

# STEP

# 6

## YOUR HOME'S LIGHTING

**IDEAL LIGHTING = THE BEST LAMPS FOR EACH APPLICATION  
+ THE BEST FIXTURES FOR EACH APPLICATION  
+ EFFICIENT AND COMFORTABLE LIGHTING LAYOUT  
+ EFFICIENT AND CONVENIENT CONTROLS**

We will follow this “formula” to organize our discussion of Step 6. Good lighting is one of the most desirable features of a home. It enhances enjoyment of your activities, while poor lighting is annoying and may limit your activities. So, we will optimize the visual quality of your lighting, which means that you will be able to see well without eye strain. At the same time, we will achieve the best possible energy efficiency.

Your home depends on two kinds of lighting – daylighting and artificial lighting. We made daylighting an integral part of your home’s layout in Step 2. Sunlight should be your prime lighting source during the daytime. But, parts of your home will need artificial lighting to supplement daylighting. At night, of course, you depend entirely on artificial lighting.

Your lighting design can be very creative. Lighting requirements throughout the home are diverse, and you have a vast selection of lighting equipment. You will base your design on a solid understanding of lighting principles, which you will apply to each of your rooms and activities individually.

If you are upgrading the lighting of an existing house, follow the recommendations in this Step. It is easy to replace fixtures that are installed on existing mounting boxes. If you are redecorating, select your color scheme to maximize energy efficiency and lighting quality, as we will explain.

**“Scene”**

Here’s an important new lighting term. We will use the word “scene” to mean the area that you want to see, and that needs good illumination. The scene could be the book you are reading, or the hobby project on your workbench, or the decor of an entire room. A key to ideal lighting is to *design your lighting appropriately for each scene.*

**HOW VISION WORKS**

The goal of lighting is to enable you to see as well as possible. This includes the ability to see details, and to do so without discomfort, such as “eye strain.” To guide your design toward this goal, let’s spend a few moments to understand how human vision responds to lighting.

**BRIGHTNESS, SIZE, AND CONTRAST**

The most basic requirement for vision is adequate light intensity. The lens in the front of the eye focuses the light from the scene on a carpet of retinal cells located at the back of the eye. In order to see, there must be enough light coming from the scene to stimulate the retinal cells.

The amount of light coming from a scene is called its “brightness.” Technically, brightness is the amount of light energy that is emitted per unit of surface area. The brightness of most scenes is determined by the amount of light that shines on the scene from the sun or from lamps. However, the brightness of some objects is determined by light that they emit themselves, as with television, computer screens, and campfires.

Increasing brightness increases your ability to see small details and small differences in color. That is why tailors, engravers, and surgeons work under high lighting intensities. Up to a point, your ability to see details increases rapidly with increasing brightness. But, beyond that point, your ability to see details increases slowly and the brightness will make you uncomfortable. After a period of exposure to excessive brightness, you will suffer “eye strain” and perhaps get a headache.

The size of details is a major factor in your ability to see, especially in dim light. If you try to read a newspaper by moonlight, you may be able to read the headlines, but probably not the small type.

Contrast is also a major factor in your ability to see. Contrast is a difference in brightness (the intensity of light) or a difference in color (the wavelength of light)

between adjacent parts of a scene. Scenes with higher contrast requires less light than scenes with lower contrast. Under dim light, black ink is easier to read on white paper than pastel ink. Similarly, it is difficult to view a photograph in dim light because much of the information consists of small differences in brightness or color.

Generally, you can’t change the size or contrast of the things that you want to see. What you can control is brightness. So, design your lighting to provide sufficient brightness for the activities.

The amount of light that you need to see well increases during adulthood. Above the age of 60, the need for more light increases rapidly. Select your lamps and fixtures to provide the option of increased light for older occupants.

