

4 Memory

Much like a person, a computer with no memory would be helpless. Before your Mac can run a program, or even display icons on the desktop, it has to load instructions into memory. Before you can edit a report, change the figures in a spreadsheet, or retouch an image, the Mac has to read the file into memory. And when you create a new document, it exists only in memory until you save it on disk.

The more memory you have available, and the more efficiently you use however much you have, the more you can do with your Mac: start up more programs, open bigger files, install more system extensions, look at more elaborate screensavers. And more memory makes many operations faster.

Fortunately, Macs are free of most of the arcane and archaic memory restrictions that bedevil users of DOS and DOS/Windows PCs. Unfortunately, the Mac memory story has become pretty convoluted in its own right. The aim of this chapter is to help you through this maze. You'll find out what memory is and what it can do for you, how to determine how much you need, how to make the most of what you have, and how to add more if you need it.

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Memory Basics

Macs have several kinds of memory, but what people normally mean when they talk about a computer's memory is its *random access memory*, a term that's generally abbreviated to *RAM*. When the clerk at Sears, say, tells you the Performa 475 comes with 4 megabytes of memory, or when you try to open a scanned image in Adobe Photoshop and instead you get a dialog box informing you that there isn't enough memory, it's RAM you're dealing with.

Physical Foundations

(HN)

Physically, RAM is made up of a bunch of silicon chips designed to serve as a temporary holding place for digital information; inside these chips are thousands of microscopic switches, which the Mac turns on and off in particular patterns to represent words, numbers, pictures, sounds, and program code. This kind of memory is called *dynamic* because the Mac can change what's there at any time, adding, deleting, or moving information as it sees fit.

Most, but not all Macs have some memory chips soldered onto their main logic board at the factory; the rest come on small green plastic strips that plug into special slots on the logic board. You can add memory to the Mac by plugging in more of those cards (or replacing the old ones with new ones that have more memory capacity). Traditionally, these cards have been called *SIMMs* (single in-line memory modules), but PowerBooks and a few other models require different kinds of plug-in cards. Newer Power Macintosh models now use *DIMMs* (dual in-line memory modules).

Memory versus Storage

(RT)

One of the most confusing issues you'll ever have to deal with regarding your Macintosh is discerning between memory and storage. At first glance, the two seem very similar, but the differences far outweigh the similarities.

To your Macintosh, *memory* is a temporary holding place. It is where information is kept that needs to be retrieved quickly or constantly changed or updated. *Storage* is more permanent, where information can be kept for long periods of time. For instance, while you are working in your word processor, typing a document, the document is being written into RAM. When you save the document, that information currently in RAM is placed onto a hard drive. When you switch off your computer, RAM information is gone, but the information on the hard drive remains.

**HOT TIP**

RAM Speed versus Drive Speed

(RT)

Memory (RAM) speed is measured in *nanoseconds*, which is billionths of a second. Older Macintosh models used 100- to 150-nanosecond RAM. A typical Power Macintosh 8100 uses 60- to 80-nanosecond RAM. This means that a typical piece of information travels from the computer CPU to the RAM in about 60 billionths of a second.

Storage (hard drive) speed is measured in *milliseconds*, which is thousandths of a second. A fast hard drive may be rated at 9 milliseconds, which means information travels from the CPU to the storage device in about 9 thousandths of a second.

To put this speed issue in perspective, let's assume that RAM and a hard drive are going to have a race. Where would you put your money? Well, in the time it takes the hard drive to travel one mile, RAM would have lots of round-the-world travel stickers, as it would have traveled 111,111 miles.

My favorite memory analogy: Memory is a chalkboard; you can quickly add information (with chalk), subtract information (with an eraser), but the amount of information is limited to the size of your chalkboard.

Storage is a filing cabinet initially filled with blank pieces of paper; you can add information by writing on those pieces of paper and then you can file them away. To remove information, you simply tear up the pieces of paper you no longer want and throw them out. The amount of information you have is limited to the size of your filing cabinet.

Of course, it takes longer to retrieve information from the filing cabinet, as you have to open the correct drawer and folder and pull out the right papers and read them; retrieving information from the chalkboard requires merely a glance in the direction of the information.

The main similarity between memory and storage is in the way they are measured. Both mediums' capacities are measured in numbers of bytes. Usually this number is many, many bytes, so terms that reflect this are used: *kilobytes* (K) are 1,000 bytes; *megabytes* (MB) are 1 million bytes, or 1,000K; *gigabytes* (GB) are 1 billion bytes, or 1 million K, or 1,000MB. See [“Measuring Memory Size”](#) later in this section for more information on memory-specific measurements.

The three major differences between the two media are polar opposites of each other; one's strength is the other's weakness.

Speed. Memory is much faster than storage ([see the “RAM Speed versus Drive Speed” sidebar](#)). The reason for this drastic speed difference is due to the mechanical nature of storage versus the electronic nature of memory.

Volatility. Memory is terribly volatile. Most types of RAM can only hold information while power is supplied to them. When the power is removed, the information is gone. Storage information exists regardless of whether power is supplied to it or not; power is only needed to move information to and from the storage medium.

Price. The price of memory versus storage is in proportion to their respective speeds. Memory costs more than 100 times as much as storage per megabyte. For instance, as of this writing, 8MB RAM SIMMs were priced at about \$250, which works out to about \$31.25 per megabyte. A 1GB internal hard drive was running about \$250, which works out to about \$.25 per megabyte.

Other issues cloud the differences as well, such as *virtual memory* (storage masquerading as memory, discussed in the section “Virtual Memory”), and *RAM disks* (memory pretending to be storage, discussed in the section “RAM Disks”).

Measuring Memory Size

(RT)

Every internal computer size measurement is built upon the concept of on or off. When you start adding many of these on or off switches together, you begin to have something that the computer can understand. This on or off switch is represented by a *bit* (*binary digit*). Each bit is on or off, according to the computer. The common way for us to represent on or off is by using the number 1 as on and 0 as off. So the numbers 10011011 would be interpreted by the computer as “on off off on on off on on.”

Why Does it Say I’m Out of Memory When There’s Still Plenty of Room on My Hard Disk?

(HN)

That’s a question almost every new computer user poses sooner or later.

