Even though Lightroom may be the central tool in our post-processing workflow, we still need to accessorize the workshop around it. Software can’t work without hardware, and the integrity of your workflow is certainly affected by the quality of your hardware. Now, I’m not just referring to working with a computer. In fact, I’d bet the computer is probably the tool photographers need the least amount of help with. Computers are such an integral part of everyone’s life these days that I suspect most of you have some idea about how to buy a good vs. a not-so-good computer. But how many of us know how to shop for a monitor designed to work with graphics applications and that support color-critical workflows? How many of us know how to shop for the hardware needed for a back-up storage system? The accessories we use will help make or break the integrity of our digital workflow, and this special online section aims to provide you with the basic tools needed to start building yours with confidence.

**THE DIGITAL DARKROOM**

Traditionally, the darkroom—the workshop of the creative photographer—has been a place filled with enlargers and chemicals. It is the place where film was...
developed, where prints were made, where images were cropped, and where prints were dodged and burned. Digital photographers still perform the same steps darkroom photographers take; we just happen to do it with a much different tool set. Developing film with chemicals has been replaced with developing raw files on computers in Lightroom. Computer monitors and raw files have replaced light tables for your negatives and slides, digital printers have taken the place of enlargers, and images are stored on hard drives instead of in notebooks and cabinets. Thus, a photographer’s workflow has always been, and still is, dependent on the right tools.

**Getting the Right Computer for Lightroom**

Workflow is a personal thing, and so the tools a photographer should use depends on many factors that are unique to that photographer. For some photographers the prime consideration is budget, for others it’s performance, and for others it’s simplicity and portability. So, when talking about getting the right computer for Lightroom, really the discussion is about getting the right computer for you. But what is that? The right computer might be the new sleek black Power Mac with all the bells and whistles, or a MacBook pro laptop, or a Dell, or a build-it-yourself PC machine, or even something second-hand.

My first suggestion would be to consider what kind of machine you might need independent of the brand and platform, and what’s going to support your photographic lifestyle. For example, I know many photographers that just have laptops and that’s the only computer they have. These photographers are always on the go, prefer the portability of a laptop, and don’t feel the need to invest in an additional stationary computer even though stationary computers can be configured with higher performance hardware. On the other hand, I know several studio photographers that only use stationary computers and have no need for the portability of a laptop or its inferior performance—speaking generally of course. Personally, I use both. As a nature and underwater photographer, I travel a lot and need high-performance machines both in the field and then in my studio. Essentially, I don’t want you to think you need to get something because it’s more expensive, or more of a professional machine. Get what you need. Although, the biggest question I get from the photographer shopping for a computer is still, “should I buy a Mac, or should I buy a PC?”

**Macs vs. PCs**

Some rivalries never die. What’s better: Coke vs. Pepsi, checkers vs. chess, Nikon vs. Canon, or you bet, Mac vs. PC? In terms of which one you should get to run Lightroom, it honestly doesn’t matter. Both platforms can run Lightroom without problems and either computer type can be equipped with high performance hardware sufficient to
work with Lightroom catalogs and archives that contain hundreds of thousands of images. But there are differences, and I do have different recommendations depending on who is asking. Speaking generally, I would say that PCs are computers for people into the computer experience, while Macs are computers for people that are into the user experience.

A PC, or a computer that runs Windows, is a computer that can be, and often is, built from scratch. PCs tend to be much more customizable than Macs. There are almost no restrictions for what and how you can upgrade your PC, while Macs tend to restrict such freedom and even have performance ceilings that many of their machines can’t exceed. The new Mac mini, for example, completely restricts the ability to upgrade RAM, and for the DIY (do it yourself) user, this is a legitimate deal breaker. Additionally, almost all of the computer hardware made is designed for compatibility with PCs, while Mac compatible hardware tends to be a much smaller market. However, a benefit of the larger and more competitive market means that PC hardware tends to be more affordable than Mac hardware. A build-it-yourself PC, when compared to a Mac that is its hardware equivalent, can therefore be a fraction of the price.

Yet, such freedom does come at a cost. If you like playing with computers, learning about them, doing all the upgrades yourself, doing all the maintenance yourself, the PC platform might be for you. On the other, I think most people want to buy a computer with the intention of not learning computing, but instead to have their computer simply run the applications that they need it to run.

The fact that Apple is built by Apple and is not as customizable as a PC is precisely what Apple has leveraged with their business model. Unlike the early days of personal computing, today we use devices; we use tablets, phones, smart watches, laptops, and desktop machines. The culture of computers has changed, and changed the way we live our lives. Instead of the single bulky machine that replaced our typewriters and ran some databases, computers now go with us wherever we go and manage almost everything we do. For the average user, computing today is about

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systems integration and ease of user experience, and Apple does this well. If you have an Apple computer, with an Apple phone, with an Apple tablet, than you know what I’m talking about. I’m not saying you can’t integrate Windows-based devices with other Windows-based devices, but Apple products are designed to work with Apple products. All of their machines and their hardware are built with this in mind. Most importantly, the operating system Macs use has a unified interface. Meaning, Apple has strict guidelines for software developers so all of the utilities and all of the applications on a Mac actually feel like they are part of the same system. The user experience feels much more streamlined.

