figure 2.1 Premedical students applying to medical school

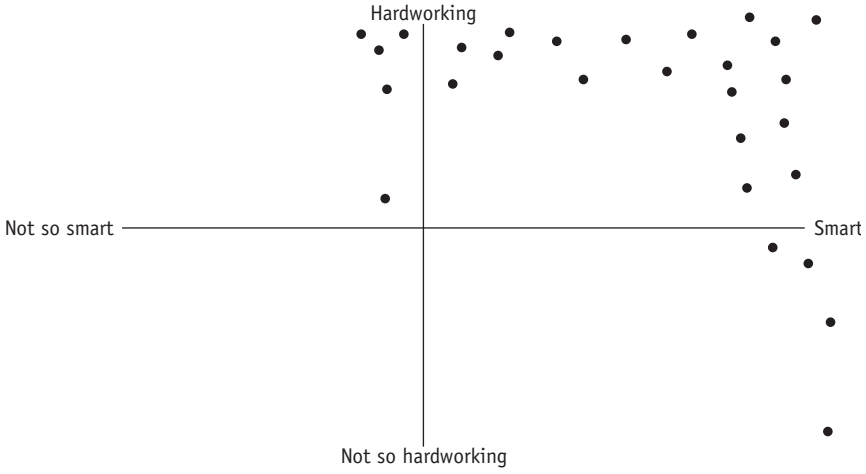

Figure 2.2 Premedical students accepted into medical school

student yet didn't make the cut. They managed to do fairly well in their premed courses, got decent MCAT scores, engaged in extracurricular activities, and probably received a few interviews. Some of these students probably were on a few waitlists. The students in the upper right-hand quadrant who made the cut were either very hardworking, extremely intelligent, or both. The intelligent could get away with working a little less hard than those with less intelligence, but on average, these students were both intelligent and hardworking.

Let's look at the lower right-hand quadrant of figure 2.2. Here many fewer students made the cut. These are the students who many consider bright but who are also lazy. The students from this quadrant who didn't make the cut had the intelligence to do well in class but didn't have the motivation to study hard enough. They typically say things like, "I could have gotten an A in that course if I just studied and handed in all the assignments on time." These students also probably relied on their high SAT scores to mask the multitude of blemishes that marked their high school transcripts. Not surprisingly, they most likely thought a good MCAT score would mask the blemishes of a spotty college transcript. Unfortunately, a stellar MCAT performance does not outweigh poor grades (unless they're in the 99.9th percentile). Students in this quadrant who made the cut were those in the 99.9th percentile on MCAT scores. Considered geniuses by their peers, they also probably get high grades despite minimal studying.

The upper left-hand quadrant of figure 2.2 represents those students who may not be the most intelligent but do work harder than the average student. They usually get decent grades but have a hard time beating the average on any given test and tend to have difficulty with trick questions or problems they've never seen before. Their MCAT scores tend to be average. But these students make up for substellar grades with a multitude of extracurricular activities, and like their intelligent and lazy counterparts, they face the obstacle that medical schools do not need to accept anyone who isn't strong in all three areas. Realistically speaking, a lot of these students have a difficult time making it into medical school. Those who are accepted

are extremely hard workers and lie on the smarter side of the quadrant, the sort of students who are propelled by a fine work ethic and who excessively study for tests. Note the one lone dot near the origin. How did this student, who isn't particularly smart or hardworking, end up getting a coveted medical school spot? The fact is, the admissions process is by no means a linear one; this person is one of the lucky ones. With no outstanding qualities, this student somehow managed to land an interview and ultimately an acceptance. How, you may ask. Your guess is as good as mine.

In the lower left-hand quadrant are the students who are not known for their intelligence or their work ethic. As figure 2.2 shows, not a single student from this quadrant made the cut. Unless one of their parents is the dean of a medical school, the students in this quadrant don't stand a chance. They are not equipped to handle the heavy workload and competition premedical courses demand, and many of them actually drop out of the premedical program.

Now let's get back to the question of why crammers cram. They do so because they have been cramming throughout their lives. Cramming is a habit. Each time they entered a new phase of school (middle school, high school, college) and faced more work, rather than shy away from the challenge, they met it head on, but the habit of leaving all the work until the last minute remained. The only factor that changed was that each stage required more hard work and therefore more time cramming.

