

How should we make light?

Explore energy efficiency and different ways to make light from excited atoms, heated wires, and solid-state semiconductor circuits.

Can we make light without wasting energy making heat?



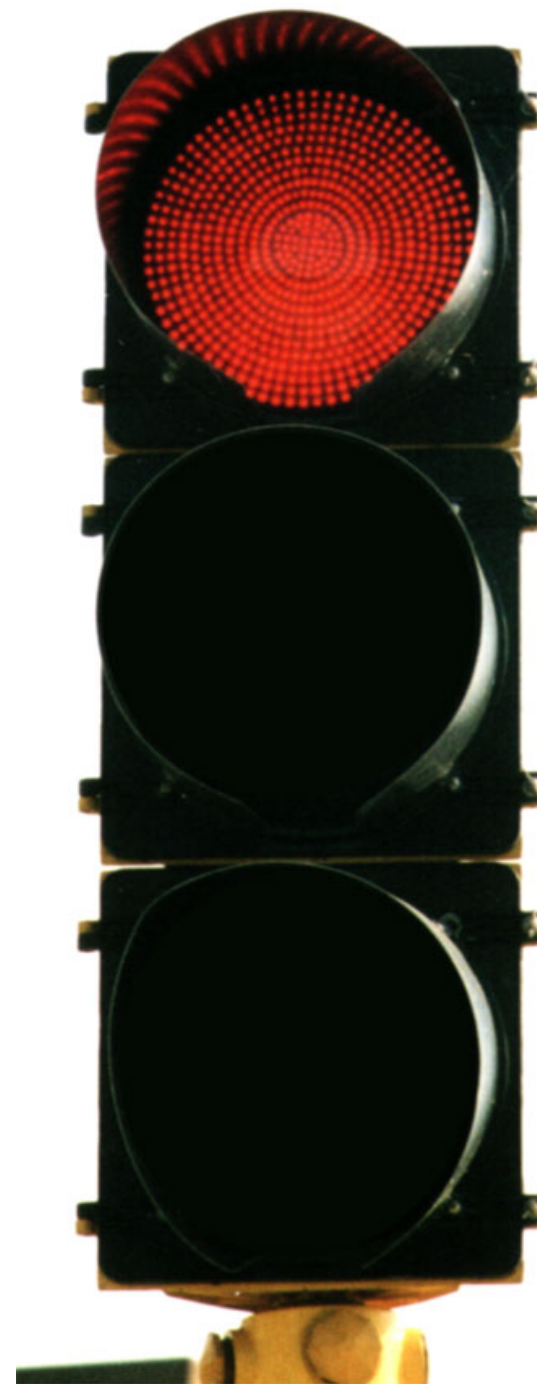
Are all red lights the same?

Which gives off more heat?

Which uses more energy?

How many watts does each light use?

(These are real size traffic lights.)





Caution: these are bright!

Which one is hotter?

(Use the infrared thermometer to measure.)





What colors can you make by slowly turning on a light bulb?

Turn the big top knob.

(This is an incandescent bulb like the one Thomas Edison made.)



Does a fluorescent light use hydrogen or mercury excitation?



(Use the spectrometer to record the spectrum of all three.)



Which lights are directional?
Which would be better for a ceiling light?
A lamp? A streetlight?



LED Street Lights in Bilbao, Spain



What color are excited sodium atoms?

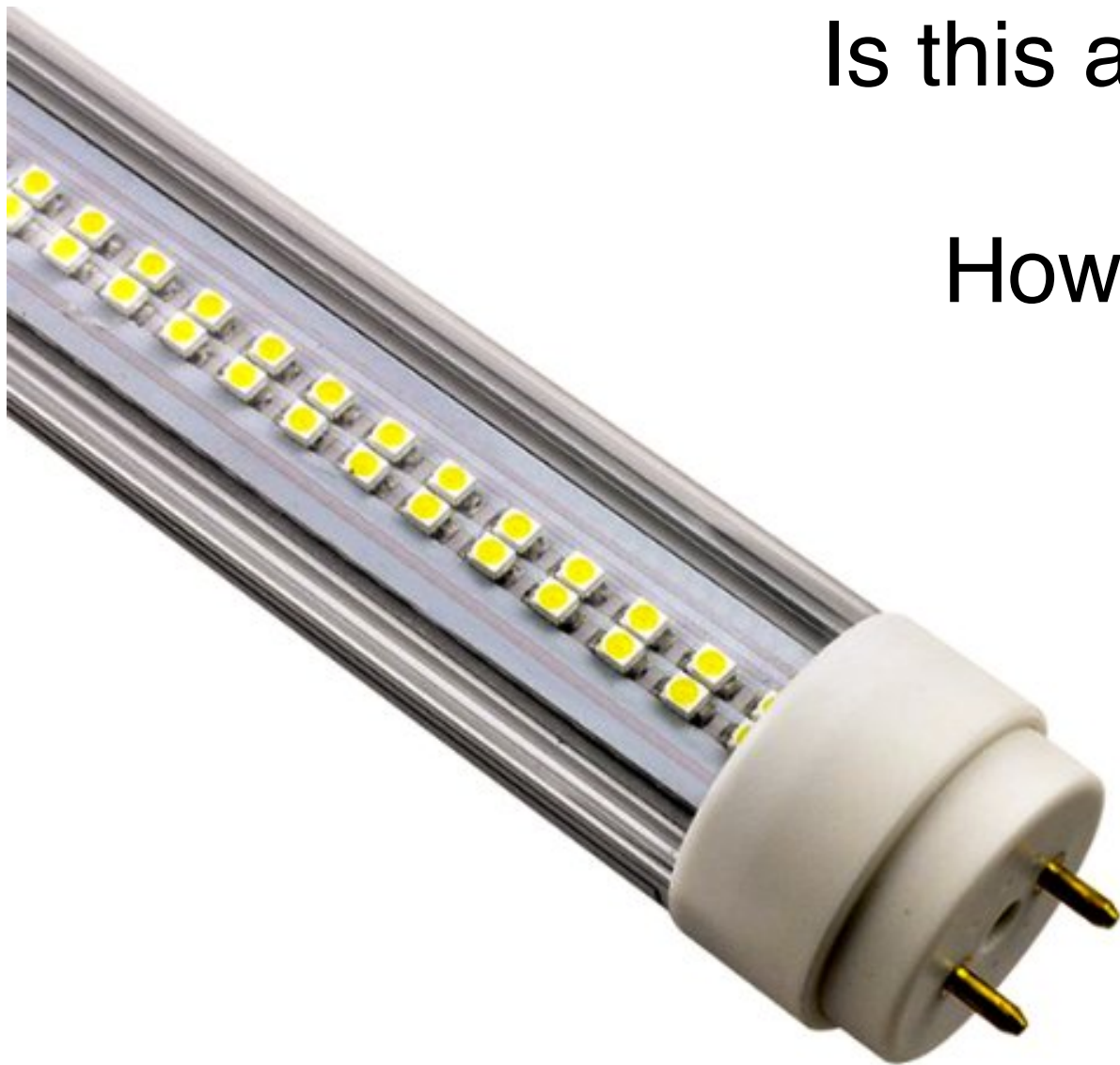
(Dip a hot poker into the salt water next to the burner.)