So what do I recommend? I’ll go back to what I previously stated, “both platforms can run Lightroom without problems.” I know Macs have developed a reputation over the years of being better for graphics applications and photographers, but it isn’t necessarily true these days. In the 80’s and 90’s Macs clearly had the better software selection for graphics applications, and creatives and artists caught on to this fact. But things have changed; both PCs and Macs now have a fine selection of applications to choose from. So, my recommendation comes down to this: if you are familiar with PCs, if you are comfortable with them, if you like the customization that comes with that kind of platform, then stick with them. From a Lightroom user’s standpoint, I don’t see a reason to change. On the other hand, if you are the user that’s been thinking about making the jump to Mac, who might be a little tired of the maintenance or expertise needed with PCs, or frankly doesn’t care either way which platform they use, then I certainly suggest giving Mac a try. The ease of the user experience and simplicity of integrating multiple devices is supreme—in my humble opinion.

**Lightroom’s Minimum Requirements**

Needless to say, when shopping for the right computer we need to be sure we are sufficiently configuring our computer for Lightroom and our workflow. To be sure you are getting a powerful enough machine, refer to Adobe’s list of the minimum requirements. They list them for all versions of Lightroom at: [http://helpx.adobe.com/lightroom/system-requirements.html](http://helpx.adobe.com/lightroom/system-requirements.html). Lightroom 6 does require a bit more than Lightroom 5, and below is a list of what’s needed for Lightroom’s most recent release. But when you refer to this list, I can’t stress enough that this is a list of specifications are the *minimum* requirements, and the minimum is very different from what I recommend.

**Windows**

- Intel Pentium or AMD Athlon 64 processor*
- Microsoft Windows 7 with Service Pack 1, Windows 8.1, or Windows 10
• 2 GB of RAM (but please use more; a minimum of 8!)
• 1 GB of Video RAM (VRAM). 2 GB of dedicated VRAM is suggested for large, high-resolution monitors, such as 4K- and 5K-resolution monitors
• 2 GB of available hard-disk space
• 1024 x 768 display
• DVD-ROM drive required if purchasing Adobe® Photoshop® Lightroom® retail boxed version
• OpenGL 3.3 and DirectX 10-capable video adapter for GPU-related functionality
• Internet connection and registration are necessary for required software activation, membership validation, and access to online services

Mac OS

• Multicore Intel processor with 64-bit support – dual-core processor recommended for HD or AVCHD video functionality
• Mac OS X 10.9, 10.10, or 10.11 – Lightroom CC 2015.1/Lightroom 6.1 and earlier versions are supported on Mac OS X 10.8
• 2 GB of RAM (but please use more; a minimum of 8!)
• 2 GB of available hard-disk space (cannot install on a volume that uses a case-sensitive file system or on removable flash storage devices)
• 1 GB of Video RAM (VRAM). 2 GB of dedicated VRAM is suggested for large, high-resolution monitors, such as 4K- and 5K-resolution monitors
• 1024 x 768 display
• DVD-ROM drive required if purchasing Adobe® Photoshop® Lightroom® retail boxed version
• OpenGL 3.3—capable video adapter for GPU-related functionality
• Internet connection and registration are necessary for required software activation, membership validation, and access to online services

Suggested Requirements for Lightroom

The minimum requirements should never be the goal for how you to configure your computer. Instead, they tell us what is needed to just get Lightroom working. If your computer isn’t configured with any one of the requirements, you will need to upgrade your system. So what should your goal be? How do we ensure that Lightroom doesn’t just run, but runs well?

My first suggestion is to make sure that everything is up to date. Make sure that Lightroom is running its most recent version and make sure that your operating system is running its most recent version. Sure, you can run Lightroom 4 on a Mac v10.7 operating system, but each of these is several generations old and will not work as efficiently as Lightroom 6 coupled with a computer’s most recent OS. It’s safe to say that one of the big things that the

NOTE: Lightroom 6 is only compatible with 64-bit operating systems. This does restrict some users with older systems, but this choice allows Adobe to expand Lightroom’s performance. Lightroom users with 32-bit operating systems will be able to run Lightroom 5, but you will not be able to upgrade until your system upgrades.
software engineers at Microsoft, Apple, and Adobe focus on with each new version of their software is performance. As each new version of Lightroom, Apple’s operating systems, and Windows is released, they are intended to perform better than the previous version.

Secondly, have a goal to exceed the minimum requirements wherever you can. Adobe says you need at least 2GB of RAM to run Lightroom, but 8GB is recommended. I suggest doubling that. Sixteen gigabytes will improve performance considerably and will certainly help if you are the kind of computer user that has more than one application open at a time, which I think describes most people. Use fast hard drives. Have them be 7200 RPM hard drives, or better yet use SSDs (solid state drives), which are considerably faster (we’ll get into hard drives later). That said, if you have both kinds of hard drives in your setup, I would suggest running your catalog off of your SSD for a faster catalog. I also suggest storing your images on external hard drives with ample amounts of storage capacity.

You should use a high-performance display. Adobe’s minimum requirement is listed as a display with a resolution of 1024x768, but what I STRONGLY suggest is using a high-resolution wide gamut monitor with at least 1920x1200 pixels. The monitor I’m using is an NEC PA272W with 99.3% Adobe RGB coverage and 2560x1440 pixels. Granted this is $1299 US, but for me, it’s worth the price. Make sure you are using a good video card that will run your display at its native resolution, whether you are working with a high-performance or not. The good news is that the built-in video card that comes with your computer will usually suffice, but if you are upgrading your display per my suggestion, then I urge you to also look at your video card’s compatibility, and possibly replace it. Again, this kind of hardware is not only important to run Lightroom well; it is integral to building a well-rounded digital darkroom.

Let’s go over each of these items in greater detail to give you a better idea of what I’m referring to as I suggest high-performance monitors and fast hard drives.