The fact is that the Mac, left to its own devices, is very clear about the distinction between storage and memory, and it won’t substitute one for the other unless you give it some special instructions (described later in the section on RAM disks and virtual memory). The processor in the machine can’t work on information that’s only on disk; it must first load that information into memory so it can have quick access to it. If there’s no room in memory for the application you want to start up or the big document you’re trying to open, all the disk space in the world won’t help (unless you’ve set up virtual memory). And if, conversely, your hard disk is full, you can’t save a file there, even if half your memory is free.

**HOT TIP**

A string of eight of these bits is a *byte*. A byte can be one of up to 256 different combinations, from 00000000 (zero), 00000001 (one), 00000010 (two), 00000011 (three), 00000100 (four), all the way up to 11111110 (254), and 11111111 (255). You can also think of a byte as 2 to the eighth power (2^8). But this unit is still much too small to use for measuring.

A *kilobyte* is about 1,000 bytes. Actually, it's 1,024 bytes, because it's 2^{10} bytes. When you multiply 2 times itself you get the numbers 2, 4, 8, 16, 32, 64, 128, 256, 512, 1,024. Kilobytes are usually referred to as "K." You can say "That file is 25K" instead of "That file is 25 kilobytes."

Memory is measured in the next major increment, a *megabyte*. There are 1,024K in 1 megabyte. Unlike K, however, don't say the popular written abbreviation "MB" but instead say "meg." So you would say that your Mac came with 8 "megs" of RAM. Most Macintosh models come with either 8MB or 16MB of RAM, though some are configured with more. The table "RAM Configurations by Model," at the end of this chapter, shows how much memory can be put into all Macintosh and Mac clone computers.

Hard Drives are becoming larger and larger, and it's not too unusual to find hard drives as large as several *gigabytes*. A gigabyte is 1,024MB, or about a billion bytes. Gigabytes are commonly written as GB and spoken as "gigs."

Even bigger and undoubtedly on the near horizon are *terabytes*, 1,024GB. Terabytes are still relatively uncommon, and thus no "official" way to write or say them is in computer vogue. Maybe a terabyte is big enough to demand full pronunciation of the term.

How Much Memory?

(HN)

In theory, memory is one of those good things you can't really have too much of. But your Mac will set some limits for you, and so will your budget.

How Much Do You Need?

(RT)

The old saying, "You can never have too much money or too much RAM" is still a good rule of thumb, though Macintosh computers are limited to the maximum amount of RAM that can be installed (see "[How Much Memory Can You Have?](#)").

The money part of that saying is true, especially when it comes to buying RAM. RAM costs amount to a large percentage of your overall system investment, sometimes

costing as much as or more than the rest of the entire system. Usually, the more RAM you have, the better off you'll be when it comes to speed and productivity, but you might have to hold off on that new addition to the house for a few years.

The more realistic question for most of us, on a fairly rigid budget, is to determine the exact amount needed, so none of your hard earned (or easily inherited) money is spent on RAM you aren't really taking advantage of. This is a tough question, and the answer may not be as obvious as you'd like.

If you have an old, all-in-one Mac (Plus, SE, or Classic), you've got a low RAM limit anyway, and you may find that your budget for memory outweighs your machine's capacity.

The 32-Bit Problem on Older Macs

(RT)

When the first Macintosh computers were made, no one envisioned that the Macintosh would be around for a dozen years, or that anyone would ever have a need for more than about 8MB of RAM (which in 1984 wasn't just excessive, but downright silly). So the architects of the original Mac (and the Lisa before it) engineered the Macintosh to recognize 24-bit-long addresses, which translates into about 16 million different addresses. Of course, not all of these could be used for memory, and it turned out that only about half of those addresses could be used for memory; about 8 million addresses. Doing the math, you would discover that this is roughly 8MB, the "ceiling" of memory which no Macintosh could exceed.

When the Mac II shipped, a few things started changing. Color required more memory than before, and the applications using the new, 68020 processor were bigger and more complex, also requiring more memory. Programs such as PageMaker and Photoshop started to suck quite a bit of memory from the total available. And the popularity of MultiFinder, which allowed more than one program to run at a time, increased dramatically the need for more than 8MB of RAM.

Apple responded by inserting new hardware into newer Macintosh computers, and upgrading the software to take advantage of more memory. The switch was from 24-bit to 32-bit, which worked out to a total of 4GB of address space, with 1GB of that space available for RAM.

Problems started occurring when new Macintosh computers designed to take advantage of 32-bit addressing had 24-bit software running on them. Although this problem has almost been entirely eliminated (the last non-32-bit system was the Mac IIcx, made in 1989) due to the widespread use of new machines, the problems may linger on existing older machines that are still in use.

To remedy this problem, owners of Mac IIs and the SE/30 can use either MODE32 (available from most on-line services) or Apple's 32-bit Enabler. But this is a software solution to a hardware problem; thus many problems may still occur, and your best bet is to upgrade to a machine that is *32-bit clean*.

Of course, if you have a more recent Macintosh or Power Macintosh, the upward limit of 768MB or more of RAM is costly enough to wonder how Junior is ever going to be able to go to college.

The minimum amount of RAM as of this writing, for your Macintosh to be usable and functional is not 8MB of RAM, but 16MB. Some software programs need more than the 5MB left over after your system software takes its chunk out of the original 8MB. And 16MB is the minimum, which over the next few years will become harder and harder to survive with, as software begins to take up more and more of your precious RAM. Even games are starting to require more and more RAM; in 1989 I could play every game available on a 2MB Mac II, while several games now *require* 10MB of application memory.



Now, how far above the minimum should you go? The best thing to do is to figure out which software you'll be using with your computer, and how many programs you'll need open at the same time. For instance, I use Adobe Photoshop, Adobe Illustrator, Microsoft Excel, and Microsoft Word every day; often I'll switch to one and then back to another. I need enough RAM to run all four of these programs. But then sometimes I'll run America Online, or Netscape, or I'll want to play a quick game of Strategic Conquest or Marathon 2: Durandal. And I don't want to quit Word to play a game (Word takes about 10 to 15 years to load, it seems, with time off for good behavior or few fonts). So I've figured out how much RAM I need for my main four programs and the system software (about 30MB), and multiplied that times 1.5, for a total of 45MB. There isn't a Macintosh available that'll take 45MB, so instead I've got to round it to the nearest number my Mac will take: 48MB in my case. If I'm using RAM compression software like RAM Doubler, I can get away with less ([see "RAM Doubler"](#) later in this chapter), for a modest performance gain.