Is the color the same as a sodium lamp?



Is this an LED lamp?

How can you tell?

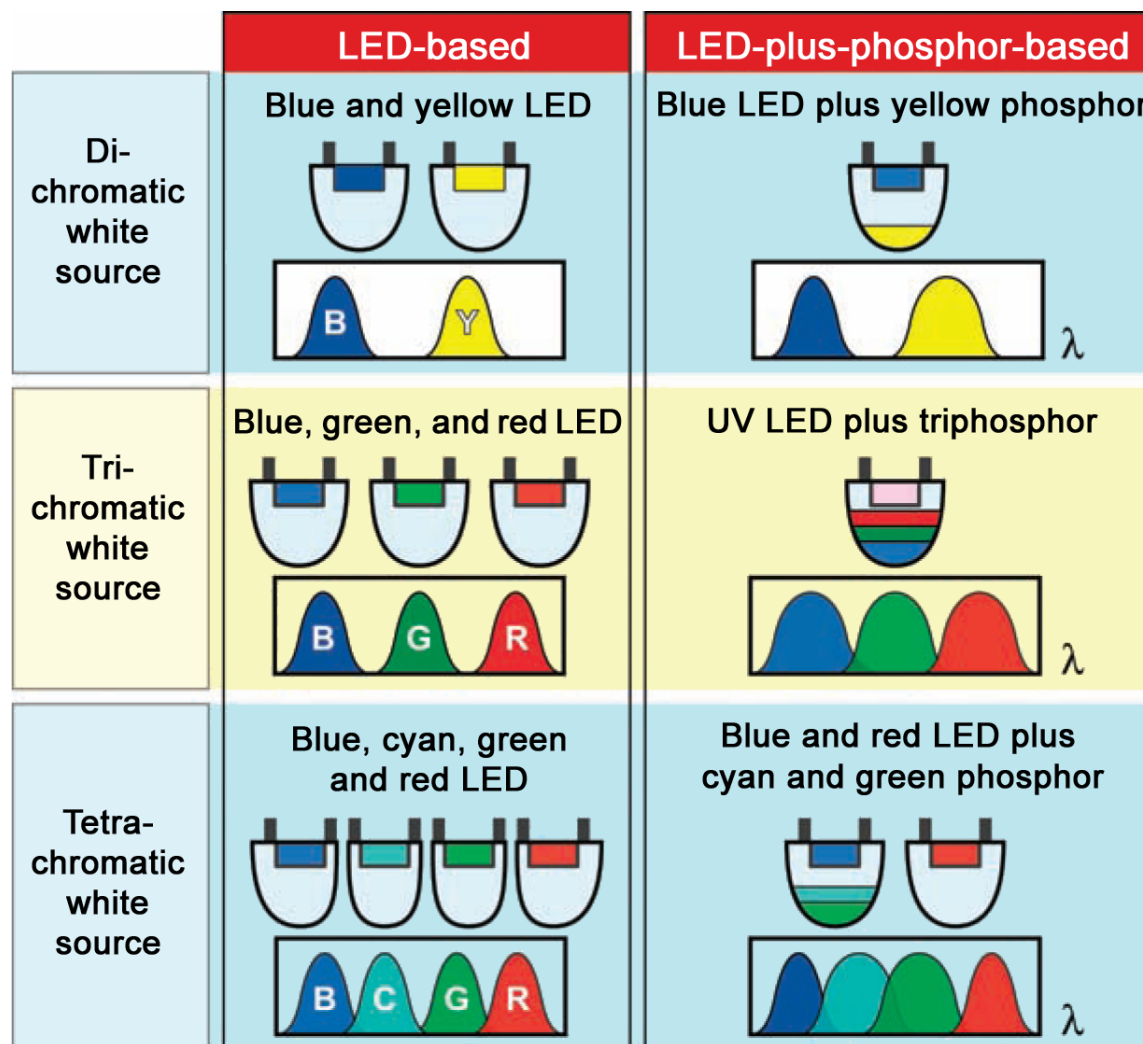


How can you make white light?

Does adding



change the
color you
see?