**Hard Drive Basics**

The modern data storage drive comes in two basic flavors. There are hard disk drives (HDD) and solid-state drives (SSD). HDDs are equipped with a hard plate, which is a rapidly spinning magnetic metal or glass plate covered with a magnetic medium that has countless “sectors” that store your data. And when I say rapidly, most HDD’s spin at 5400 RPM or 7200 RPM (revolutions per minute). 7200-RPM drives have faster read and write speeds, so if you want better performance, go with 7200 RPMs. SSDs, on the other hand, have no moving parts and are therefore more durable, quieter, have faster read and write times, use less power, and are more shock resistant. SSDs use flash memory, which is the same kind of
technology used with camera memory cards and thumb drives. SSDs haven’t replaced HDDs yet, but it may not be long before they do. The two big hold-ups for SSD world domination are price and longevity, but both are getting better. This gap between the two will shrink, but as of now HDDs are king.

Hard drives also come in different shapes and sizes: there are 3.5-inch and 2.5-inch drives, internal and external drives, RAID hard drive arrays, DROBOs, NAS drives, and there are desktop hard drives and portable drives. 3.5-inch drives are generally used for either non-portable external hard drive systems, or as internal hard drives for computer towers or non-portable computers. 2.5-inch drives are used as internal drives for laptops or in small portable external drive enclosures. Of course the big question is . . . what should you use? Or, do you have the right kind of set up? The answer, logically, is that it depends on your workflow needs, but for every photographer building an archive, I have two big suggestions: store your images on high performance external drives, and make sure your drive systems have built-in redundancy to protect against hardware failure. In Chapter 2 of Creative Workflow in Lightroom, I go into greater detail on what a storage redundancy workflow is in the sections “Storage Redundancy,” and “Creating a Backup Workflow.” But for now, let’s look a little closer at hard drive array options, which is the first thing I suggest you buy for a file backup workflow, and arguably the most important tool of your digital darkroom.

RAIDs, Drobos, JBODs & NAS’s . . . Oh My!

Many photographers wrestle with the question of which storage system is the best system. Fact of the matter is you’ll get a hundred different answers from a hundred different people. Naturally, weigh your workflow needs against the speed of a drive system, its reliability, its cost, and its ease of use. I typically suggest a Drobo or a RAID 1 array as a good way to go for the average still photographer, but before we choose the best hardware to get, let’s cover some more of our options.

I suggest Drobo to many of my clients because they are dead simple to use and understand, while configuring or recovering data from RAIDs or JBODs can take a bit more computer savvy. However, I must say that a lot of photographers have negative things to say about Drobo because if your Drobo box fails for some reason, your data could be held hostage until you buy or replace your Drobo box.

RAID: RAID stands for Redundant Array of Independent Disks, and there is an endless selection of RAID arrays available on the market. There are also many ways that you can configure a RAID. Some are built for speed, some for security, and some for both. RAID hard drive arrays can come with as little as two hard drives, but can be equipped with a lot more. But regardless of the amount of drives present, you can configure a RAID system to distribute...
data across different drives in configurations called RAID Levels, and the two most popular RAID Levels with photographers are RAID 1 and RAID 5. RAID Level 1 is a dual disk hard drive array that mirrors your data from a primary drive to a secondary drive creating an exact copy that allows for easy data recovery in the event of a hard drive failure. G-Tech (www.g-technology.com) is a great company that makes both portable and stationary RAID drives, and they specifically target the photographer and videographer market (see Figure 1.2). The reason why I recommend RAID 1 configurations for the average photographer is that they are easy to understand and work just fine for the photographer with a modest archive of files. As of the writing of this book, the typical dual hard drive RAID array sold can only accommodate 6TB of data when configured as RAID 1. Note that such a dual drive array can be listed on a manufacturer’s site as capable of 12TB of data storage, but that doesn’t mean you’ll get 12TB when it’s configured to RAID 1. A RAID 1 configuration sacrifices total storage capacity for the sake of storage security. On the other hand, if you need more than 6TB of storage capacity, than 2-disks arrays will not be enough.

RAID 5 is a configuration that provides security in the event of a hard drive failure, and allows you to use more than two drives. RAID Level 5 requires at least 3 disks to run, and “stripes” parity over multiple drives, which is an additional kind of data used for recovery. If a single disk starts to fail, since its data is distributed over other parity blocks on other hard drives the data can be recovered, but managing RAID 5 configurations takes a bit more computer savvy than the simplistic RAID 1 approach. I suggest to let your storage capacity needs be your guide here, and go with the bigger box only if needed. In either case, chat with the RAID array vendor, read the users manuals, and create a clear plan on what to do in the event of a hard drive failure—which can be slightly different from vendor to vendor.

**JBOD:** A JBOD stands for Just a Bunch Of Disks. And it’s not a fancy name for a fancy product; it’s literally just a bunch of disks. Typically, JBOD’s are hard drive arrays that look like RAIDs but aren’t
configured like a RAID. Meaning, a RAID array with four hard drives, depending on how it’s configured, could show up on your computer as one hard drive, while a JBOD array with four hard drives will show up on your computer as four separate hard drives. The problem with JBOD configurations is they offer nothing. They offer no redundancy in data to protect you against hard drive failure and, unlike certain RAID configurations, offer no increase in performance. You do have the option of manually performing storage redundant tasks with JBODs, but that is more work than I think is needed, and as I said requires some computer savvy.

1.3
Synology produced a fine NAS product popular with photographers. NAS, or Networked Attached Storage, is essentially RAID-like systems that provide remote access to the user.