So is cramming better than not cramming for medical students? You might answer that the best method of studying is the one that produces the best grades. It may be that two different study methods can produce the same grade, but what about long-term gains? For reasons that will be discussed later, the main long-term gain of medical school studying is long-term retention. When deciding which method of studying is better, consider the following three factors:

- The ability of the study method to produce good test grades
- The ability of the study method to create good long-term retention
- The efficiency of the study method

Grades

Test grades concern most medical students, so does cramming or not cramming produce superior test results? Every medical school test has a finite body of information students are responsible for knowing, and thus your job as a medical student is to be sure you review and learn all the material before test day. Generally speaking, the more you prepare for a test, the better you will perform. (Caution: this association is not linear—see chapter 3, "Diminishing Returns.") The number of hours you choose to study is entirely up to you, but if you wish to obtain a score in the high 90s, you'll have to study a lot more than a student who is content with a score in the low 80s.

Since the ability to obtain a high grade on a test is a question of the number of hours spent studying, whether or not you cram won't matter. If you decide to cram but end up spending four times as many hours studying as a noncrammer, you'll likely obtain a superior test score. In other words, crammers are just as capable of getting high grades as are noncrammers. A test is a measure of one's knowledge of a given material on a specific day, and how you arrived there matters little. No one cares what you knew the week before the test or how much you'll retain a week after. Crammers are experts at making sure they know what they need to on test day since they've been doing this their whole lives.

Long-Term Retention

All medical students wish to become doctors. Some have had that desire for their entire lives. For most medical students, the decision to become a doctor was likely based on two factors: the rewarding nature of the medical field and the respect and compensation doctors receive. Doctors have many responsibilities, but primarily they must provide the best health care they can to patients in need. The human body entails level upon level of complexity and multiple systems influencing each other at the same time. It is probably the most complicated machine we know of, and doctors are presented with the monumental task of understanding the human body well enough to treat all of its potential problems. Obviously, the

more doctors understand about the human body, the better they will be able to fix it. Knowledge is what separates doctors of today from healers of centuries ago, who bled people out to get rid of their "bad blood." And where do doctors acquire the knowledge they need? Much of it is acquired during medical school and residency, but to keep up with current treatment modalities and stay on the frontier of medicine, doctors must pursue lifelong learning. In effect, medical training has three periods or stages of learning: medical school itself, residency, and postresidency.

The knowledge learned during these three stages is interconnected. That is, the knowledge you acquire after your residency is built upon what you learn in residency, and the knowledge you learn in residency is built upon what you learn in medical school. Thus, if you forget what you learn in medical school, you've lost your base of knowledge, and grasping, for instance, current treatment modalities for kidney disease will be far more difficult if you can't remember how chronic kidney disease arises in the first place.

Obviously, the human brain is not a computer. Since so much information is being continuously poured into medical students' brains, it is only natural to forget some of it. As hard as you try, you won't remember every detail about every subject, but you need to remember as much as possible of this knowledge base. How can you maximize your long-term retention of knowledge? Two main factors play a role: repetition and caring about long-term retention.

At first, the notion of caring may sound silly. *Surely*, you might think, *every medical student is desperately trying to hold on to everything because that knowledge and understanding are necessary to becoming a good physician*. Sadly, this is not necessarily true. Before medical school, students must take chemistry, biology, organic chemistry, physics, some math, and a little English, but how much of that material must doctors know to do their jobs? Not much, as it happens. Doctors don't have to remember many details of college chemistry; they needn't remember the details of organic chemistry and physics. And guess how much calculus doctors need to know. If you guessed none, you're correct! Much biology needs

to be retained, but generally you can forget most of the knowledge you obtain in college with few negative consequences. Once you pass your courses and take the MCAT, there's little reason to retain that knowledge, and most students forget much of what they learned in premedical courses. Obviously, some students remember more than others due to a combination of memory and intellectual curiosity, and it is the latter over which we have some control.

Intellectual curiosity means having questions about the way the world works and wanting to know the answers. Having intellectual curiosity about a subject results in a greater probability of remembering details related to it because genuine interest sparks the mind to retain those details. Imagine that two students who have the same ability to memorize are taking an astronomy course. Student A finds astronomy fascinating, while Student B is taking the class for credit and finds it boring. Student A is more likely to think about astronomy in his free time, and since he spends more time thinking about it, he has a greater probability of remembering the details long term.

Although forgetting premedical subject details has no dire consequences for medical students, simply forgetting everything will prove problematic in that forgetting knowledge can become a habit. This often occurs for those who take every class as a means to obtain a degree rather than for the pursuit of knowledge, and a habit created in undergraduate study will bleed into medical school. Unlike the knowledge learned in premedical classes, forgetting medical knowledge does have serious consequences.