E. Fred Schubert and Jong Kyu Kim, "Solid-State Light Sources Getting Smart", *Science*, **308**, 1274 (2005).

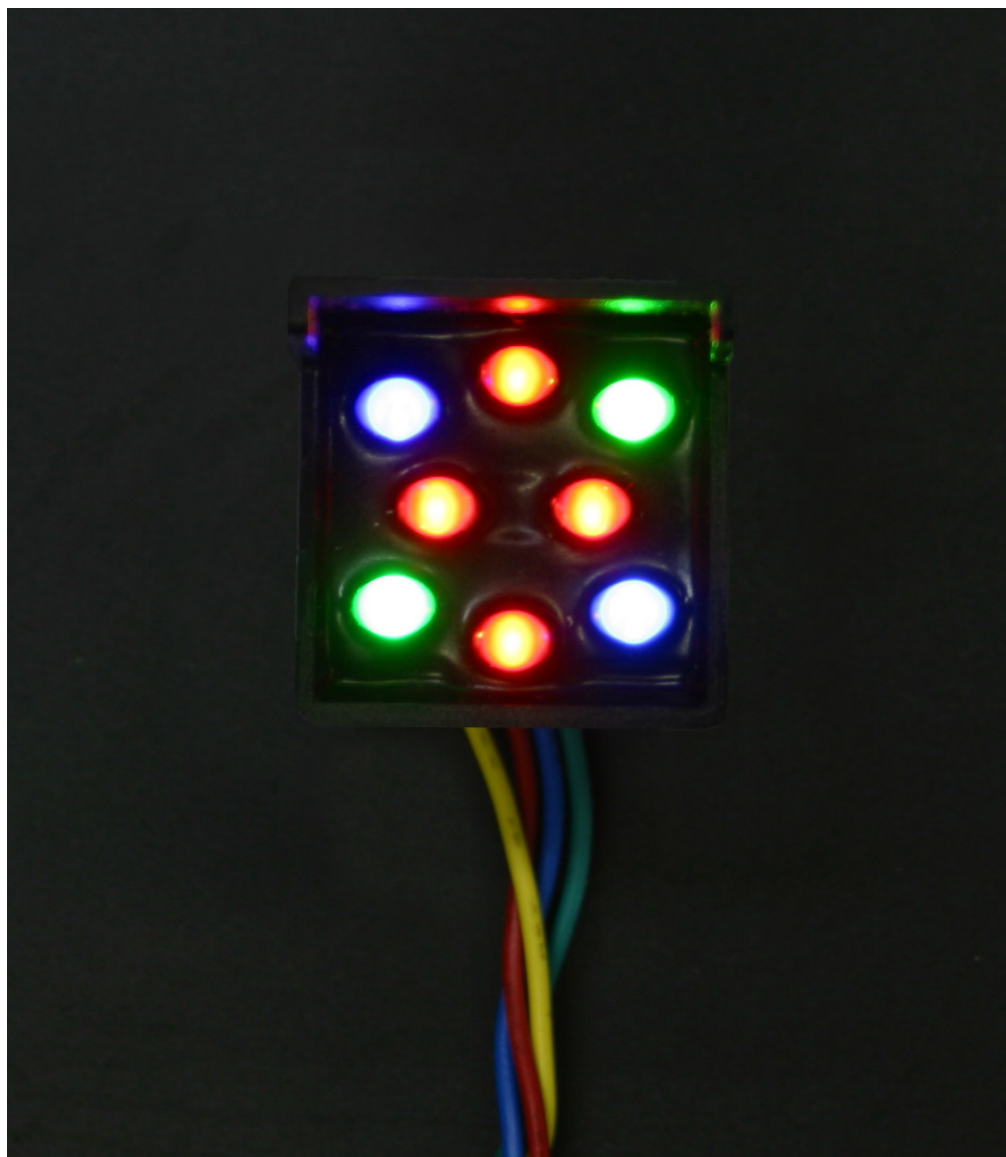


How can you make white light?

Is there a blue light inside my white light?

(Use the spectrometer to measure the spectrum of white and blue.)





Can you mix colors to make white light?

Does it look the same up close as far away?

(This is a pixel from a stadium display screen.)



Which makes more light?
(Both are 4W)



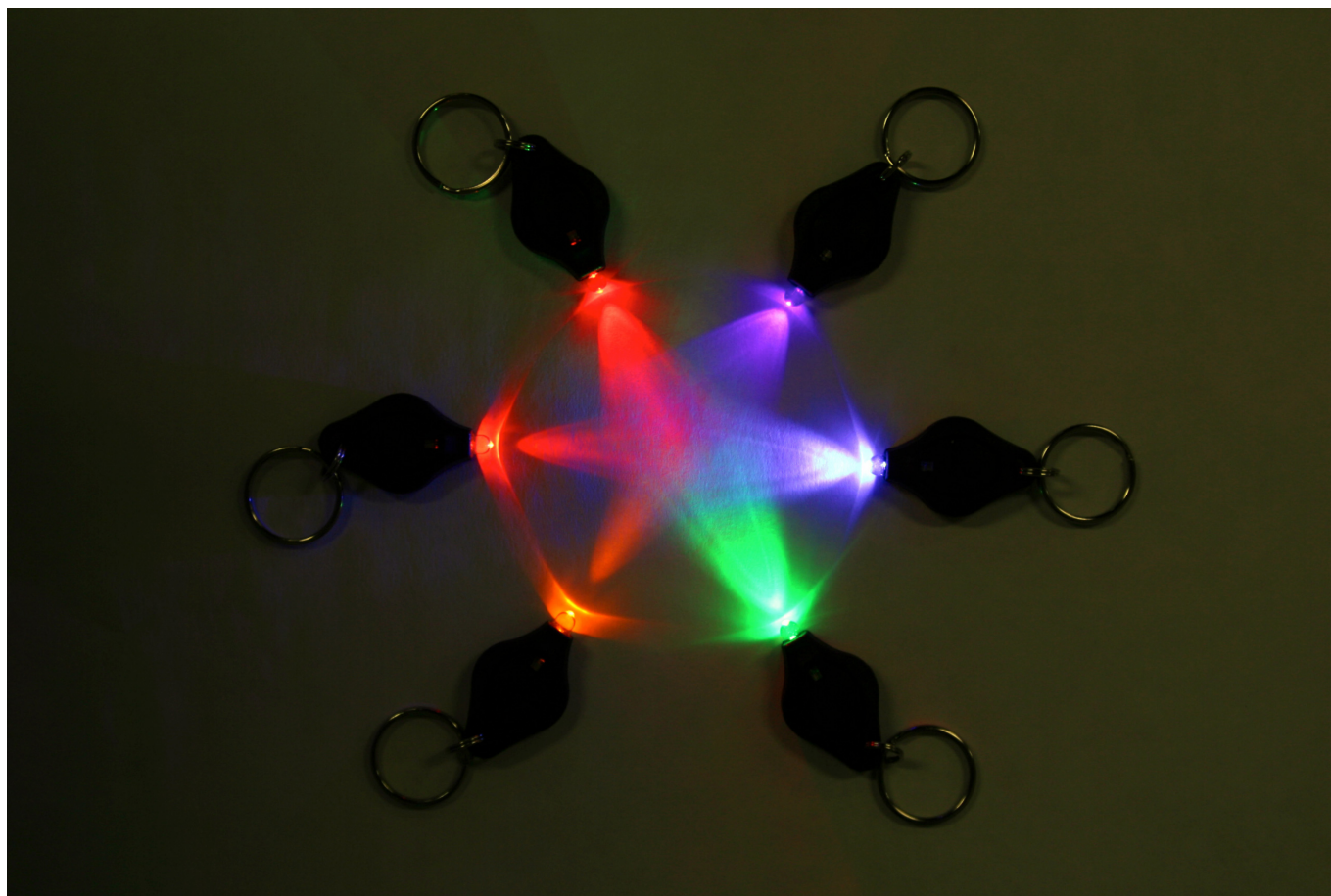
How Should We Make Light?