NAS: NAS stands for Networked Attached Storage and are basically storage drives that are attached through your network instead of directly to your computer. NAS systems can be simple single-drive units or multi-drive RAID arrays. A NAS may be a good choice if you need remote access to your images, but I do caution you: Lightroom is not designed to work off of a network, nor is it designed to work well in a multi-user environment. If you want a NAS because other parties need remote access to your archive and your catalog, then I suggest making available a set of derivative files and catalogs designated for third party use. To say that another way, make copies of your catalog and images for others to use. Lightroom instead works best in a single-user environment. A popular choice for NAS systems for photographers is through a company called Synology (www.synology.com) as shown in Figure 1.3.

Drobo: Drobo (see Figure 1.4) is a flavor of redundant storage that’s similar to RAID, but is very easy to use and requires no knowledge or understanding of RAID Levels, data recovery.

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protocols, and can easily work with 2-disk arrays or many more. Like a RAID, Drobos are boxes with multiple hard drives, but they aren’t configured in RAID Levels. Instead they use their own proprietary technology to generate storage redundancy that they call Beyond RAID. Essentially, it’s a storage strategy also referred to as Abstracted RAID that creates volumes that are buffered over the drive array. Unfortunately, Drobo’s very simple user experience can come at a price. As I previously mentioned, occasionally the Drobo box itself fails and your data cannot be accessed until you have purchased or replaced your original box. But if you go into Drobo with that in mind, you’ll know what you’re in for and how to protect yourself. The two big ways I suggest doing that is to get Drobo’s extended warranty that they offer, and most importantly, do not have your files stored only on the Drobo. It’s one thing using RAIDs, NAS’s, or Drobos to protect against hardware failure, and it’s something else to create a backup of your image archive. Storage redundant systems should not be considered a backup! In Chapter 2 of *Creative Workflow in Lightroom* in the section “Creating a Backup Workflow,” we elaborate on the distinction between protecting and backing up.

**Displays**

A display is typically thought of as a tool for the computer and not necessarily a tool for the artist. As a result I find that the display is a terribly undervalued tool for the modern photographer. The display is where and how we see the richness of our images’ color and tonality, where we see our images’ detail and texture, and it’s the window we look through when developing our raw files in the pursuit of creating an expressive and impactful final print. Assuming you are such a
printer, that you are a photographer with a color-critical workflow, why skimp on the quality of such a window? My suggestion is to get a good quality display and a good colorimeter to profile your display in the pursuit of color accuracy and consistency when printing your work, or when sending your work to clients. There are many specifications to look at when buying a monitor. Fortunately, only a few really matter. Pay attention to the technology used for your LCD display, the size of its gamut, its resolution, and its physical size.

**LCD Technology**

LCD stands for liquid crystal display, and LCD's work by sandwiching a liquid crystal solution with two thin sheets of polarizing material. As the liquid is introduced to a current it aligns, essentially stopping light from coming through (see Figure 1.5). LCD screens are all flat panels and are lighter and more portable than their older and much larger CRTs (cathode ray tube). Flat panels can be marketed as either LED displays or as LCD displays, but they both utilize LCD technology—LED is actually referring to the backlight technology, but more on that.
One of the benefits of IPS screen technology over TN is the expanded viewing angle. TN screens will fade if viewed at a slight angle while IPS screens will look just as bright and colorful.

Later. Even though LCD screens are today's common choice, not all LCD displays are created equally.

**In-Plane Switching (IPS):** When purchasing a display for photography you'll want to pay attention to the display's specifications that list its *Panel Type* or its *Panel Technology*. There are a few types available on the market, but the two most popular are IPS and TN (Twisted Nematic). Basically, you want to get the IPS monitor. TN technology is known for its fast response time while IPS technology is known for its noticeably better color reproduction and viewing angles. Figure 1.6 illustrates the difference between a viewing angle with an IPS display vs. a TN display. The difference is quite noticeable.

**1.7**

LCDs are backlit by either Cold Cathode Fluorescent Lamps (CCFL) or by LEDs (light emitting diodes); although there are variations of each technology.
Backlight: In addition to the type of panel you’re using, it’s important to pay attention to the type of backlight your monitor is using. Liquid crystal technology refers to the method of light and color transfer, but not the light source. Typically your choices will be CCFL and LED (see Figure 1.7). CCFL stands for Cold Cathode Fluorescent Lamp and, although still widely used, CCFL is an older technology. LEDs, or light emitting diodes, are just all around a better choice. LED displays can offer better color gamut and contrast ratios, they draw less power, and last a lot longer. More importantly, LED technology such as RGB LED and GB-R LED is precisely the kind of technology that’s used to make monitors that have 99% Adobe RGB coverage, which is ideally what you want for a display.

Wide-Gamut Displays
All devices such as cameras, printers, and displays have a scope, or a range of color, that they can reproduce, and this is referred to as the device’s gamut. The term wide-gamut is essentially a marketing term in the display world that refers to a display’s ability to show most of the Adobe RGB spectrum as opposed to, say sRGB. Seeing color on a display with Adobe RGB is preferable because the sRGB gamut is smaller, and though it is just fine for viewing on standard computer monitors and the web, it doesn’t quite have the color gamut reach needed for working with high-end printers.

Earlier I mentioned that I own a NEC PA272W 27-inch monitor. The specs for this monitor indicate that it uses GB-R LED technology and can reproduce 99.3% of the Adobe RGB color space. Basically

1.8.1 and 1.8.2
Here are a couple of my favorite monitors for photographers: the Eizo CG277 and the NEC PA272W. If you are interested in the best displays for photography, stick to the Eizo CG line or the NEC PA line of displays.