**SHADOWS WITHIN THE SCENE**

An object creates shadows that help you to perceive its size and shape. This is especially useful for seeing small objects against a background. For example, your ability to see threads in a piece of fabric comes from the small shadows cast by the threads. In fabric of a single color, you are seeing mostly the shadows of the threads, rather than the threads themselves. Although you are not aware of such small shadows, they create “texture” in the scene.

Lighting that accentuates the sharpness of shadows within a scene is called “harsh.” Harsh lighting is created by small, concentrated light sources. The contrast is increased by illuminating the surfaces at a grazing angle, which lengthens the shadows. Metal engraving is an extreme example. The shadows within the cut surface make it possible for the engraver to see his work.

Lighting that subdues shadows in surfaces is called “soft.” Most home lighting should be fairly soft. Soft lighting is created by light that comes from a large area, so that the shadows do not have distinct edges. For example, formal table lamps have large translucent shades to soften their lighting.

**COLOR VISION**

The sun emits radiation over a broad band of wavelengths. However, the sunlight that humans can see consists of a fairly narrow band of these wavelengths, which is called the “visible spectrum.”\* Within the visible spectrum, sunlight contains a fairly uniform distribution of light energy, as you can in Figure 2-1, in Step 2.

The perception of “color” is the ability of your eyes to distinguish between the wavelengths within this narrow band. This ability is the most interesting aspect of vision. Human beings share this ability with many insects, birds, and fish. However, many higher animals cannot distinguish colors, or they have only limited ability to see colors. Defects in color vision are fairly common among humans, but usually are limited to inability to distinguish certain specific colors.

**“Cone” Cells for Color, “Rod” Cells at Night**

The retina of your eye has two types of cells that sense light. These are called “cone” cells and “rods” cells because of their different shapes.

The cone cells make it possible to see colors. There are three kinds of cone cells. One kind has a peak response to yellow light, another kind to green light, and a third to blue light. The type of cone cell that responds mainly to blue wavelengths is weaker than the cone cells that peak at green and yellow. Figure 6-1 shows the response of the three types of cone cells to different wavelengths of light.

Your brain compares the response of the three types of cone cells to light that enters the eye and deduces its color from that. For example, a green light source stimulates the green-sensing cone cells more strongly than it stimulates the yellow-sensing cells, and it stimulates the blue-sensing cells only weakly. From this, the brain infers that the incoming light is green. (People who are “colorblind” generally have a deficiency in one or more of the three types of cone cells.)

Cone cells respond strongly to daylight and to normal indoor lighting, and they remain somewhat sensitive during darker twilight. But, they shut down almost completely under low nighttime light levels.

In addition to revealing colors, cone cells also allow you to see finer detail, such as you need for reading. This is because the cone cells are clustered densely near the center of your visual field. Therefore, if you are

outside at early dawn, you will start to see color and you will start to be able to read at about the same time.

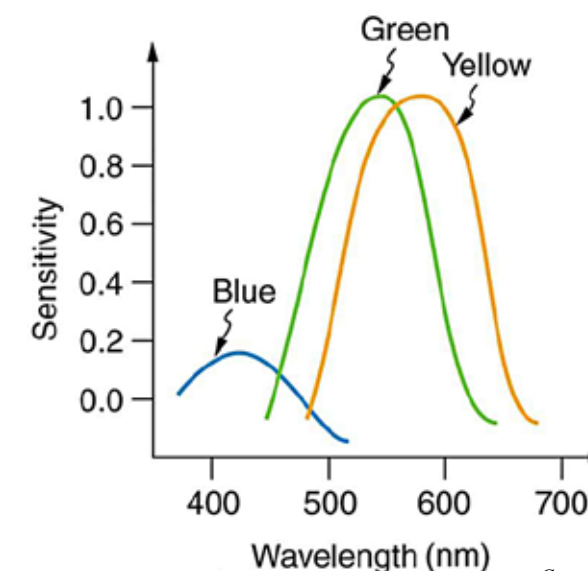
The rod cells enable you to see at night. They sense only light intensity, not color. But, they are much more sensitive than the cone cells. When you look at an outdoor scene that is illuminated by moonlight, only your rod cells are working. Because rod cells cannot sense differences in color, you see the world at night as black-and-white.