Beloit College Chemistry Department



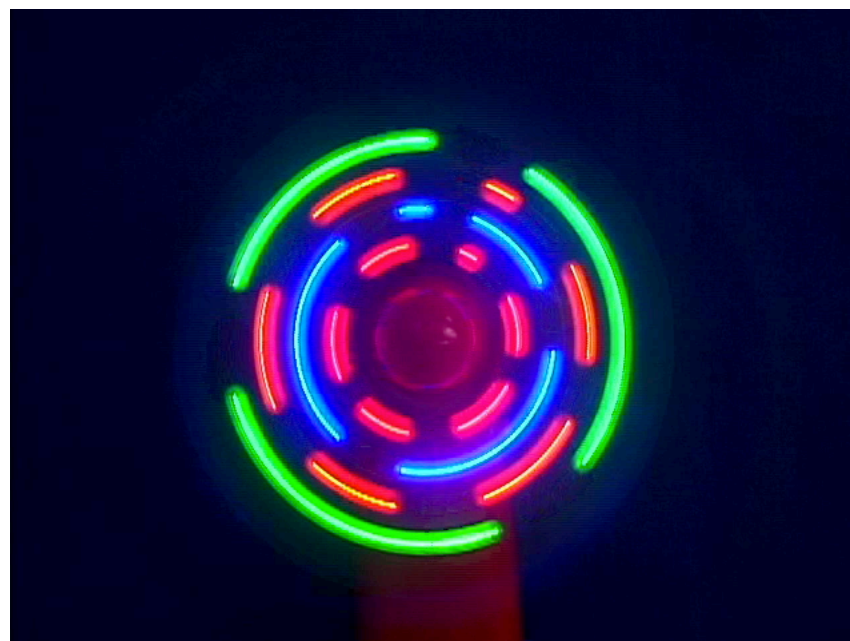
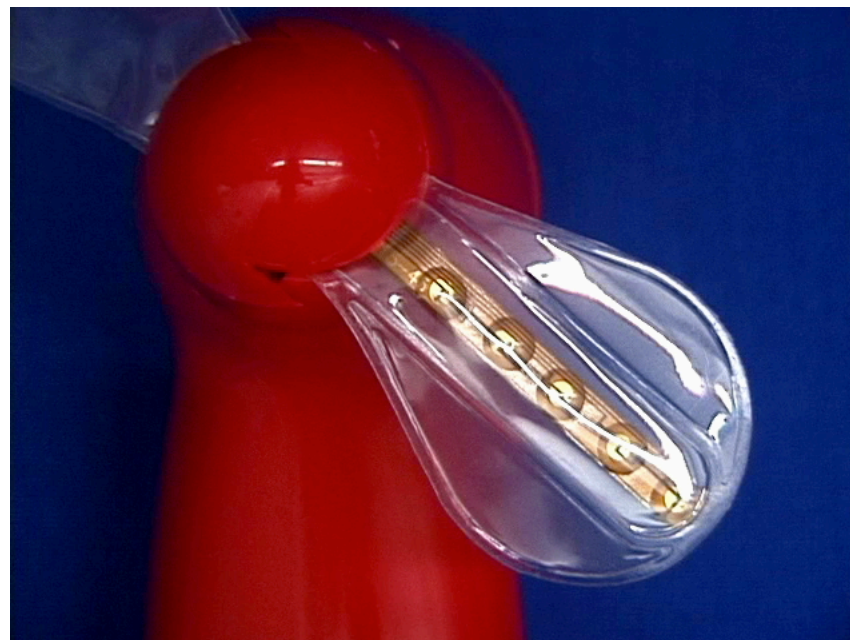
Which color can excite the glow-in-the-dark material?

(Try waving each over the yellow sheet)



How fast can an LED
turn on and off?

(Does it look different
when the fan is
spinning?)



Which light turns on faster?

(These are
brake lights.
Flipping the
switch turns
both on at the
same time.)



Is this difference important?