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you want to see a specification for your monitor that lists Adobe RGB coverage somewhere around 99% to be wide gamut. But this does come with a price—literally. My NEC monitor retails for $1299 US, but I think such an investment is a necessity for a well-rounded digital darkroom. However, and this is a big however, if you are a photographer that doesn’t print or plan to print your work, then a wide-gamut monitor may be overkill. If all you are doing is reproducing images for viewing on computers, for sending out to social media outlets and web sites, then a monitor with sRGB coverage is all you need, and such monitors can be found much more easily and for less money. But I’m writing this with the assumption that your goal, the ultimate goal of the creative Lightroom user, is to end up with beautiful, finely crafted prints. If this is you, go wide-gamut. I suggest looking at both Eizo’s CG line of displays and NEC’s PA line when shopping (see Figure 1.8). NEC has come a long way in the last few years and I think offers the most bang-for-the-buck, but Eizo is certainly known in the industry for setting the standard of quality and they make exceptional monitors.

**Display Resolution**

The resolution of the display refers to the number of pixels found on the screen, which in turn dictates the amount of detail that can be rendered. Currently, displays that are considered high resolution have a pixel density of about 94 pixels per inch or more. To mention my NEC 27-inch monitor again, it is equipped with 2560x1440 pixels, which equals 104 pixels per square inch (PPI), which is considered very good. If you want to calculate the pixel density of a monitor, as it’s usually not listed with a display’s technical specifications, try going to a web site called DPI love, or dpi.lv to calculate your screens pixel density (see Figure 1.9). But like megapixels in cameras, pixels on the screen are only part of the picture.

Resolution in the world of displays has turned into a funny thing to talk about as of late. In 2014 Apple announced the release of their 27-inch retina display for their iMac line of computers, and boy are retina displays nice to look at. Their new display contains an impressive pixel resolution of 5120x2880, but the monitor with the better resolution isn’t necessarily the better choice for the creative photographer. I think it’s a grand choice for video, but for photography the bigger concern should be color accuracy and the ability of that monitor to hold that color over time.

**Direct Hardware Calibration**

Calibrating your monitor is a critical part of the creative photographer’s workflow, especially if he intends to make prints. Calibrating a monitor ensures that the colors you are seeing on your monitor are ideal for communicating with other devices, and displays for users with color critical workflows can also offer something called *direct hardware calibration*. Direct hardware calibration requires specialized hardware inside of the display and features 10, 12, 14 or 16-bit LUTs (color Look

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**NOTE:** Many of the high performance displays like Eizo’s CG line and NEC’s PA line also have the capability of supporting 10-bit color, and the demand for 10-bit color is growing. Confusingly, bit-color depth and gamut are different, but an increase in either of them means that you can see more color. Basically, gamut refers to the range of color while bit-depth refers to the variety of shades within that given range. In an ideal world we would be able to utilize both, but 10-bit display support is not currently offered with Lightroom.

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Up Tables) instead of the 8-bit tables in video cards. What does all this gibberish mean? Essentially, displays that offer direct hardware calibration can generate much smoother and more accurate color profiles with the display's available gamut. Admittedly, I’m getting ahead of myself a little bit. In Chapter 6 in Creative Workflow in Lightroom, I have a section called “Consistency With Devices,” where I talk in greater detail about what monitor calibration is and what profiles are. But for now, with respect to this discussion on building your digital darkroom, displays that offer direct hardware calibration are ideal.

Displays in Conclusion

As much as I’m touting the need for biggest baddest display, I don’t mean to imply that you won’t get good color if you don’t go out and buy the best Eizo or NEC monitor that money can buy. To be honest, getting a good display that shows 99% of the Adobe RGB space, that has IPS technology with GB-R LED backlighting, and that has direct hardware calibration doesn’t mean squat unless the photographer has some idea of what basic ICC color management is. In the section “Consistency with Devices” found in Chapter 6, I provide a deeper
discussion on what ICC color management is and how to begin practicing it. Without good color management, you could be looking at the color on the best display on the market, but it may be the wrong color as a result. So, my first suggestion is to adopt ICC color management practices. If you can do that with the best display, you’ll be in better shape. I know many photographers that use regular old Apple displays that have a limited gamut and no direct hardware calibration, and that are able to achieve good reproductive quality after calibrating their displays. Bearing this in mind, here is a list of my top five monitors to buy that are currently on the market. These are not the priciest monitors, but are in my opinion the monitors that provide the best bang-for-the-buck.

1. NEC 27-inch PA272W with SpectraViewII Color Calibration solution (see Figure 1.10.1).
   a. **Price:** $1549 US
   b. **Color gamut:** 99.3% of Adobe RGB space
   c. **Resolution:** 2560x1440
   d. **Calibration type:** Direct hardware calibration
   e. **Backlight:** GB-R LED
   f. **Panel technology:** AH-IPS

2. Eizo CG277 27-inch with Hardware Calibration (see Figure 1.10.2).
   a. **Price:** $2300 US
   b. **Color gamut:** 99% of Adobe RGB space
   c. **Resolution:** 2560x1440
   d. **Calibration type:** Direct hardware calibration
   e. **Backlight:** LED
   f. **Panel technology:** IPS
3. NEC 24-inch PA242W (see Figure 1.10.3).
   a. **Price:** $1050 US
   b. **Color gamut:** 99.3% of Adobe RGB space
   c. **Resolution:** 1920x1200
   d. **Calibration type:** Direct hardware calibration
   e. **Backlight:** GB-R LED
   f. **Panel technology:** AH-IPS
4. BenQ PG2401PT 24-inch (see Figure 1.10.4).
   a. **Price:** $899 US
   b. **Color gamut:** 99% of Adobe RGB space
   c. **Resolution:** 1920x1200
   d. **Calibration type:** Direct hardware calibration
   e. **Backlight:** LED
   f. **Panel technology:** IPS