This isn't an exact science, and it's better to err on the low side when doing your initial figuring. You can always buy more memory. The only problem you might run into is when you have a limited number of SIMM slots, and you fill them up with low-capacity SIMMs. In this case, you'll have to replace some SIMMs to upgrade, which will cost more than if you had the right capacity SIMMS to start with.

The industry doesn't see any dramatic decline or increase in the future of RAM prices over the next three years, unlike most other system components where prices seem to be eternally dropping.

How Much Memory Can You Have?

(TA/HN)

No matter what Mac model you have, there's a built-in limit on how much memory you can install. You can't add extra memory at all to the original 128K Mac or to the

512K or 512K Enhanced models (unless you get some unauthorized modifications made to your hardware). And the Plus, the SE, and the original Classic are limited to a maximum of 4MB of RAM.

Early Mac II models, such as the II, IIx, and IIcx, as well as the closely related SE/30, had the hardware to handle more memory, but System 6 and code in the machines' ROMs (Read Only Memory chips) imposed an artificial limit of 8MB ([see the sidebar "The 32-Bit Problem on Older Macs"](#)).

The ROMs in newer Macs theoretically support up to 1GB of RAM—more than you can probably afford (unless your name is Bill Gates, at which point you probably have minimal interest in having a souped-up Macintosh) and, with current RAM chips, more than would fit in any desktop computer. That means the main limiting factor is the number of SIMM slots Apple builds into each model, although there are some products becoming available that double the number of SIMMs you can place in each slot. Another limitation is the size of the largest SIMMs available. Most current desktop models allow much more memory than most users need, but the range varies widely. Although the Quadra 650, for example, can handle up to 136MB of RAM, the 605 has only one SIMM slot, which can hold up to 32MB on top of the 4MB soldered to the logic board.

PowerBook memory capacities are also limited by space—there simply isn't room for a lot of extra chips inside the notebooks' cramped cases. ([See the sidebar "Adding Memory to PowerBooks,"](#) later in this chapter.)



A summary of how much memory each Mac model can handle is supplied in the table "RAM Configurations by Model" at the end of this chapter.

Virtual Memory

(TA/HN)

Virtual memory, as its name implies, isn't real memory—it's hard disk space that's used as temporary memory. In effect, VM (as techies call it) enables your machine to work as if, or *almost* as if, it had more RAM than it really does, so you can open more programs and larger files.

Unfortunately, though, virtual memory doesn't replace real, physical RAM SIMMs. Instead, it adds to what already exists. A notable limitation to any virtual memory scheme (including RAM Doubler) is that you never want to allocate more memory to an application than you have in physical RAM. Doing so will usually result in disaster.

Virtual memory software comes free with System 7. All you have to do to turn it on is click a few buttons in the Memory control panel and reboot. But as you'll learn in this section, virtual memory has significant downsides as well as upsides.

Using Your Mac's Virtual Memory

(RT)

The Mac's built-in virtual memory is a quick fix to low memory problems, but not a very good overall solution to the not-enough-memory woes. Virtual memory uses a hard drive as RAM, fooling the CPU into thinking that there's much more space available for short-term memory than there really is. The downside, if you've been paying attention, is quite obvious: A hard drive is just awfully slower than your memory. To further confuse the situation, Power Mac models require less memory for their applications if virtual memory is on.

Fortunately, the Mac does a bit of magic shuttling things around to prevent those types of enormous delays, but you can expect a slowdown of on the average of 300 to 1,000 percent. That's usually unacceptable in all but the most extreme circumstances.



To set up virtual memory, open the Memory control panel from the Control Panels folder in your System Folder. Turn on Virtual Memory, and pick the fastest hard drive you have from the pop-up list. The faster your hard drive, the faster it'll seem to make your system when you're using VM. Then allocate the amount of virtual memory you'd like to use. Apple recommends using no more than the amount of installed memory as virtual memory, but you can get away with much more for a slight performance penalty (at this point, it doesn't much matter if it's a wee bit slower). When you restart your Mac, you'll have that memory added to the installed "real" memory for running software.



You can turn virtual memory on and off in the Memory control panel. It's best to select the fastest hard drive you have when turning on VM.

RAM Doublor

(RT)

If there's one utility everyone should own, Connectix's RAM Doublor would be it. RAM Doublor does some fancy footwork to double the amount of RAM without having to use a hard disk as RAM. RAM Doublor achieves this seemingly incredible magical feat by using compression techniques to compress what is currently being spit out by the CPU, on the fly, while the information is going into RAM, and decompresses it on the way out from memory.

A performance hit is the penalty, but it's slight enough (5 to 10 percent) to not be a burden. And all you do is install it and forget about it. It's that simple.

Many users, upon upgrading their memory to the amount they need, keep RAM Doubler installed because it is "like an addiction." After all, if you're used to 64MB with RAM Doubler, and then you buy 32MB RAM, wouldn't it be amazing to have 128MB of RAM with RAM Doubler? Sure.

Applications' Virtual Memory Schemes (RT)

Some applications, like Adobe Photoshop, contain their own virtual memory schemes. Oftentimes this is a fallback for when the program knows there won't be enough memory allocated to it to perform a certain task, so instead of just stopping you from doing that particular thing, it uses a hard drive as temporary, virtual RAM.

Unfortunately, many programs that have their own virtual memory schemes have either serious conflicts (serious being a locked system or a bomb window) or tremendous slowdowns when Apple's VM is on.



Managing Your Memory (HN)

You probably don't think much about how your Mac uses memory, and ordinarily there's no reason you should. But if you find yourself unable to open as many programs as you think you should be able to, or if your programs are crashing or telling you they don't have sufficient memory, knowing what's going on back there can sometimes help you solve the problem.

How the Mac Divvies Up Its RAM (HN)


Some of your RAM is consumed by the Mac operating system; the rest is available for applications.

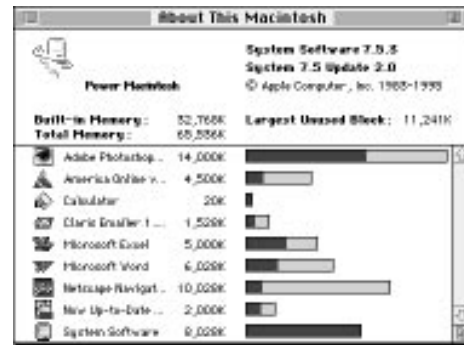
What the system takes is called the *system heap*. Its size depends on many factors, including the version of the system you are running; the extensions, cards, and other add-ons you've installed; and the size of the Disk Cache setting in the Memory control panel. (For more on the disk cache setting [see "The Memory Control Panel Cache,"](#) later in this chapter.)