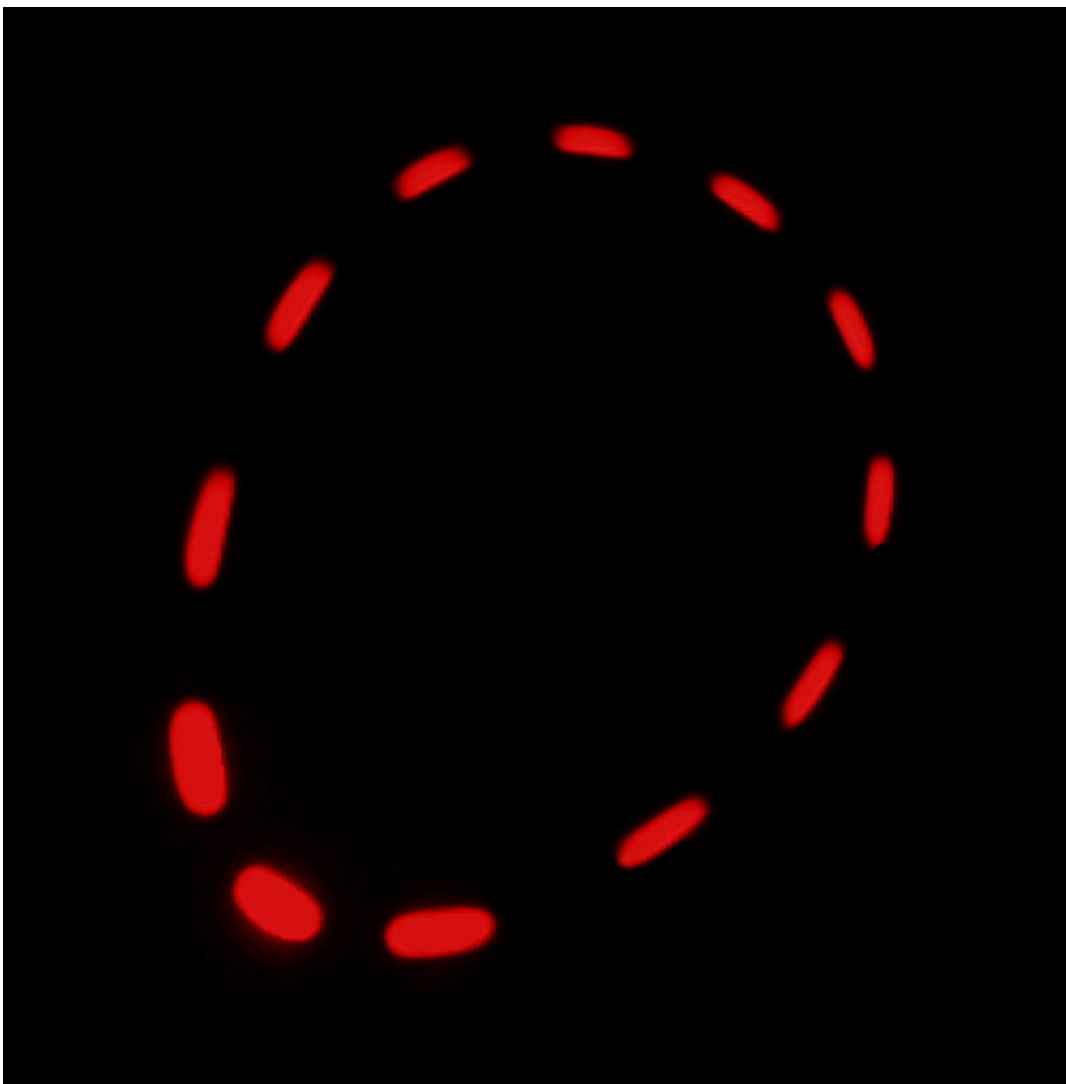


What color light
can you make
using the remote
control?

How many
individual colors
are used to mix
all the colors?

(Use the spectrometer to measure the
spectrum of each color.)





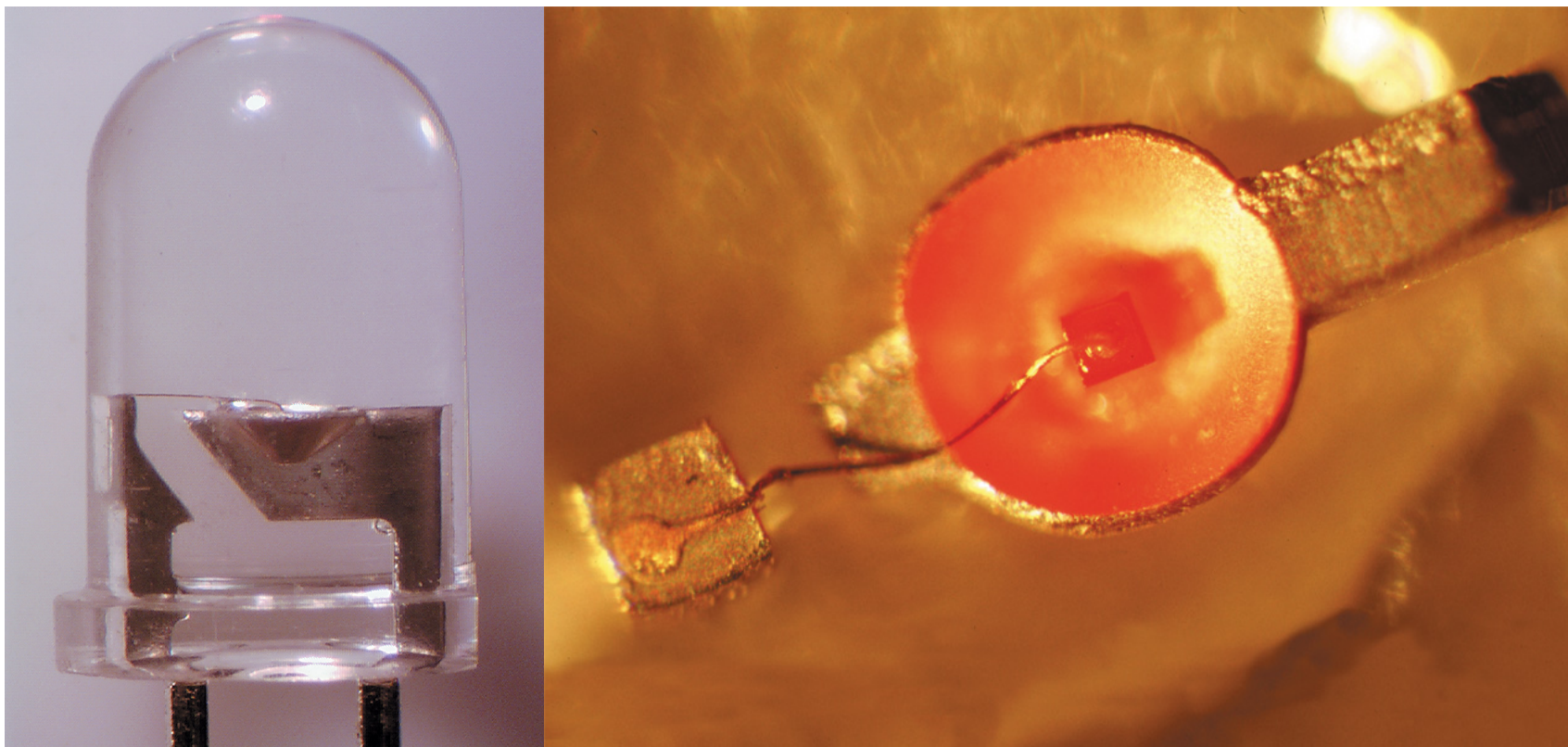
Is the light on all the time?