Remembering what you learn in medical school is no easy task, but the first step is to care about the subject matter. The more you care about a subject, the better your chance of remembering it; however we've all had the experience of forgetting something we care about, something that is important to us. Another factor in enhancing memory is exposure. The more exposure you have to a piece of information or knowledge, the greater are your chances of remembering it. In other words, retention comes down to repetition. Just about everyone in this country knows the alphabet, but at some point in your early life, you didn't know it.

Remembering twenty-six new items in order is not easy for any child, but the alphabet song, sung over and over again, helps us. Once we know the alphabet, we use it almost every day, repeating it countless times throughout our lives, thus etching it into the deepest reaches of our memories. Compare this to your memory of an alphabet in a foreign language you once learned. Chances are that you can't remember it unless you speak that language or use that alphabet every day.

Repetition is just as relevant for learning and retaining medical school knowledge as it is for learning and retaining the alphabet. It would be nice if there were a song to aid in remembering the vast amount of medical knowledge—unfortunately, no such song exists—and it is difficult to match the level of repetition most of us experienced with the alphabet. Still, you'll remember and retain material longer the more you repeat it. The literal definition of *cramming* is to force or squeeze an object into an insufficient space; applied to studying, cramming is trying to force or squeeze a certain amount of studying into an insufficient period of time. Thus by definition, cramming assumes a paucity of time, and because medical school lectures contain a great deal of information to learn, going over the material multiple times becomes difficult. Crammers barely have enough time to study everything once, and this means that on average, crammers use little repetition. Little repetition translates to less long-term comprehension, which means crammers will retain far less information than will noncrammers.

One caveat: some people are able to read or hear a piece of information once and remember it forever. This ability is rare, but within the average population is a spectrum of memory abilities, and those with good memories require less repetition to retain knowledge than does someone with a less strong memory. However, in comparing study methods for the purposes of drawing figure 2.3, I assumed the memory abilities of the crammer and noncrammer are otherwise equal.

Indeed, I made three assumptions in creating the figure. The first is that neither student had previous knowledge of the subject matter. The second assumption is that a linear relationship exists between repetition

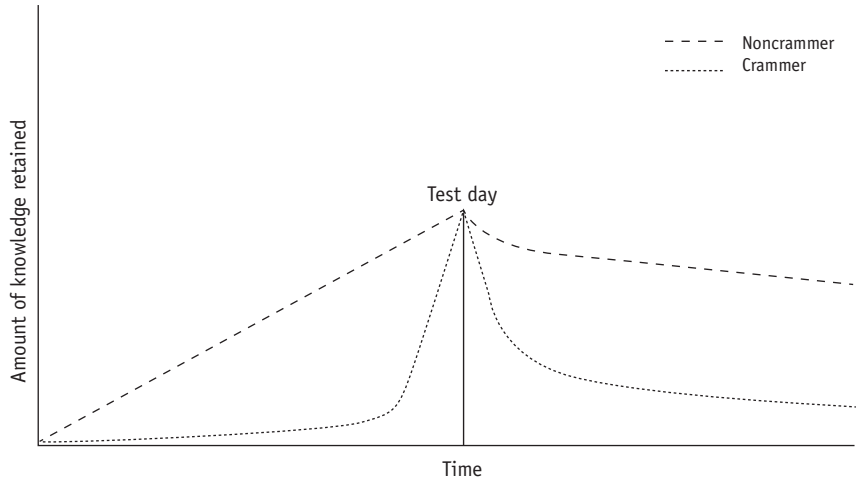

Figure 2.3 Long-term retention: crammer versus noncrammer

and long-term retention of knowledge. (While in truth this relationship is probably logarithmic, with a relative plateau of retention abilities after a certain number of repetitions, for this graph I am assuming that the number of times a medical student reviews the subject material is well below the threshold for the plateau phase and can thus be approximated linearly.) And the third assumption is that the crammer and noncrammer have equal memorization abilities.

You can see that the noncrammer and crammer start on equal ground. As time progresses, the noncrammer studies at a constant rate, while the crammer studies very little. The noncrammer may study a few hours each day, while the crammer attends the lecture but does no other studying. At this point, the noncrammer is gaining knowledge retention through constant studying and repetition, while the crammer is idling. As test day approaches, the crammer begins to study, proceeding from zero to possible all-night study sessions. This progression is visible in the slope of the crammer's line—it is much steeper than that of the noncrammer. As test day arrives, the crammer and noncrammer have reached the same

level of retention. This will last just long enough for them to take the test. Following the test, no matter the study method, it is natural for them to lose some knowledge as they quickly forget many of the small details they struggled to remember in the first place. These are the pieces of information that require more repetitions to retain than does the average slice of information. Afterward, we're usually left with a base of knowledge that slowly deteriorates if we do not continue to have repeated exposure to it. As is evident in studying the two lines, the crammer's knowledge after the test drops much more quickly as a result of having done fewer repetitions. Clearly, as time passes, the long-term retention of the material is much greater in the noncrammer.

