SPECTRA

Fingerprints for light sources.

Materials
1. A shoebox or a mailing tube about 2 inches (5 cm) in diameter and about 1 foot (30 cm) long
2. Scissors or utility knife
3. Index cards
4. Tape
5. Diffraction grating (inexpensive holographic diffraction gratings are available online)
6. A light source

Introduction
Using a diffraction grating, you can observe that what seems to be a single color of light may really be a combination of colors, called a spectrum. You can also compare the spectra produced by different light sources.

Assembly
(30 minutes or less)
1. At one end of the shoebox or mailing tube, cut a rectangular hole measuring about 3/4-inch (2 cm) wide by 1 1/4-inches (3.5 cm) high.
2. Cover the hole with pieces of index card to create a vertical slit about 3/16-inch (5 mm) wide.
3. Tape these pieces lightly in place for now, because you may want to adjust the width of the slit before permanently securing them.
4. At the opposite end from the slit, cut an opening measuring about 2 x 2 inches (5 x 5 cm). If you're using a mailing tube, simply remove the cap at the far end.
5. Cover this opening with a slide-mounted grating or a piece of grating material cut from a sheet. It's important that the scratches on the grating are parallel to the slit in the other end of the tube or box, but you may not be able to judge this until you try out your device.
6. Tape the grating lightly in place for now, and move it if necessary as directed in Step 10.

Exploratorium Science Snackbook: Spectra 175
Etcetera
In addition to examining commonly available light sources, you might want to examine the spectra produced by specific gases. Power supplies and a variety of gas tubes are sold by scientific supply companies. Try to find a neon sign-making shop that gives tours, and see how the different gases that fill the glass tubes glow in different spectra.

7. If you are using a shoebox, put the top on the box.
8. Hold the shoebox or the tube so the slit is facing a light source. (Light from an ordinary lamp is a good starter.) Be sure the slit is oriented vertically.
9. Look through the diffraction grating into the box or the tube. You should see colors. The spectrum of the light source should extend to the left and right of the slit.
10. If you don’t see the spectrum extending to both sides, the scratches on the grating are not parallel to the slit. Turn the grating one-quarter turn and look again. Adjust as necessary until the spectrum extends to the left and right of the vertical slit, and then tape the grating securely in place.
11. Adjust the slit width until you obtain a spectrum that is both reasonably bright and reasonably well defined.

The result is a simple spectroscope, a device used to form and examine the unique combination of colors that make up any light. These colors are called a spectrum (plural: spectra).

To Do and Notice
(30 minutes or more)
Compare the spectra of various sources: Different kinds of light will give you different spectra.
When you view different light sources, look for specific colors and notice the spacing between colored lines. The heated tungsten filament of an incandescent lightbulb produces a continuous spectrum, and one color shades into another. The electrically excited mercury vapor in a fluorescent bulb produces distinct colored lines; the phosphors that coat the inside of the bulb produce a continuous spectrum.
Some other suggested light sources are a candle flame, the flame from a Bunsen burner, a flashlight, a camping lantern, yellow streetlights (sodium produces the color), blue streetlights (mercury vapor produces the color), and neon signs.
Different light sources produce different spectra. You can see the solar spectrum by looking at sunlight reflecting off a piece of white paper. (Never look directly at the sun.)
When atoms of different materials are excited by electric current or another source of energy, they glow with a unique spectrum. Atoms of different elements have different colors in their spectra. These characteristic color patterns represent specific atoms just as fingerprints serve to identify specific people.
A diffraction grating acts like a prism, spreading light into its component colors. The light you see from a light source is the sum of all these colors. Each color corresponds to a different frequency of light. While prisms sort light by frequency, diffraction gratings sort light by wavelength, with violet light (the shortest wavelength of visible light) at one end of the spectrum and red light (the longest wavelength of visible light) at the other.
When atoms in a dilute gas (like the mercury vapor in a mercury street light) radiate light, the light can be seen through a diffraction grating as a line spectrum, made up of bright lines of color. Each line in the spectrum of such a gas corresponds to one frequency of light emission, and is produced by an electron changing energy levels in the atom.
In solids, liquids, and densely packed gases, the situation is not so simple. As atoms emit light, they collide with other atoms. This changes the frequency of the light each atom emits. That’s why solids, liquids, and dense gases have broad bands of light in their spectra.