5. Hewlitt Packard Dreamcolor Z24X 24-inch (see Figure 1.10.5).
   a. **Price:** $599 US
   b. **Color gamut:** 99% of Adobe RGB space
   c. **Resolution:** 1920x1200
   d. **Calibration type:** Direct hardware calibration
   e. **Backlight:** LED
   f. **Panel technology:** IPS
Colorimeters

Colorimeters, also called display calibration devices, can look similar to a regular computer mouse, but plug into your USB port and are hung directly on your monitor. A colorimeter works in conjunction with software and some input from you to create an ICC profile that your monitor and video card reference when displaying color, contrast, and brightness values. In a nutshell, a display calibration device trains your monitor to show color tonality based on industry wide standards set by the ICC (international color consortium). Working with a profiled screen is the first step in creating consistency with a color management workflow.

As important a tool as the display is for the photographer, the one tool every photographer should have in his or her digital darkroom is the display calibration device. It’s such an indispensable tool that Eizo builds them into their CG line of displays (see Figure 1.11) and NEC bundles them with much of their PA line of displays. What that tells us is that display calibration tools are required even when buying the best monitors available. Whether you are able to see the full Adobe RGB space or just part of it, in order to make a print that looks like what you see on your screen you need to begin adopting ICC color management practices. In Chapter 6, the section “Consistency With Devices,” and in Chapter 9, the section “Printer Profiles,” I elaborate on ICC color management and how to use printer profiles, but here we’ll talk a bit more about what to look for in a display calibration device, and what a few good models are.

Ambient Light Detection

How a display projects light and color can be viewed differently depending on the ambient light conditions of a room. Most display calibration devices come with ability to evaluate not only the light coming off the screen, but also the light in the room. Instead of pointing the colorimeter at the screen, there’s a phase of the...
calibration process where you point it away from the screen to measure the ambient light in your home or studio. I think this is a terribly important feature. Many colorimeters also come with a feature that can measure ambient light conditions in the room as they change throughout the day, but I’ve found that this feature is less important. For photographers that are working in rooms that have big changes in ambient light, I think it’s better to stabilize the light in the room than to have your profile updated throughout the day.

**Works with Specific Monitor Technology**

One of the goals of display calibration is calibration accuracy. Some colorimeters can specifically target a calibration based on the backlight and panel technology being used. Panel technology such as IPS (In-Plane Switching) or TN (Twisted Nematic), along with backlight technology, such as RGB LED, White LED, or CCFL can play a big role in how colors are displayed. So, using a colorimeter that can work with the subtleties of the different technologies can help in getting a more accurate calibration.

**Brightness Uniformity**

Displays are subject to a phenomenon called drifting and this is one of the reasons displays not only need to be calibrated, but should be calibrated about every 4 to 6 weeks depending on the quality and stability of the display. Essentially, colors and brightness values can shift over time and need to be brought back into their proper state. But drifting doesn’t always occur uniformly across the whole monitor. A long time ago I had a monitor that suffered from this affect and every few weeks I would notice that the center of the screen looked normal, one corner was gray, while the other corner was dark gray. So, some display calibration devices now offer the ability to test for brightness uniformity across the screen. Figure 1.12 shows a screen that is divided into 9 different sectors that are being analyzed for their brightness values.

**Profile Validation**

A typical thing a photographer might say after calibrating their monitor for the first time is, “what the hell?” If you are not ready for it, a calibrated monitor can look very different from what you are used to. Frankly, whether or not your monitor looks strange or perfect after a calibration, being skeptical of the quality of the calibration is normal and suggested. Considering, it’s a good idea to have a calibration device that can check the validity of your profile. Look for features with colorimeters that are called Quality Assurance, or Display QA functionality. Figure 1.13 shows a screen shot of a standard patch set about to be analyzed for a quality assurance report that provides
something called a Delta E value that helps determine if your profile is within an acceptable range.

**My Top Five Colorimeter Choices**

Akin to my suggestions for monitors, here are my suggestions for colorimeters that deliver the best bang-for-the-buck. Personally, I own the X-Rite i1 Display Pro and another colorimeter that comes with the NEC PA272W monitor, which is basically a slightly modified X-Rite i1 Display Pro that works the NEC's direct hardware calibration feature. I think the X-Rite tools are great and I highly recommend them. Many
An important feature for any colorimeter is the ability to check the validity of a calibration. Here is a picture of an Industry Standard Target used with X-Rite’s i1 Display Pro calibration system to check a recently made profile.

love the Spyder from Datacolor as well, and some colorimeters have the added feature of being able to calibrate your iPad/iPhone through a free app.