What RAM is left over after all that is called the *application heap*. As you launch programs you want to work with, each lays claim to a chunk of the application heap, on a first-come, first-serve basis, and programs don't give up what they've claimed until you quit.

About This Macintosh...

(HN)

To see where your RAM is going, go to the Finder and choose About This Macintosh from the  menu. In addition to detailing how much total memory is available and the size of the largest unused block of memory (see the figure at right), this screen shows with numbers and bar graphs how much memory the system and open applications have claimed. The filled-in part of each bar represents the portion of reserved memory actually in use.



Choosing About This Macintosh from the Apple menu displays a wealth of memory-related information. Note that the version of system software is 7.5.3, which uses more RAM than any previous version.

**HOT TIP**




The About This Macintosh dialog box can be a useful tool for tuning and troubleshooting your system. If you find that an application's bar has a lot of unfilled white space—more than a third of the bar's total length, say—when you are using the program in the normal way (typical number and complexity of documents open, typical range of features in use), it may be taking more memory than it really needs. Conversely, if an application's bar is almost entirely filled, it's running low on free memory—a condition that can cause crashes.

Changing Applications' Memory Usage

(HN)

How much RAM a program normally takes is determined by information provided by the developer and stored inside a part of the program called the *SIZE resource*. But if your analysis of About This Macintosh suggests that some programs should be taking more or less RAM, you can easily change these settings.

**HOT TIP**

To do this, close the program whose memory you want to change (if it's open). Then click on the program's icon on the desktop, and press    or choose Get Info from the Finder's File menu. In the lower-right corner of the Get Info box that appears you will see a box called Memory Requirements containing (under System 7.1 and later) three items: suggested size, minimum size, and preferred size. The suggested size is the developer's advice about how much RAM the program needs. The minimum size is the minimum RAM the program requires; if that much isn't available, you won't be able to launch the program. The preferred size item determines how much memory the program will grab if it can. (System 6 has just one "application memory size" field, and System 7 doesn't display the "minimum" field.)

You can control how much memory your applications use by editing the values in the minimum and preferred fields. My advice is to never reduce the minimum value



Selecting an application and choosing *Get Info* from the *File* menu displays the application's *Get Info* dialog box. You can use the *Get Info* dialog box to change the amount of memory that the application requests in the *Preferred size* text field.

at all: Doing so would only increase the risk of poor performance and crashes. I'd also hesitate before setting the preferred amount to less than the developer's suggestion, even if *About This Macintosh* shows some memory going to waste (represented by white space within the bar). If, however, the preferred value is far above the suggested size, and you consistently see a lot of white space in the bar when you're using the program normally, you should be able to reduce the preferred setting safely, thus freeing up some memory for other programs.

If you've got the memory to spare, however, it's often a good idea to increase the settings. I routinely increase both the preferred and minimum memory sizes for each new program I install by about 25 percent. In some cases that's probably an unnecessary extravagance, but in my experience it tends to reduce the number of crashes I suffer, and I'm willing to sacrifice some RAM in the interest of stability. This is an especially good idea for Power Mac users running 68K applications.



Don't Let the System Take It All!

(HN)

No matter how you slice it, System 7 needs a good bit of RAM—usually at least 2MB, and up to 8MB in System 7.5.3. But if you want to preserve as much as possible for applications, here are several things to check:

- *The Disk Cache setting in the Memory control panel.* The disk cache is a section of your system heap the Mac operating system sets aside for holding (caching) information you've recently read from disk, so it can be retrieved quickly if it's needed again (for more details see [“The Memory Control Panel Cache,”](#) later in this chapter). If you prefer to have the RAM free for other purposes, you can reduce the cache setting.
- *The RAM Disk setting in the Memory control panel.* Memory set aside for a RAM disk (see [“RAM Disks,”](#) later in this chapter) reduces the amount available for applications. (It is counted as part of the system's memory allocation in *About This Macintosh*.) If you are not using your RAM disk, shut it off via the Memory control panel and reboot so you can use the memory for other things.
- *The amount of memory you're devoting to extensions.* Unfortunately, the Mac alone doesn't give you that information, and neither do the developers of most extensions. But most of the leading commercial and shareware extension managers

(with the exception of Apple’s own Extensions Manager that ships with System 7.5 and later)—utilities that let you monitor and control the loading of extensions—provide information on the amount of memory each extension requests as it loads. (Extension managers are described in Chapter 13.) Another option is **TattleTech**, a utility from Decision Maker’s Software that reports detailed information about all aspects of your system. It’s “good-causeware” (the author, John Mancino, asks you to make a donation to a nonprofit organization of your choice), and it’s excellent. Each extension might not take up a lot of memory, but taken together, they add up.

- *The number of fonts you are using.* The number of fonts you use can have an effect on the amount of memory your system consumes (see Chapter 14 for more on how to handle fonts).

Why Won’t My Program Open When About This Macintosh Says I Have Enough Free Memory?

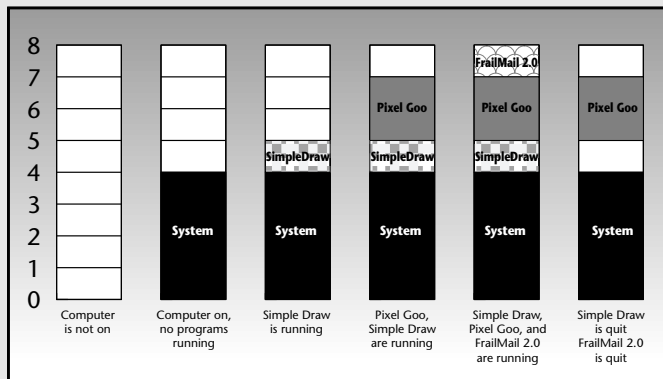
(HN)

Occasionally, if you’ve opened and closed several applications, you may find yourself unable to open another program, even though you think you should have enough RAM available for it. That’s usually due to a condition called *memory fragmentation*, which can leave parts of your free memory inaccessible.

Suppose you start a session with 4MB of free memory. You open a program that takes 1MB, then another that takes 2MB, then a third that takes the remaining 1MB. After working for awhile you close the first and third applications. That leaves you with a total of 2MB free, but in two separate 1MB chunks, separated by the 2MB allocated to the application that’s still open.

If you should now try to open a fourth program, one that requires 2MB of RAM, you’ll run smack into a “not enough memory” dialog because the Mac requires a contiguous block of memory for each application.