The “visible spectrum” is actually the sum of four separate spectra, one for each type of cone cell and one for rod cells. Together, the cone cells cover the entire visual spectrum, as shown Figure 6-1.

The rod cell response curve has approximately the same shape as the green or yellow response curves shown in Figure 6-1, but it is about 100 times more sensitive. Also, it is shifted further toward the blue colors, peaking at a wavelength toward the blue side of green. Rod cells do not respond to red colors. Therefore, anything red will appear jet black at night.

Our eyes do not have the same sensitivity for all colors. The eye is most sensitive to colors near the center of the visible spectrum. Greater light intensity is needed to reveal colors toward the blue and red ends of the spectrum. For this reason, you can see green objects in dimmer light than you can see red or blue objects.

Artificial lighting inside houses is much dimmer than direct sunlight. Typical room lighting is only a fraction of one percent of the intensity of direct sunlight. For this reason, if your decor depends on colors that lie toward the red and/or blue ends of the visible spectrum, select lamps that emit those colors strongly. Otherwise, you will need to increase the overall brightness of your lighting.



**Figure 6-1.** The three types of human cone cells have their peak sensitivity at different wavelengths. This is what makes color vision possible.

\* Light that is visible to humans lies in the narrow band of wavelengths between approximately 0.0004 and 0.0007 millimeters (0.4 and 0.7 microns). This band lies within the short wavelength end of the solar spectrum, where solar intensity is greatest. Within this range, the intensity of sunlight is fairly constant. Birds and insects can see shorter wavelengths than humans, into the ultraviolet range.

## HOME LIGHTING WORKSHEET

 ALL ROOMS AND SPACES

- \_\_\_ Locate all fixtures to avoid glare and veiling reflections, and to provide uniform illumination of individual scenes.
- \_\_\_ For most applications, select fixtures that have a wide radiating surface to soften shadows in the scene.
- \_\_\_ Use very light interior colors, especially for walls and ceiling.
- \_\_\_ Match the color characteristics of the lamps to the colors of the surfaces and furnishings in the room.
- \_\_\_ Favor LED lamps for their instant starting, long life, and good color rendering.
- \_\_\_ When using LED lamps, select a low color temperature to provide good color rendering.
- \_\_\_ When using LED lamps in fixtures controlled by dimmers, select lamps and fixtures that provide smooth and continuous dimming over a wide range of light output.
- \_\_\_ Where incandescent lamps may be appropriate, install fixtures that allow later replacement of the incandescent lamps with LED lamps.

 BEDROOMS

- \_\_\_ Install one or more ceiling fixtures for cleaning and changing bedding. The same fixtures should have a dimmer for mood lighting, to accommodate sleepers, and to avoid discomfort for night-adapted vision.
- \_\_\_ In a climate that has a warm season, coordinate the location of ceiling fixtures with the location of a ceiling fan, which generally should be installed over the bed. Either select a fan that includes lights under its hub, or be careful to avoid interference between the fan and other light fixtures.
- \_\_\_ Consider track lighting or separate ceiling-mounted spotlights to illuminate wardrobes, dressers, art objects, etc.

- \_\_\_ Install reading lights on or near the bed(s). These may be mounted on the bed, on the adjacent wall, or on side tables. Portable wall-mounted fixtures generally work best.

 SPARE BEDROOMS (USED AS STORAGE ROOM, SEWING ROOM, ETC.)

- \_\_\_ Generally, use the same ceiling fixtures as in bedrooms.
- \_\_\_ Select the other fixture type(s) for the specific activities in the room.
- \_\_\_ Install dimming, if appropriate for the activity.

