Laser Science
Persistence of Vision

Have you ever drawn shapes in the air with a flashlight or a sparkler? You were fooling your eyes! Our eyes are slow; they're good at seeing stuff appear, but not so good at seeing stuff disappear. It takes a moment for bright pictures to fade away in your eyes. (Try closing your eyes. Do you instantly see black, or can you still see a bit of what you saw before you closed your eyes?)

If you move a light, you see where it *is*, while also seeing where it *was.* Move it faster and you start to see a line showing where the light was. If you move the light faster, the line becomes longer and starts to form a shape. If you can repeat the shape fast enough, you'll be drawing it again before the first one faded away and it will look like it's floating there. Scientists call this "Persistence of Vision."

What if the dot turns off for a moment, while moving? It will stop making the line and then start again later. You can make dotted lines and shapes. It's like drawing, picking up your pencil, drawing some more, and picking up your pencil again.

Try it! Draw in the air: Spin around a flashlight, sparkler, or anything that glows and won't break. See if you can make pictures in the air, like you saw in the laser show. Even better, find something that flashes quickly and spin that. See if you get dotted lines.

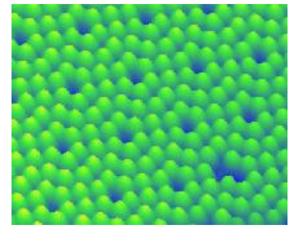
Movies work on the same idea. When you watch a movie, you see a series of pictures separated by a black screen. You don't see the flicker between pictures because your eye holds an image of one picture until the next picture appears. Most modern video projectors use this idea too; they project only one color at a time, and alternate so quickly that your eye combines the colors. The next time you're at a movie, try shaking a finger back and forth in front of the picture. Your finger will become part of the flickering movie.

This is hiding in your pocket or purse right now. Light Emitting Diodes (LEDs) are our modern day Chanukah jar of oil; they make lots of light using very little power, and can last a long time. But they can't dim; they're either off or on, but not in between. So how can we fool your eyes into seeing an LED at half brightness? Flash the light off and on quickly, so it's only on half of the time.

Try it! Dim your cellphone or laptop display and shake it quickly in the dark. If the picture breaks up into dots instead of smooth lines, it's flashing. We shook our MacBook for you. The dotted vertical line in the picture to the right is the standby light at half brightness.

Explore more science (and download this sheet) at: w***ondergy.com/laser***

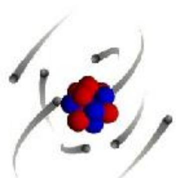
Laser Science
Lights and Lasers



Look at stuff closer. Waaaaay closer. Everything is made out of tiny bits, called atoms. You can think of them as incredibly small batteries. They have + and – parts, you can charge them up, and you can get their energy back out.

You can charge atoms by giving them electricity, bouncing them around with heat, shining light on them, and generally finding ways to get them to absorb energy in some way. Once atoms have their energy, they can't keep it for long. They'll usually let some of it go, either by bouncing around and warming up other atoms, letting it flow down a wire as electricity, or by glowing. In a light bulb, they do all three.

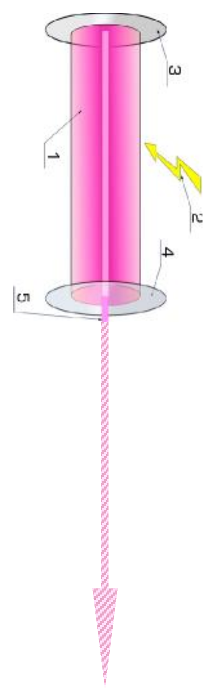
Old School
The old way of making light was by getting atoms hot. Really hot. The flames of a fire are around 1000°F and light bulbs glow between 2000-3000°F. When atoms get hot, they bounce around, pick up energy, and give it off as light. "Incandescent" light bulbs work this way, making light by heating a tungsten wire. They waste a lot of energy as heat, but are good for easy bake ovens.



New School
Unlike a battery, it's really just the tiny negative parts (electrons) of the atom that pick up and let go of energy. Since those old days, we've gotten better at charging up the electrons without disturbing the rest of the atom. What's the best way to excite electrons? Electricity!

You've probably heard about Compact Fluorescent Lights (CFL's). These lights work by flowing a tiny bit of electricity through a gas (mercury) in a curled-up tube. The atoms' electrons grab energy from the electricity and let it go as light, making them glow. Some atoms do start bouncing around and heat the light up, but not much. It's a great way to save energy.

Really new school
Back in 1917, Albert Einstein figured something out: atoms carrying energy work a lot like people carrying books: They can only hold so many. Once they're filled up, handing them an extra book will cause an avalanche! So how do you fill up atoms? Trap the light.



Think of a Neon Pizza sign (1). Electricity (2) charges up the atoms inside and they glow with light. But what if you put a mirror at both ends of the tube? The light would bounce back and forth. If some of that **light** ran into a charged up atom, it would make (**stimulate**) it give off (**emit**) its energy as light (**radiation**), travelling together with the light that bumped into it. So now even more light starts bouncing back and forth through the tube, building up more and more and more light (**amplification**), all travelling together between two mirrors. It's like an avalanche of light! ("Laser" stands for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation.)

Our neon pizza sign has one good mirror (3) and one not-so-good mirror (4). Just like the interview room on cop shows, one mirror lets a little bit of the light through. Instead of seeing the criminal, you see laser light! (5)

So why use a Laser for Laser Shows? Okay, besides the cool name.
Since laser light is made by bouncing between two mirrors, all the light is travelling in the same direction, back and forth. Anything that isn't straight doesn't make it to the next mirror and doesn't come out with the laser beam. Parallel light can stay together much longer, so a laser can make a tiny dot on a wall far away.

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