The only solution I know of is to close the 2MB application, so you’re back to having 4MB of free memory. Then you should be able to reopen that program, plus the second 2MB application that wouldn’t open earlier.



Using Memory to Improve Performance

(HN)

If you are fortunate enough to have a surplus of memory and you're looking for a little extra performance, there are several ways you can use some of the former to add to the latter.

The Memory Control Panel Cache

(HN)

Because RAM is speedier than any disk, your Mac should work faster when it can get the data it needs from memory instead of storage. That's why Apple built a *disk cache* (sometimes known also as a *RAM cache*) into the Mac operating system.

The cache is a portion of your Mac's memory set aside to hold information you have recently read from disk. How does this help performance? The answer is that, statistically speaking, there's a significant probability that data you've just read from disk will be needed again soon. That's not always true, of course, but it's true often enough to make the cache worthwhile. Under System 7 you can't even shut it off (though you can control how much RAM it gets).

The problem is that Apple's caching algorithms are not very efficient, so the disk cache provides only a slight performance boost, at best. And the larger the cache, the longer it takes to search it, so more time goes to waste when there's a *miss* (the desired data isn't there), and it takes longer to find it even when it is there.



The optimal point depends on your work habits and the software you're using, but most users find that a setting of 96K or 128K works best; some argue for 256K. Higher amounts slow performance, so you should reset it even if you have RAM to burn.

It's especially important to set the cache to the minimum level if you're using Adobe's Photoshop, because interactions between the disk cache and Photoshop's own built-in virtual memory system can cause serious delays.

Alternate Caches

(HN)

Some hard disk drivers implement their own caching schemes, and they do a better job than Apple does. (Hard disk drivers and what they do are described in Chapter 5.) **Spot On** (\$100, MacPeak Research) and version 3 of **Drive7** (\$90, Casa Blanca Works) let you turn on caching and choose among several configuration options in their control panels. It's hard to know just how much good all this does, but in my experience it provides a small but perceptible performance boost.

RAM Disks

(RT)

If you feel the need for speed, and you have some extra RAM lying around in your system, not being used by your applications, then you're a candidate for a RAM disk. RAM disks are really your RAM pretending to be a disk drive; they even appear on your desktop like any other disk.



RAM disks can improve your system performance to such an extreme state that your computer will be waiting for you, instead of the other way around. When you start up your system from a RAM disk, it takes a few seconds, even if you have half a screen full of extensions. It takes more time to double-click an application than it does for it to launch. And saving 10MB files is a snap. And why not? The information isn't going anywhere; it's just being redistributed around your RAM SIMMs.

Of course, there are a few drawbacks:

RAM disks are expensive. This is the big one. In order to have a 32MB RAM disk (big enough for a small System Folder and a few tiny applications), you need to have 32MB of *extra* RAM. Now, I don't know about you, but I've never had any "extra" RAM.... I always seem to be wanting more than I currently have. And 32MB of RAM will run you about \$800 to \$900. Considering you could get a 4GB drive for that amount, you might have second thoughts.

RAM disks are cumbersome. Because the information on a RAM disk only exists while power is supplied to the CPU, when you shut down the CPU, the RAM disk contents are toast. This is especially annoying if you have your System Folder on the RAM disk. The other problem is that files you save to the RAM disk will eventually have to be moved to a hard disk to permanently store them. One little plus is that a hangup or restart won't disturb the RAM disk contents, as long as power isn't cut off from the CPU.

PowerBooking With RAM Disks

(RT)



POWERBOOK

On a PowerBook, you can run your system off a RAM disk, saving to it and starting up from it, never having to spin up the hard drive, making your battery sessions longer than you ever dreamed. This keeps the PowerBook nice and quiet as well.

If you have a PowerBook 100, you have a slow PowerBook. *But*, you have the only computer ever made by Apple that retains what is on the RAM disk when you shut down. As long as the battery isn't entirely drained, the RAM disk contents are still on the RAM disk the next time you start up the PowerBook (which almost makes up for the incredibly slow processor).

There are several RAM disk programs which work better than the built-in RAM Disk of the Memory control panel. The shareware program **RamDisk+** by Roger Bates has many useful features that make up for many of the cumbersome disadvantages of RAM disks. Other commercial RAM disk utilities include **Atticus RAMDiskSaver** (\$70) and **Maxima** (\$100) from Connectix.

Adding More Memory

(HN)

The earliest Macs, back in 1984 and 1985, had their meager memory soldered to their logic boards and no slots for adding more. Fortunately, Apple came to its senses before too long, and since 1986 almost every new Mac has had slots that make it easy to add more memory.

Except in the case of the Mac Portable, PowerBooks, and some versions of the original Mac Classic (all of which require specially designed memory cards), adding memory means plugging in extra SIMMs or DIMMs.

Buying Memory

(RT)

If you can install memory yourself (see [“Installing Memory Yourself,”](#) later in this chapter), consider ordering memory via a company such as Newer Technology. Newer’s reliability and customer service is top-notch, and its technical support is the best I’ve ever encountered. The prices are usually a bit higher than some other memory mail order suppliers, but that’s a small price to pay for peace of mind in the murky world of RAM.

Be careful if you choose a different vendor, as they may not know their products and the Macintosh line as well as the experts at Newer. Make sure you have your Mac model’s requirements handy (see the table [“RAM Configurations by Model,”](#) at the end of the chapter) and specify not just the pins and the capacity, but the speed as well. Oftentimes slower RAM will appear to work fine in a machine requiring faster SIMMs, but the machine will be plagued with crashes and other problems.

If you’re a little uncertain of your installation abilities, you can take your Mac to a computer store such as CompUSA, where they’ll install memory for you. Usually they’ll guarantee their service and maybe do some quick testing of the RAM before you pick up the machine. Of course, for this personal service you’ll pay a premium,

both for the RAM and the installation. (If you've blown all your cash just getting the memory and don't want to pay to have it installed, try bribing your local Mac guru with a bag of Skittles.)

Investing in Memory

(RT)

OK, the bad news: Memory is a terrible investment. While you don't use it up, and there are precious few (if any) reports of memory going bad after it's been used too much, memory just doesn't hold its value. Used memory sells for about 25 percent less than the current market price, and memory prices rarely go up, but instead hover at

**POWERBOOK**

Adding Memory to PowerBooks

(TA/HN)

Boosting the memory in Apple's notebook models presents some special problems. RAM for PowerBooks tends to be more expensive than for desktop Macs, since the notebooks require lower-power chips and specially designed memory expansion cards rather than standard SIMMs. To compound the problem, the design seems to change with each new model. Apple makes its specs available to selected outside manufacturers, but sometimes not in final form until just before or even after new models are released; the manufacturer then has to design the card and find sources for the necessary components.

