where you must discern the kind of problem you're trying to solve in order to apply the correct solution. (This is explained more fully in Chapter 3.)

How it feels: Blocked practice—that is, mastering all of one type of problem before progressing to practice another type—feels (and looks) like you're getting better mastery as you go, whereas interrupting the study of one type to practice a different type feels disruptive and counterproductive. Even when learners achieve superior mastery from interleaved practice, they persist in feeling that blocked practice serves them better. You may also experience this feeling, but you now have the advantage of knowing that studies show that this feeling is illusory.

Other Effective Study Strategies

ELABORATION improves your mastery of new material and multiplies the mental cues available to you for later recall and application of it (Chapter 4).

What is it? Elaboration is the process of finding additional layers of meaning in new material.

For instance: Examples include relating the material to what you already know, explaining it to somebody else in your own words, or explaining how it relates to your life outside of class.

A powerful form of elaboration is to discover a metaphor or visual image for the new material. For example, to better grasp the principles of angular momentum in physics, visualize how a figure skater's rotation speeds up as her arms are drawn into her body. When you study the principles of heat transfer, you may understand conduction better if you imagine warming your hands around a hot cup of cocoa. For radiation, visualize how the sun pools in the den on a wintry

day. For convection, think of the life-saving blast of A/C as your uncle squires you slowly through his favorite back-alley haunts of Atlanta. When you learned about the structure of an atom, your physics teacher may have used the analogy of the solar system with the sun as the nucleus and electrons spinning around like planets. The more that you can elaborate on how new learning relates to what you already know, the stronger your grasp of the new learning will be, and the more connections you create to remember it later.

Later in this chapter, we tell how the biology professor Mary Pat Wenderoth encourages elaboration among her students by assigning them the task of creating large "summary sheets." Students are asked to illustrate on a single sheet the various biological systems studied during the week and to show graphically and through key words how the systems interrelate with each other. This is a form of elaboration that adds layers of meaning and promotes the learning of concepts, structures, and interrelationships. Students who lack the good fortune to be in Wenderoth's class could adopt such a strategy for themselves.

GENERATION has the effect of making the mind more receptive to new learning.

What is it? Generation is an attempt to answer a question or solve a problem before being shown the answer or the solution.

For instance: On a small level, the act of filling in a missing word in a text (that is, generating the word yourself rather than having it supplied by the writer) results in better learning and memory of the text than simply reading a complete text.

Many people perceive their learning is most effective when it is experiential—that is, learning by doing rather than by reading a text or hearing a lecture. Experiential learning is a

form of generation: you set out to accomplish a task, you encounter a problem, and you consult your creativity and storehouse of knowledge to try to solve it. If necessary you seek answers from experts, texts, or the Web. By wading into the unknown first and puzzling through it, you are far more likely to learn and remember the solution than if somebody first sat you down to teach it to you. Bonnie Blodgett, an award-winning gardener and writer, provides a strong example of generative learning in Chapter 4.

You can practice generation when reading new class material by trying to explain beforehand the key ideas you expect to find in the material and how you expect they will relate to your prior knowledge. Then read the material to see if you were correct. As a result of having made the initial effort, you will be more astute at gleaning the substance and relevance of the reading material, even if it differs from your expectation.

If you're in a science or math course learning different types of solutions for different types of problems, try to solve the problems before you get to class. The Physics Department at Washington University in St. Louis now requires students to work problems before class. Some students take umbrage, arguing that it's the professor's job to teach the solution, but the professors understand that when students wrestle with content beforehand, classroom learning is stronger.

REFLECTION is a combination of retrieval practice and elaboration that adds layers to learning and strengthens skills.

What is it? Reflection is the act of taking a few minutes to review what has been learned in a recent class or experience and asking yourself questions. What went well? What could have gone better? What other knowledge or experiences does it remind you of? What might you need to learn for better

mastery, or what strategies might you use the next time to get better results?

For instance: The biology professor Mary Pat Wenderoth assigns weekly low-stakes "learning paragraphs" in which students are asked to reflect on what they learned the previous week and to characterize how their class learning connects to life outside the class. This is a fine model for students to adopt for themselves and a more fruitful learning strategy than spending hours transcribing lecture slides or class notes verbatim into a notebook.

CALIBRATION is the act of aligning your judgments of what you know and don't know with objective feedback so as to avoid being carried off by the illusions of mastery that catch many learners by surprise at test time.

What is it? Everyone is subject to a host of cognitive illusions, some of which are described in Chapter 5. Mistaking fluency with a text for mastery of the underlying content is just one example. Calibration is simply the act of using an objective instrument to clear away illusions and adjust your judgment to better reflect reality. The aim is to be sure that your sense of what you know and can do is accurate.

For instance: Airline pilots use flight instruments to know when their perceptual systems are misleading them about critical factors like whether the airplane is flying level. Students use quizzes and practice tests to see whether they know as much as they think they do. It's worth being explicit here about the importance of answering the questions in the quizzes that you give yourself. Too often we will look at a question on a practice test and say to ourselves: Yup, I know that, and then move down the page without making the effort to write in the answer. If you don't supply the answer, you may be giving in to the illusion of knowing, when in fact you would have difficulty rendering an accurate or complete response. Treat practice tests as tests, check your answers, and focus your studying effort on the areas where you are not up to snuff.

MNEMONIC DEVICES help you to retrieve what you have learned and to hold arbitrary information in memory (Chapter 7).

What are they? "Mnemonic" is from the Greek word for memory, and mnemonic devices are like mental file cabinets. They give you handy ways to store information and find it again when you need it.

For instance: Here is a very simple mnemonic device that some schoolchildren are taught for remembering the US Great Lakes in geographic order, from east to west: Old Elephants Have Musty Skin. Mark Twain used mnemonics to teach his children the succession of kings and queens of England, staking the sequence and length of their reigns along the winding driveway of his estate, walking it with the children, and elaborating with images and storytelling. Psychology students at Bellerbys College in Oxford use mnemonic devices called memory palaces to organize what they have learned and must be prepared to expound upon in their A-level essay exams. Mnemonics are not tools for learning per se but for creating mental structures that make it easier to retrieve what you have learned.

Brief stories follow of two students who have used these strategies to rise to the top of their classes.

Michael Young, Medical Student

Michael Young is a high-achieving fourth-year medical student at Georgia Regents University who pulled himself up from rock bottom by changing the way he studies.