Thus far, we have determined that cramming and not cramming are equal as far as the ability to produce test grades is concerned, but when it comes to long-term retention, not cramming is a superior study method.

Efficiency

We must ask what makes one study method more efficient than another. The goal of studying is to learn and retain knowledge, and as in all subject areas, the topics in medical school are composed of concepts and varying levels of details. An efficient study method would allow any student to learn the details in less time and would create a better understanding of the subject's concepts than would a less efficient study method.

Let's compare the abilities of not cramming and cramming in helping understand concepts. Every subject is composed of a certain proportion of concepts and details we must learn to master the material. Learning concepts is vital to understanding a subject because those concepts provide the framework that supports most of the details (see chapter 1, "Conceptual Learning and Detail Worrying"). Gaining a conceptual understanding is much tougher than is learning details because it requires us to understand multistep processes as opposed to memorize straightforward facts. This means we must spend more time learning a concept than learning a detail. Some concepts make intuitive sense and aren't

complicated so they're easy to learn, but some concepts are complicated and may take a long time and much studying for us to understand.

A good example of a complicated concept is Einstein's special relativity. A central concept of special relativity is that time is not constant but is based on relative velocity. Suffice it to say that many strange results arise from this concept. One is that the faster one moves, the more time slows from an outside observer's point of view. In other words, if a traveler is moving close to the speed of light while holding a large clock, a stationary observer will see the second hand on the traveler's clock moving much slower (velocity dependent) than the second hand of his or her own wristwatch. However, the traveler will notice no difference in the movement of the clock.

I don't expect a one-paragraph explanation of special relativity to be sufficient for anyone who isn't already familiar with it to understand the concept. Special relativity is complicated, and to truly grasp it you need to spend a lot of time trying to understand it. The point is this: if you were going to be tested on special relativity and decided to cram the night before the test, you would likely fail.

Difficult and complex concepts take time to learn because they need time to settle in the brain. While no concept in medical school is nearly as complicated as is special relativity, many concepts take time to truly understand. A good example is renal physiology. The nephron is a kidney structure with electrolytes that move in and out at different places, hormones that change the balance between absorption and secretion, and many other complicated facets. Because noncrammers spread their studying out over longer periods of time, they would have more time than would crammers to try to learn renal physiology. If the noncrammers didn't understand it one day, they would likely look at it the next day, and if they still didn't understand it, they would study again the day after that. Crammers have only a limited amount of time to study and learn everything, so they do not have the luxury of revisiting the topic. If renal physiology turns out to be hard for them to understand, the crammers—with

no time to learn, understand, and review the complexities—would likely not understand the concept and as a result might well fail the test.

A concept can be likened to a plant seed, the soil being your brain. If you want to see a seed become a flower, you need to plant it in fertile soil, water it, and give it time to grow. You can water the seed as much as you like, but without time, the seed will not grow and flower. The same applies for some concepts. You might review renal physiology countless times and still be confused, but one day, for some reason, it will suddenly make sense. The seed was growing, and that day it flowered after having had time to absorb the nutrients you've poured into the soil—time, attention, focus, repetition. But crammers don't have that kind of time. Thus, in regard to the efficiency of learning concepts, not cramming has an advantage over cramming.

Although conceptual learning is important for all medical students, you will not succeed in medical school without learning a multitude of details. Unlike concepts, details—simple facts—can be learned rather easily. The hard part is trying to remember all of them. As discussed earlier, long-term retention of facts is related to repetition, and the greater the number of learning repetitions you do, the better able you will be to retain the details.

I have not yet mentioned the quality of learning repetitions. Not every learning repetition is created equal. So what makes one superior to another? Let's use an example.

Suppose you are given a list of fifty names to memorize. You find a quiet room with nothing in it but a desk, a lamp, and a clock. Assume it is 10:00 a.m. and you are completely rested. This learning repetition will be high quality because you are not tired and you face no distractions in the room. Now suppose you try to memorize the same list of names after being awake for thirty hours and you decide to study in a crowded room surrounded by friends and family. This repetition will be low quality. Clearly, being well rested and studying in a quiet room is much more efficient than being tired and studying in a crowded room.