For all these reasons, RAM expansion cards for new PowerBook models are often scarce and expensive when the machines first ship. Several times, third-party RAM vendors, unable to get adequate supplies of Apple-spec components (because Apple is taking everything available), have come out with alternative technologies. Sometimes they work fine, but there have been cases where vendors have had to stop shipments and make changes in their cards after problems cropped up.

I don't ordinarily advise people to buy memory from Apple, because it usually costs too much, but if you are buying a brand-new notebook, consider ordering it with a full complement of RAM, or else plan to wait a few months while the dust settles (and prices come down) before buying from a third party.

Fortunately, things have changed in the past few years. Current PowerBooks, following the example of Apple's Newton MessagePad and many PC laptops, have a new type of slot that makes it much easier to install extra memory (as well as tiny hard disks, modems, or other add-ons). Without even opening the case, you can just slide a credit-card-shaped circuit board into the system. It's known as a PCMCIA slot, because it's based on a standard set by an industry group called the Personal Computer Memory Card International Association, but computer industry wags have come up with lots of alternative interpretations of the name—my favorite is People Can't Memorize Computer Industry Acronyms.

about the same rate for several years. PowerBook memory is worse, because it's bought in entire chunks at a time.

By the time your 16MB SIMM is worth more than what you paid for it, that *type* of SIMM probably won't be used anymore. All those people with thousands of dollars invested in 30-pin SIMMs for their Quadra 950s can't sell it to anyone, and there are less and less of those machines around for the memory to be used in.

Make sure you're going to use the RAM you buy, and get the most out of it.

Installing Memory Yourself

(RT)

Installing RAM SIMMs in most desktop Macs isn't too difficult, and poses relatively little danger to the motherboard and the SIMMs themselves. PowerBooks can be a little more difficult, depending on the model, since there are tighter quarters and less room to maneuver around in, and they require a special tool to open them up. The all-in-one Macs of the '80s (Mac Plus, SE, SE/30, and Classics) are a different matter; the copper tube of the monitor is exposed during the installation, which can provide enough of a charge to send you to the emergency room, or worse. In addition, the compact Macs require a special tool to open; unless you have several to do at once, it's cheaper and easier to pay a qualified technician to add RAM to these machines.

Apple states that you are voiding your warranty by adding memory yourself, instead of taking it to an authorized technician (but then again, if you don't tell them *you* put in extra memory, they probably won't even ask).

Most RAM you can buy comes with basic installation instructions, but there are a few things you should always do:

- *Unplug the Mac and any attached devices.* For PowerBooks, remove the battery.
- *Carefully remove the cover and any components obstructing the SIMM slots.*
- *Before handling the memory, touch the Mac's power supply.* This will discharge any static you and/or the Mac have built up.
- *Ensure a proper fit.* SIMMs only go in one direction! Look for the little hole in the one end of the SIMM, and make sure it matches the SIMM bracket on the motherboard.
- *Never force the SIMMs into position;* you can damage both the SIMM and the socket this way.



Where Did All My New Memory Go?

(HN)

With the latest Mac models you don't have to do anything special to take advantage of any amount of memory your Mac can handle. But with older machines there is a small but easily overlooked extra step required: opening the Memory control panel, clicking on one radio button to switch from 24-bit addressing to 32-bit addressing, and restarting your Mac.

The way Macs used to keep track of what was in memory, 24-bit addressing imposes a limit of 8MB on system memory, regardless of how much is installed. Switching to 32-bit mode removes that limit. (For more on 24- and 32-bit addressing, [see the sidebar "The 32-Bit Problem on Older Macs,"](#) earlier in this chapter.)

If your older Mac came with 8 or fewer megs of RAM, it is probably set to run in 24-bit mode. If you forget to change it, you can spend \$300 for another 8 megs, install it, and find that you don't have any more memory available than before. (If you are in 24-bit mode, About This Macintosh depicts any installed memory beyond 8 megs as part of what the Mac system takes up.)

Finding Out More

(HN)

As you've undoubtedly figured out by now, the Mac memory story is pretty complicated. Connectix, in addition to developing a whole series of useful, memory-related utilities, has done the Macintosh community a major service by producing a comprehensive handbook on the subject called the *Macintosh Memory Guide*. It contains a detailed history of Mac memory, along with tables detailing everything you need to know about memory options and requirements for all Mac models past and present.

Connectix used to give the booklet away free. Now it only distributes and updates it in electronic form, via user groups and on-line services. But if you prefer hard copy, you can get an up-to-date version of much of the same material in booklet form from Technology Works ([see Appendix D](#) for contact information). Ask for the *Memory Solutions Guide*.

Another information resource along the same lines is *SimmStack*, a HyperCard stack developed and regularly updated by Apple's Mark Hansen. It, too, is available free from on-line services and user groups.

SIMM Nitty Gritty

In the remaining pages of this chapter, we give you the lowdown info on memory. This is the Cliff-Claven type of information to know if you want to get into a conversation with a Mac-head who *really* knows his or her technical stuff. At the end of this chapter, there's a handy table detailing all the existing Macintosh models (as of this writing) and what memory configurations are present in each one.

Where Are All Those Pins?

(GS)

When you read an ad or a product description for memory chips, no doubt you see the reference to pins—30-pin, 72-pin, 168-pin, that sort of thing. But when you look at the RAM module itself, there are no pins, just little rectangular strips all in a row at one end. Well it's those metallic strips that manufacturers call *pins*, and they are used to make electrical contact between the RAM board and your Mac. The older type of Mac RAM has 30 pins. More recently Apple briefly standardized on 72-pin SIMMs. But to make matters more confusing, the newest generation of Macs and compatibles use still another kind of RAM, called DIMMs, which contain 168 pins.

When you buy RAM for your Mac, you need to know what kind fits the model you have; otherwise, it's like putting a square block into a round hole. It just won't fit.

Here's the basic rundown of the kinds of RAM available for your Mac:

SIMMs. A *SIMM* is a *single-inline memory module*, and it's the form in which most memory upgrades for Macs are supplied. Basically, it's a printed circuit card containing a bunch of memory chips. The chips may all be on one side or on two sides (depending on how much RAM the module contains).