 DRESSING ROOMS

- \_\_\_ Provide individual light fixtures to highlight areas within the dressing room, such as wardrobes, dressers, tie racks, and art objects, while maintaining a lower overall mood lighting. Consider track lighting or individually mounted spotlights.
- \_\_\_ Install any spotlights so that occupants cannot see the lamps from any position in the room.
- \_\_\_ Control all the fixtures with dimmers for mood lighting, to accommodate sleepers in adjacent bedrooms, and to avoid discomfort for night-adapted vision.
- \_\_\_ Provide adequate lighting for cleaning, generally on the ceiling. The previous lighting may suffice. If not, install additional lighting that complements the previous lighting.

 TOILET ROOMS (WITHOUT SHOWER)

- \_\_\_ Over the basin mirror, install a fixture with large surface area and low glare. A wide fluorescent or LED fixture with a large diffuser is best. A fixture with several large globe lamps is satisfactory. Install the fixture(s) to provide good illumination of the face without being close to the line of sight into the mirror. For a small toilet room, this may be all the lighting that is needed.

## HOME LIGHTING WORKSHEET

- \_\_\_ If the toilet room is used by bedroom occupants, control the basin fixture with a dimmer. This limits the fixture to incandescent or dimmable LED lamps.
- \_\_\_ For a larger toilet room, also install a ceiling fixture, perhaps in combination with a ceiling exhaust fan and/or ceiling heater. This fixture should use LED lamps.
- \_\_\_ See *Toilet Rooms*, in Step 1, for related lighting and electrical issues.

 TOILET ROOMS (WITH SHOWER)

- \_\_\_ For the basin lighting, follow the previous guidelines.
- \_\_\_ Also, install a ceiling fixture, perhaps in combination with a ceiling exhaust fan and/or ceiling heater. Locate it outside the shower, to illuminate the shower for cleaning and use. This fixture should use LED lamps.

 SHOWER ROOMS

- \_\_\_ See *Shower Rooms*, in Step 1, for related lighting and electrical issues.
- \_\_\_ Install a ceiling fixture, perhaps in combination with a ceiling exhaust fan and/or ceiling heater, in the entry area outside the shower. Locate it effectively for dressing and for illuminating the shower for cleaning and use.
- \_\_\_ Select a fixture that is resistant to moisture – incandescent or LED, not fluorescent.
- \_\_\_ Install a dimmer for the lighting.

 BATHTUB ROOMS

- \_\_\_ Install one or more ceiling fixtures, perhaps in combination with a ceiling exhaust fan and/or ceiling heater. Locate the fixture(s) for dressing, for illuminating the tub during use, and for cleaning the room.
- \_\_\_ Select a fixture that is resistant to moisture – incandescent or LED, not fluorescent.
- \_\_\_ Control the lighting with a dimmer.

 KITCHEN

- \_\_\_ Install one or more ceiling fixtures for whole room cleaning and for illumination into all cabinets. Select the fixtures to provide lateral and downward light distribution, with emphasis on lighting cabinets and counters.
- \_\_\_ For the ceiling fixture(s), select LED or fluorescent fixtures. For ceiling LED fixtures, select dimmable models and install a compatible dimmer. For a fluorescent fixture, install switching that selects different numbers of tubes.
- \_\_\_ For all counters, install separate work lighting, with separate switches. If the counter lighting is installed underneath cabinets, select long arrays of LED's. Install the fixtures so that the lamps are shielded from view. If the counter lighting is installed on the ceiling, install a row of surface-mounted LED spotlights, aimed straight down. Install all fixtures toward the front of the counters.
- \_\_\_ Illuminate the sink with a surface-mounted LED spotlight, aimed straight down, unless the sink is adequately illuminated by the room lighting. Install the fixture toward the front of the sink.
- \_\_\_ For maintenance and storage in the space under the sink and in any cabinet that contains plumbing or water treatment equipment, install a surface-mounted LED light. Install the light so that it does not create glare for the person working in the space. Control the light with a door switch or with a conveniently located manual switch.
- \_\_\_ Select a range hood that includes light fixtures for effective illumination of the entire range surface. For fire safety, install a range hood that is wider than the range itself.