(Try waving the light.)

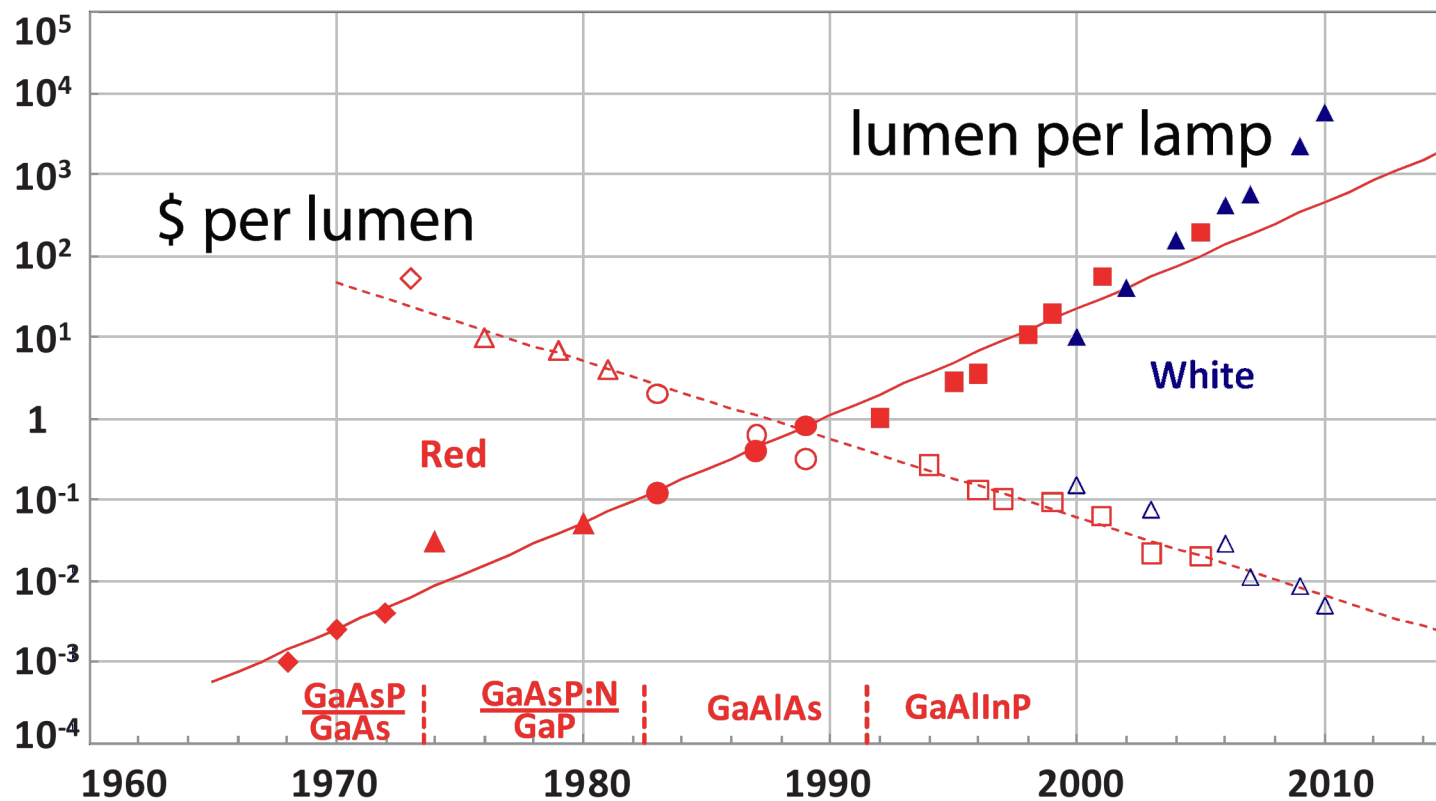
Does a battery give the same results as alternating current?