1. X-Rite i1 Display Pro (see Figure 1.14.1)
   a. **Price:** $249 US
   b. **Compatibility:** Works on all modern display technologies
   c. **Ambient light measurement:** Yes
   d. **Flare correction:** Yes
   e. **Automatic display control:** Yes
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2. Data Color Spyder4ELITE (see Figure 1.14.2)
   a. **Price**: $199 US
   b. **Compatibility**: Works on all modern display technologies
   c. **iPhone and iPad compatible**: Yes
   d. **Ambient light measurement**: Yes
   e. **Display uniformity testing**: Yes
3. X-Rite ColorMunki Display (see Figure 1.14.3)
   a. **Price**: $169 US
   b. **Compatibility**: Works on all modern display technologies
   c. **Ambient light measurement**: Yes
   d. **Automatic display control**: Yes

4. Data Color Spyder4PRO (see Figure 1.14.4)
   a. **Price**: $129 US
   b. **Compatibility**: Works on all modern display technologies
   c. **iPhone and iPad compatible**: Yes
   d. **Ambient light measurement**: Yes
Pen Tablets

Pen tablets are tools that a lot of photographers fear at first, and they indeed require a little getting used to. I’ve known many photographers that have bought them and don’t use them. Personally, I think they are a must-have and feel awkward if I’m working in Lightroom’s Develop Module without one. For the Lightroom user they are only really helpful when working in the Develop Module and while using the Adjustment Brush to make localized corrections, which I tend to do more than using global adjustment sliders. Dodging and burning and making intricate adjustments along the edges of objects in an image can often require a certain dexterity that only a pen tablet can offer. Working with a mouse when performing detail work is just more challenging than with a pen. And please, don’t do such intricate work with a laptop touch pad; you’re just making your life harder if you do. Additionally, pen tablets often come with pressure sensitivity that allows you to adjust the thickness of your brush strokes along with the brush stroke’s intensity by simply pressing harder or lighter as you paint along.

Pen tablets have a huge range in functionality and pricing. The most expensive one on the market currently is the Wacom Cintiq
The Wacom Cintiq 27QHD is Wacom’s flagship product along users to interact directly with their work through a touch screen or with a pressure sensitive mouse pen.

27QHD Touch that sells for $2800 US (see Figure 1.15). This big beauty is more than just a pen tablet, it’s also a large high-resolution display that allows you to draw on and interact directly with the image instead of a tablet that communicates with your screen. On the other end of the spectrum is the Wacom Intuos Pen & Touch Small for $99 US, which I think is a perfectly fine pen tablet to start with. It has everything you’ll need to work with the details in the Develop Module. The two main things I suggest to look for are the size of the tablet and that it has pen pressure technology. Bells and whistles beyond that are optional in my opinion. Here are my top three suggested pen tablets to look at.

1. Wacom Intuos Pro Pen & Touch Medium (see Figure 1.16)
   a. **Price:** $349 US
   b. **Active Area:** 8.8” x 5.5”
   c. **Resolution:** 2048 Levels of Pen Pressure Sensitivity
   d. **Multi-Touch Support, USB Interface:** Yes
   e. **Express View Display, Touch Ring:** Yes
   f. **Express Keys:** 8 Programmable
   g. **Included Wireless Kit:** Yes
   h. **Pressure-Sensitive, Battery-Free Pen:** Yes

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2. Wacom Intuos Pen & Touch Medium (see Figure 1.17)
   a. **Price**: $199 US
   b. **Active Area**: 8.5” x 5.3”
   c. **Resolution**: 1024 Levels of Pressure Sensitivity
   d. **USB Interface, Multi-Touch Support**: Yes
   e. **Express Keys**: 4 Programmable
   f. **Pressure-Sensitive, Battery-Free Pen**: Yes
3. Wacom Intuos Pen & Touch Small (see Figure 1.18)
   a. **Price:** $99 US
   b. Active Area: 6.0” x 3.7”
   c. **Resolution:** 1024 Levels of Pressure Sensitivity
   d. **USB Interface, Multi-Touch Support:** Yes
   e. **Express Keys:** 4 Programmable
   f. Pressure-Sensitive, Battery-Free Pen: Yes

**Ink Jet Printers**

It’s safe to say that home and studio ink jet printing has come a long way in the last decade. It wasn’t that long ago that I had difficulty finding digital ink jet prints that could compete with traditional papers that ran through developers and fixers, whether from a lab or darkroom. But the opposite is true for me today. I think the amount of control and consistency, the range of tone, and the quality of the papers, make home and studio ink jet printing one of the best options available for your digital workflow.

How much do I like ink jet printing? Five years ago my workflow consisted of some of my prints coming through an Epson 3800 prosumer ink-jet in my studio, while the bulk of my printing was still being sent to a print lab using analog papers. Long story short, the lab I was working with closed their doors, and I was
contemplating establishing a relationship with another lab when I decided to go another direction. I was so impressed with the quality of the work coming out of my little Epson 3800 that I began investing in my own large format ink jet printers and I haven’t made an analog print since. In fact, I started getting so many requests from clients to help them with their printing that I began my own print services business. I now make ink jet prints in any size from small prints to mural size prints and canvas wraps, and still think the quality is better than what I was getting from working with outside labs. And the quality of the photo papers available today keeps getting better. Ultimately, my point is that if you haven’t jumped into printing for yourself, and you are still relying on outside labs and analog papers, try working with ink jets. The quality available today is amazingly good.

Buying your first printer can be a bit intimidating. Initially when looking at all the printer selections available on the market, your head may very well explode. There are dye-sublimation printers, solvent printers, dye-ink printers, all-in-one printers, printers for posters and graphics, direct-to-garment printers, and printers for corporate and graphics arts. But within this big world there is a small section dedicated to photographers. The first thing I would suggest is to stick with printers that use aqueous inks. You don’t need to look for this on a specification sheet per se, but if the product says dye-sublimation, solvent printing (solvent printers are usually very large and bulky anyway), or if it’s intended for a business or commercial application like posters and infographics, or if the printer is an all-in-one, it’s safe to say you’re looking at a printer that’s not intended for fine-art photographers. I would suggest keeping your selection to Epson or Canon prosumer and professional level printers (although good things have been said about Hewlett Packard’s large format graphics printers). Here are my top five picks for printers.

