



## On Chanukah, science, and miracles

mir-a-cle: noun \`mir-i-kəl, a very amazing or unusual event, thing, or achievement (*Merriam-Webster*)

The stories of Chanukah are amazing! A tiny guerilla army ousts a major occupying force. One tiny jar of oil burns for 8 days. Often things seem too small to make a difference, and we're amazed when they do. Many times we feel that way about ourselves or our resources. If we believe that we are too limited, then we will be.

Science is awesome! It's fun. It's interesting. However, science is not just about discovery; it's also about discovering what is possible. It's about realizing that a drop of water, a rock, a jar of oil, or anything else we find has powers far beyond what we might first believe. Water can carve mountains or quench fire. Rocks may become buildings or computers. Oil may become medicine or make light. The more we discover about our world, the more miraculous things we can do with even small things.

Discovery is truly miraculous. Each time we use something in a better way, we give ourselves new powers. Sometimes those powers look amazing, and sometimes they're subtle, but even the subtle ones can make a big difference. By finding ways to make one jar of oil last eight days, how to use less gas in our car, or how to make our cellphone battery last eight times as long, we change what is possible. Cars can reach between cities, cellphones can show videos, and lights can stay on. Science pays back.

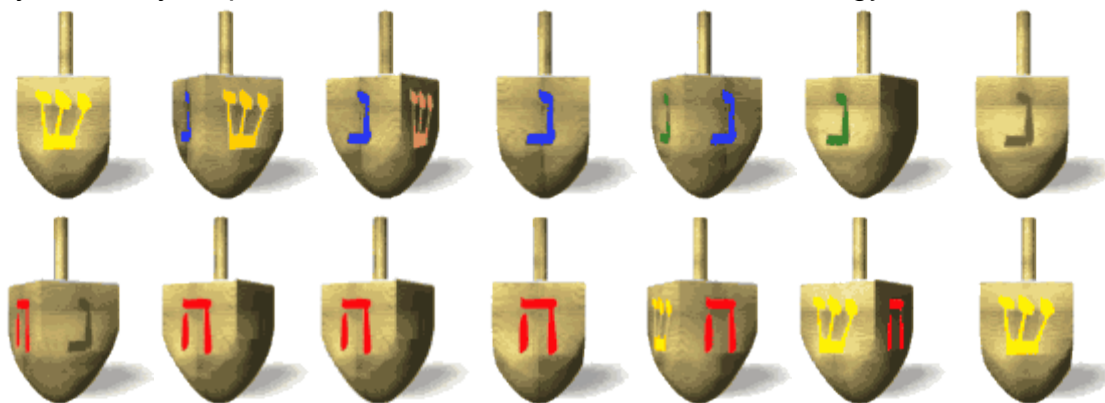
Wondergy's Festival of Light laser show celebrates this, and relies on it. The entire laser show is made from just one laser dot, one tiny beam of light. By exploring how light works, and how our vision works, we take one tiny thing and make it capable of amazing displays. It is the product of many tiny miracles.

Ken Fink  
President, Wondergy Science Entertainment

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### Make a flip-book (*Relates to science on other side*)

*Try it!* Draw a series of pictures that are almost, but not exactly the same. Flip through the images quickly, and you'll see your pictures move! See this animated at [wondergy.com/fol](http://wondergy.com/fol)



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*To learn more about lasers and persistence of vision, call or email us with questions, or to bring Wondergy to your school or party!*



# Laser Science

## Persistence of Vision



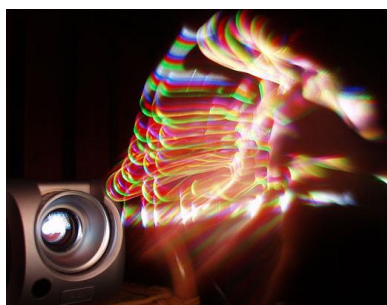
Have you ever drawn shapes in the air with a flashlight or a sparkler? You were fooling your eyes! Our eyes are slow; they're good at seeing stuff appear, but not so good at seeing stuff disappear. It takes a moment for bright pictures to fade away in your eyes. (Try closing your eyes. Do you instantly 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 miracle is hiding in your purse or pocket 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 it 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.



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