DIMMs. *DIMM* stands for *dual-inline memory module* and it's the form in which RAM is supplied for all the latest Macs. A single DIMM supports a 64-bit *data path* (the amount of information that can simultaneously travel to and from the DIMM) and you can install just one, but some of the new Macs can deliver faster performance if you install DIMMs in identical pairs, because both modules are addressed at the same time by a process called *interleaving*.

DRAM. Short for *dynamic random access memory*, this is the kind of RAM found not only in Macs but in PCs as well.

Flash RAM. This is a kind of RAM that is designed to work just like a hard drive, only much, much faster. This sort of RAM is considered “nonvolatile,” meaning the data you store in Flash RAM can last up to ten years. You can buy Flash RAM in PC card form for the newest PowerBooks, but they’re very expensive for the amount of storage capacity they offer.

SRAM. Your basic PowerBook contains another type of RAM, called *static RAM* which requires very little power. Another advantage is that SRAM will hold data for long periods of time, which explains how you can awaken your PowerBook from the sleep mode and find all of your open programs and open documents intact.

VRAM. *VRAM* is a high-speed form of RAM that is used on a Mac’s video card (the “V” is for video). It is ideally suited to the fast screen refresh and huge data movement needed for good video performance.

PRAM. Your Mac’s *PRAM*, or *parameter RAM*, is a small amount of memory that holds your basic system settings, such as mouse tracking speed, monitor resolution, network selection (LocalTalk or Ethernet, for example), and screen depth (the number of colors displayed) and so forth. It’s powered by a small lithium battery. “Zapping the PRAM” (holding down the     keys when your Mac starts) quite often clears up odd behavior and unexplained crashes. (See [Chapter 7](#) for more details on zapping the PRAM.)

All RAM is Not Alike!

(GS)

From dealer to mail order catalog to magazine ad, if you want to buy more RAM for your Mac or compatible, you are confronted with a bewildering array of choices and prices. You can save hundreds of dollars if you just do a little shopping around.

But just how real are those ultra-cheap prices you see advertised? Are they run by firms who will disappear with your money and not deliver—or deliver a bad product? If you’ve got any doubts whatever about the reliability of a firm, call the Better Business Bureau or consumer protection agency in their city and see how they rate. Ask your friends, check the chatter in the message boards of the on-line services or Usenet newsgroups ([see Chapter 23](#)) and see how others have fared with these firms.

Or stick with the tried and true. You may pay a little more to buy your RAM from a firm such as Newer Technology or TechWorks, but you’ll get a lifetime warranty, prompt technical support, and high quality merchandise. And if you truly want to save as much as possible, give The Chip Merchant a call. They won’t give you any

installation instructions with their memory chips, but I've always found their products of high quality, and they are absolutely reliable in delivering exactly what they promise at the advertised price.

Stay away from *composite* SIMMs or DIMMs. Composite SIMMs/DIMMs use lots of low-density memory chips on a module, to save a few bucks. But they can also create logic board timing problems, and cause crashes and general grief. The most likely composite memory modules are 16MB and 32MB types. If the 16MB module has 8 or 9 memory chips, you're doing okay. If it has twice that many, stay away. A noncomposite 32MB SIMM will have the same layout as the 16MB version, but it'll have two sides (the same number of chips on each side).

If your Mac suddenly starts crashing repeatedly, displays a Sad Mac or occasional multiple startup notes from time to time after installing new RAM, you can bet something is wrong with the installation or the performance of your RAM upgrade. Try reinstalling your memory upgrade, or ask your dealer for assistance (and replacements if need be).



RAM Configurations by Model						(GS)
Mac Model	RAM soldered on (MB)	RAM Slots	Available Sizes (MB)	Maximum RAM (MB)	RAM Speed	Notes
128*	128K	0	N/A	128K	N/A	
512K/512Ke*	512K	0	N/A	512K	N/A	
Plus*	0	4	256K, 1	4	150 ns	1, 4
SE*	0	4	256K, 1	4	150 ns	1, 4
SE/30*	0	8	256K, 1, 4	32	120 ns	4
Classic*	1	2	256K, 1	4	150 ns	1, 2
Classic II	2	2	1, 2, 4	4	150 ns	1, 2
Color Classic	4	2	1, 2, 4	10	100 ns	3
LC*	2	2	1, 2, 4	10	100 ns	3
LC II*	4	2	1, 2, 4	10	100 ns	3, 8
LCIII, Performa 450/550*	4	1	1, 2, 4, 8, 16, 32	36	80 ns	3, 8
Performa 200*	2	2	1, 2, 4	10	100 ns	3
Performa 400*, 405*, 430*	4	2	1, 2, 4	10	100 ns	3, 8
Performa/LC 475, 476*	4	1	4, 8, 16, 36	36	80 ns	
Performa 600*	4	4	256K, 1, 2, 4, 16	68	80 ns	3, 10
Performa/LC 550*	4	1	1, 2, 4, 8, 16, 32	36	80 ns	
Performa/LC 550*	4	1	1, 2, 4, 8, 16, 32	36	80 ns	