Light Emitting Diodes



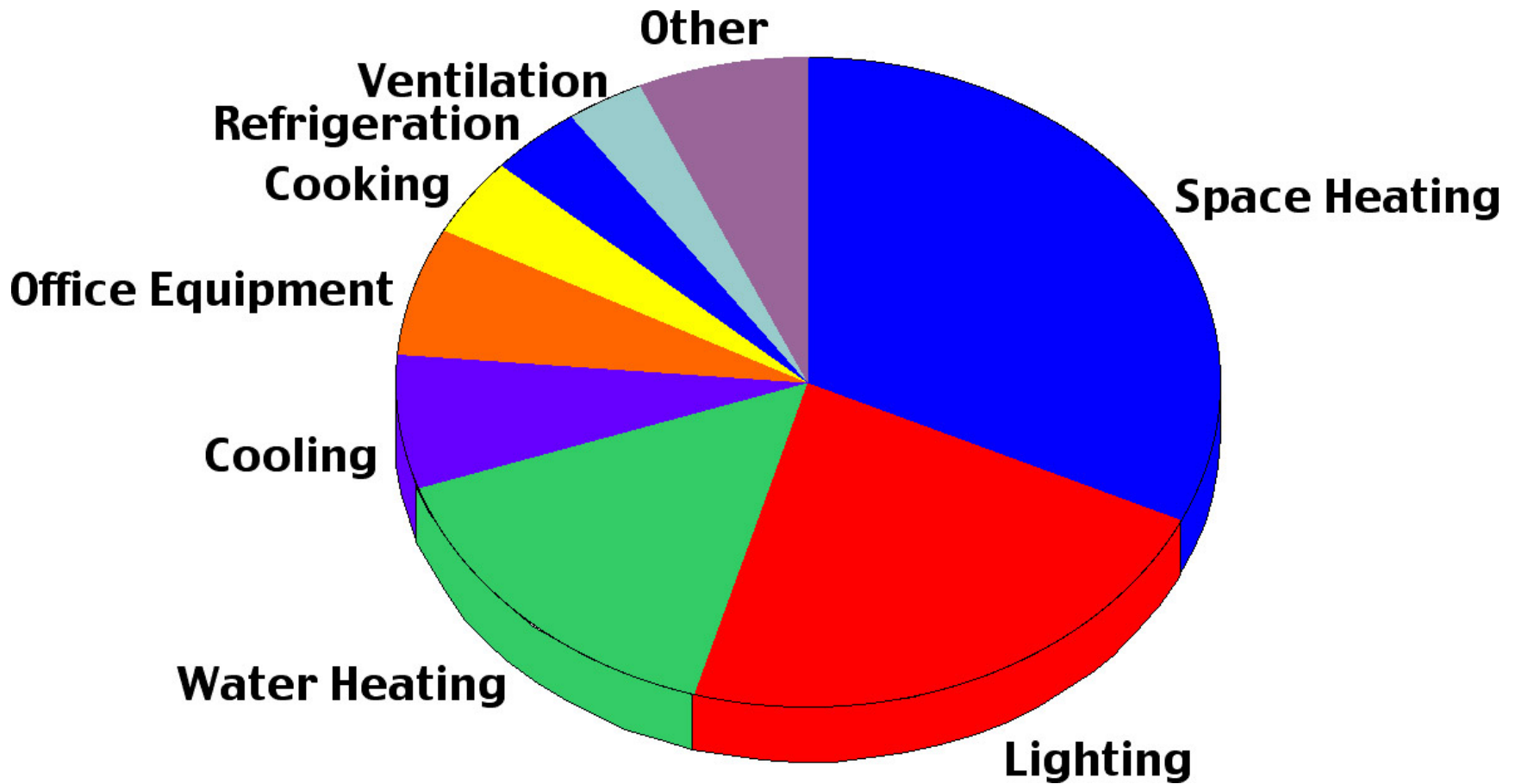
LED Performance



Light output has doubled every two years while the cost has halved every two years.



Lighting applications consume about 20% of all electricity generated worldwide.



LEDs versus Incandescent Bulbs

- **Lower energy consumption**
 - 1/10 power required
 - Less heat generated
- **Faster illumination rate**
 - 200 milliseconds faster (19 ft at 65 mph)
 - Usable for video display
- **Durability**
 - Single LED failure not catastrophic
 - 100,000-hour lifetime
 - Scheduled replacement not required
- **Color**
 - Single color signals most efficient
 - White light from fluorescent excitation