1. Epson SureColor P7000 (see Figure 1.19)  
   a. **Price**: $3995 US  
   b. **Printer width**: 24-inches  
   c. **Cartridge configuration**: 11 individual tanks  
   d. **Ink type**: UltraChrome HDX pigment inks  
   e. **Ink droplet size**: 3.5 picoliter  
   f. **Resolution**: 2880x1440  
   g. **Palette**: Cyan, Orange, Yellow, Light Cyan, Matte Black, Photo Black, Vivid Magenta, Light Black, Green, Light Light Black, Vivid Light Magenta
2. Canon image PROGRAF ipf6400 (see Figure 1.20)
   a. **Price**: $3000 US
   b. **Printer width**: 24-inches
   c. **Cartridge configuration**: 12 individual tanks
   d. **Ink type**: LUCIA EX pigment ink
   e. **Ink droplet size**: 4 picoliter
   f. **Resolution**: 2400x1200
   g. **Palette**: Cyan, Photo Cyan, Magenta, Photo Magenta, Yellow, Black, Matte Black, Red, Green, Blue, Gray, Photo Gray
3. Epson SureColor P800 (see Figure 1.21)
   a. **Price**: $1200 US
   b. **Printer width**: 17-inches
   c. **Cartridge configuration**: 9 individual tanks
   d. **Ink type**: UltraChrome HDX pigment inks
   e. **Ink droplet size**: 3.5 picoliter
   f. **Resolution**: 2880x1440
   g. **Palette**: Cyan, Yellow, Light Cyan, Matte Black, Photo Black, Light Black, Green, Light Light Black, Vivid Light Magenta
4. Canon Pixma Pro-1 (see Figure 1.22)
   a. **Price:** $999 US
   b. **Printer width:** 13-inches
   c. **Cartridge configuration:** 12 individual tanks
   d. **Ink type:** LUCIA pigment ink
   e. **Ink droplet size:** 4 picoliter
   f. **Resolution:** 4800x2400
   g. **Palette:** Cyan, Photo Cyan, Magenta, Photo Magenta, Yellow, Black, Matte Black, Red, Green, Blue, Gray, Photo Gray
5. Epson SureColor P600 (see Figure 1.23)
   a. **Price**: $799 US
   b. **Printer width**: 13-inches
   c. **Cartridge configuration**: 9 individual tanks
   d. **Ink type**: UltraChrome HDX pigment inks
   e. **Ink droplet size**: 2 picoliter
   f. **Resolution**: 5760x1440
   g. **Palette**: Photo Black or Matte Black, Cyan, Vivid Magenta, Yellow, Light Cyan, Vivid Light Magenta, Light Black, Light Light Black
The value of these suggested printers is that they are designed with the photographer in mind. They use archival inks, and they do a great job of printing both color and black and white images. Each also comes equipped with matte black inks as well as photo black so you can print on glossy, semi-gloss, and matte papers. I am personally a fan of the Epson printers and use nothing but Epson for my print services business, but for the most part, comparing Epson and Canon printers is akin to comparing Nikon and Canon cameras. Both are great; in some instances Nikon does better than Canon, and in others Canon does better than Nikon.

One of the biggest comparisons between Epson and Canon has to do with print head technology. The print head is the component that delivers the ink to the paper. Epson uses what they call a Micro Piezo print head while Canon (and Hewlett Packard) use the standard thermal print head technology. Essentially piezo print heads use ultra-fine crystals that react to an electrical charge and push out a droplet of ink. Canon's thermal print heads come with a tiny heating element that warms and pushes ink droplets out onto a paper. The Micro Piezo heads are certainly one of the reasons I like
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the Epson printers. They can deliver an impressive 360 DPI (dots per inch), while a thermal head’s resolution is 300 DPI. Admittedly, while the difference in these specifications look good on paper, you would be hard pressed to notice a difference.

Sidebar: What Is a Giclée?
In essence, a giclée is nothing more than a fancy word for an inkjet print. The term was coined in the early 1990’s by a printmaker working at Nash Editions named Jack Duganne to distinguish the quality of the process from any old inkjet print. Nash Editions had adapted a printer called an IRIS printer, which was originally designed for prepress proofing, to work as a fine-art tool. Inkjet printers prior to this had rarely been used for fine-art applications, but they were well known as a tool for home office and industrial use. Thus, to avoid any negative connotations, the giclée was born.

Putting the Pieces Together
Putting a digital darkroom together at first can seem like a lot, but I think advances in technology and digital photography have not only made taking pictures a friendly task, but have helped the whole process. If you have never had the luxury of putting together a darkroom, developing your own film, using enlargers, chemical developers and fixers, and washing and drying your prints, then you’ll just have to trust me. Putting together a workshop for your photography is much easier than it used to be. I understand I have suggested a lot here. First and foremost, we need our cameras, we need our computers with Lightroom installed, and we NEED those storage drives. If you have to choose between getting the good display or getting the right tools to facilitate a solid storage workflow equipped with properly backing up all your work, then I suggest the storage set up. The first goal should be to make sure our images are good and safe, and then we can put our attention on the quality of our work. And that’s when discussions come in regarding getting the right display and accessories like pen tablets and printers. Now let’s get into understanding our workflow through Lightroom.