RAM Configurations by Model (continued)						
Mac Model	RAM soldered on (MB)	RAM Slots	Available Sizes (MB)	Maximum RAM (MB)	RAM Speed	Notes
Performa/LC 575*	4	1	1, 2, 4, 8 16, 32	36	80 ns	
LC 580	4	2	1, 2, 4, 8 16, 32	52	80 ns	
Performa/LC 5200/5300	0	2	4, 8, 16, 32	64	80 ns	
II*	0	8	256K, 1, 4	20	120 ns	1, 4, 5, 6, 7
IIx*	0	8	256K, 1, 4 16	32 128	120 ns	1, 4 5, 6, 7
IIcx*	0	8	256K, 1, 4	32	120 ns	4
IIci*	0	8	256K, 512K, 1, 4	32	80 ns	3
IIfx*	0	8	1, 4, 16	32	80 ns	3, 9
IIsi*	1	4	256K, 512K, 1, 2, 4	17	100 ns	3
IIvi/IIvx*	4	4	256K, 1, 2, 4, 16	68	80 ns	3, 10
Macintosh TV	4	1	1, 4	8	80 ns	3
Centris/Quadra 610, WS60*	4	4	4, 8, 16, 32	68	80 ns	3
Centris/Quadra 650*	8	4	4, 8, 16, 32	132	80 ns	3, 13
Centris/Quadra 660AV*	4	4	4, 8, 16, 32	68	80 ns	3, 13
Quadra 605*	4	1	48, 8, 16, 36	36	80 ns	3,
Quadra 700*	4	4	1, 4	20	80 ns	3
Quadra 900/950, WS95*	0	16	1, 4, 8, 16	256	80 ns	3
Quadra 800/840AV, WS80*	8	4	4, 8, 16, 32	136	60 ns	3, 13
Power Mac 6100/6100AV*	8	2	4, 8, 16, 32	72	80 ns	14
Power Mac 7100/7100AV*	8	4	4, 8, 16, 32	136	80 ns	14
Power Mac 8100/8100AV*	8	8	4, 8, 16, 32	264	80 ns	14
Performa 6200/6300	0	2	4, 8, 16, 32	64	80 ns	
Power Mac 7200	0	4	4, 8, 16, 32, 64	264	70 ns	15
Power Mac 7500	0	8	4, 8, 16, 32, 64	512	70 ns	15, 16
Power Mac 8500	0	8	4, 8, 16 32, 64	512	70 ns	15, 16
Power Mac 9500	0	12	4, 8, 16, 32, 64, 128	1536	70 ns	15, 16
Portable*	1	1	N/A	9	100 ns	4, 11, 12
Portable* (backlit)	1	1	N/A	8	100 ns	4, 11, 12
PowerBook 100*	2	1	N/A	8	100 ns	

RAM Configurations by Model (continued)						
Mac Model	RAM soldered on (MB)	RAM Slots	Available Sizes (MB)	Maximum RAM (MB)	RAM Speed	Notes
PowerBook 140*, 145*	2	1	N/A	8	100 ns	
PowerBook 145B*	2	1	N/A	8	100 ns	
PowerBook 150*	4	1	4, 8, 12, 20, 28, 36	40	100 ns	
PowerBook 170*	2	1	N/A	8	100 ns	
PowerBook 160*	4	1	4, 8	14	85 ns	
PowerBook 165*	4	1	4, 8	14	85 ns	
PowerBook 165c*	4	1	4, 6, 8, 10	14	85 ns	
PowerBook 180*	4	1	4, 8	14	85 ns	
PowerBook 180c*	4	1	4, 6, 8, 10	14	85 or	
PowerBook 500 Series	4	1	4, 8, 12, 20, 32	36	70 ns	
PowerBook 5300 Series	8 or 16	1	4, 8, 12, 16, 32, 48	64	70 ns	
PowerBook 190 Series	4 or 8	1	4, 8, 16, 32	36 or 40	70 ns	
PowerBook Duo 210/230*	4	1	4, 6, 8, 10, 12, 16, 20	24	70 ns	
PowerBook Duo 250/270c*	4	1	4, 6, 8, 10, 12, 16, 20	24	70 ns	
PowerBook Duo 280/280c*	4	1	4, 6, 8, 10, 12, 16, 20, 24, 36	40	70 ns	
PowerBook 2300 Series	8	1	4, 8, 12, 16, 20, 24, 32, 36, 48	56	70 ns	
Macintosh Compatibles						
DayStar Genesis MP 132/150	0	12	4, 8, 16, 32, 64, 128	1536	70 ns	15, 16
Power Computing Power 100/120	8	8	4, 8, 16, 32	200	80 ns	14
Power Computing PowerWave 120/132/150	0	8	4, 8, 16, 32, 64	512	70 ns	15, 16
Radius System 100	8	8	4, 8, 16, 32	264	80 ns	14
Radius 81/110	8	8	4, 8, 16, 32	264	80 ns	14
Notes						
* No longer being manufactured.						
1 Third-party 1MB SIMMs with only two chips are incompatible with these computers. Apple two-chip 1MB SIMMs may be found, however, in the SE/30, IIci, IIsi, LC, and Quadra 950.						
2 The computer has 1MB of RAM soldered to its logic board. Additional RAM requires an expansion card. Apple's Macintosh Classic 1MB Memory Expansion Card has 1MB of additional RAM and two SIMM connectors.						

RAM Configurations by Model (continued)

Notes *(continued)*

- 3** These systems have 32-bit-clean ROMs. Computers with 32-bit-clean ROMs can take advantage of more than 8MB of physical RAM under System 7.
- 4** The ROMs in these systems are not 32-bit-clean, but with the 32-Bit System Enabler under System 7.1, or Connectix MODE32 with System 7.0 through 7.5.1, they can run in 32-bit mode and can take advantage of more than 8MB of physical RAM.
- 5** The Mac II and IIx require special 4MB SIMMs. Be sure to specify your Macintosh model when ordering these SIMMs and make certain the vendor knows the difference. The Mac II requires the Macintosh II FDHD Upgrade to use 4MB SIMMs.
- 6** To take advantage of more than 8MB of physical RAM, the Macintosh II must have a PMMU installed and Apple's 32-bit System Enabler or MODE 32, as described in Note 4.
- 7** The Macintosh II won't start up if you install 4MB SIMMs in Bank A. Install 4MB SIMMs in Bank B, and use 256K or 1MB SIMMs in Bank A.
- 8** These systems can address a maximum of 10MB of RAM. When the SIMM slots are filled with 4MB SIMMs, the lower 2MB of RAM on the logic board isn't recognized.
- 9** Requires 64-pin SIMMs.
- 10** Only 8-chip, 16MBx1 SIMMs have been tested on the Mac IIvi and IIvx.
- 11** The Macintosh Portable has 1MB of RAM soldered to the main logic board. You can add more RAM using an expansion card, which can have from 1MB to 4MB of RAM or, in the case of the backlit Portable, 1MB to 3MB of RAM.
- 12** If the processor-direct slot (PDS) is used for other peripherals, the maximum RAM is 5MB for the portable and 4MB for the backlit version.
- 13** These systems use memory interleaving when SIMMs in identical pairs are used (for example: two 8MB SIMMs). This can improve performance 5 to 10 percent.
- 14** These Power Macs use 32-bit, 72-pin SIMMs, and they must be installed in identical pairs.
- 15** The latest Power Macs use 64-bit, 168-pin DIMMs. They may be installed one at a time.
- 16** Installing two DIMMs in identical pairs (same size and capacity) in the corresponding A and B memory banks will offer memory interleaving. You can expect a performance improvement of 5 to 10 percent.
- 17** First two slots must each contain 4MB SIMMs.