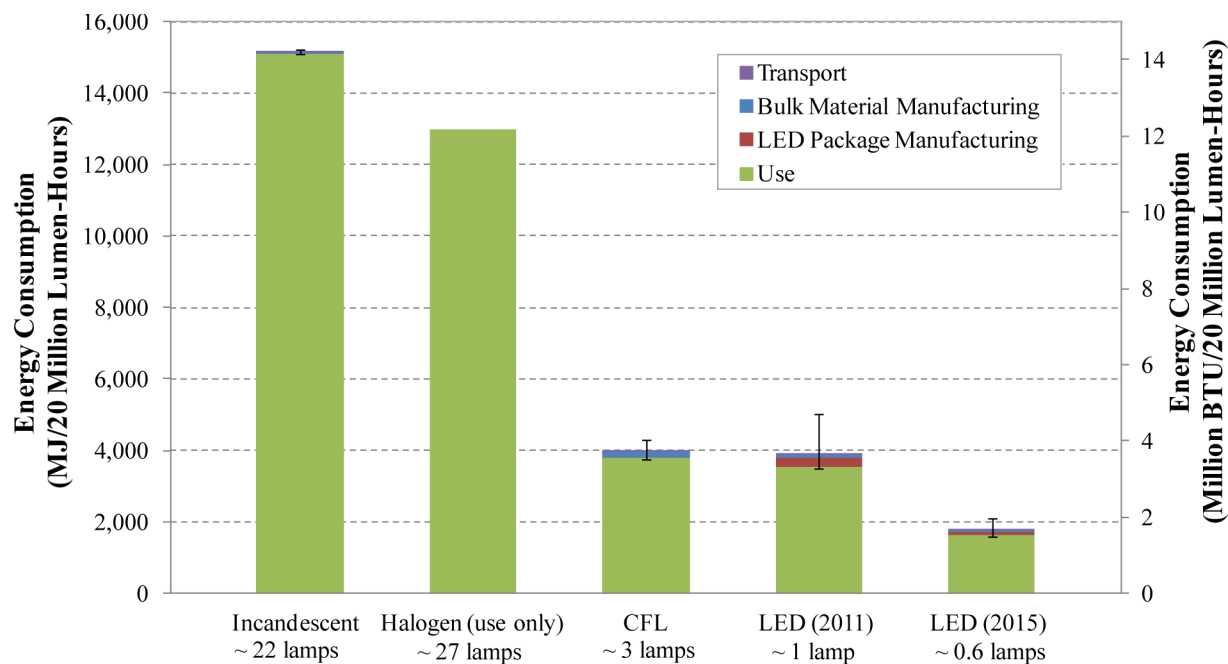


Figure 4.6 Life-Cycle Energy of Incandescent Lamps, CFLs, and LED Lamps

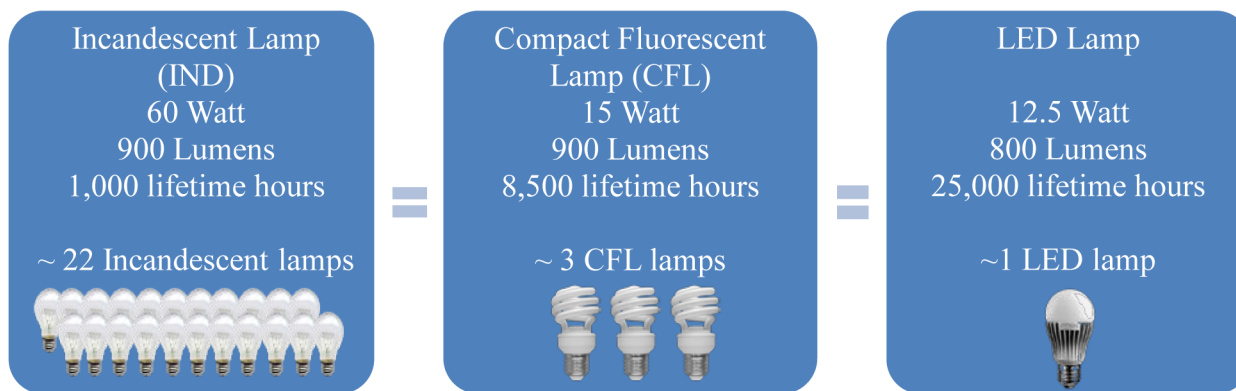


Figure 4.1 Number of Lamps Needed to Supply 20 Million Lumen-Hours

US DOE, August 2012.



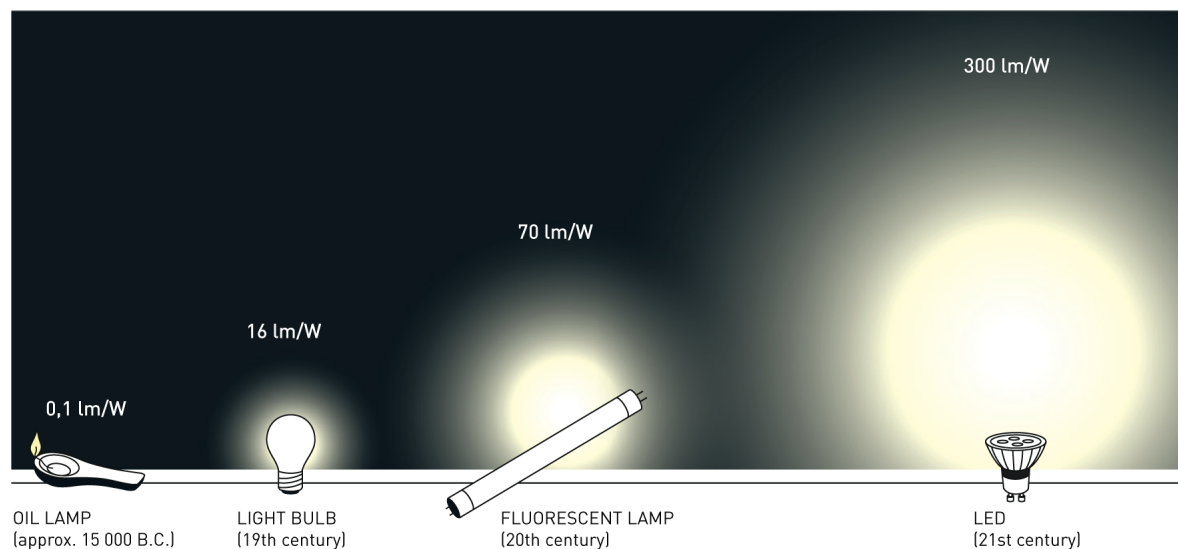
2014 NOBEL PRIZE IN PHYSICS

Isamu Akasaki
Hiroshi Amano
Shuji Nakamura



© The Nobel Foundation. Photo: Lovisa Engblom.

"for the invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources"



Room layout

Traffic lights Heat guns	Directional (3 E27 lamps: IKEA, flood, bulb)	Phosphor cap SPECTROMETER White light Flat panel White holiday Undercounter	Phosphor Microlights Ring stand	Fans Color Holiday	AC wand Color Holiday
Variac and incandescent (flooded)	SPECTROMETER Fluorescent Hydrogen Mercury	Pixel Piece of paper	4W Flood Nightlight Power meters	Brake lights	SPECTROMETER Remote control Dim brightness

Bunsen burner

SPECTROMETER Sodium Lamp

LED T8

SPECTROMETER

