Warm light

A light source should generate light, not heat.

It is not easy to transform electricity into light alone. A portion of the energy will always be 'lost' as heat, limiting the efficiency of the light source. It is not just light that can generate heat, however. Heat can generate light too, and it can help us to understand what light is.

With this worksheet, you will learn more about the relationship between heat and making light.

1 How do you recognize an **efficient** light source? There is a simple "hands-on" technique to find out if a light source is efficient: if it get's warm, and it's not a heater, then energy is wasted.

Please examine the following list and rate the light sources. If you need to check before writing down your answers, please be careful: The objects may be very hot.

	Hot ... Cold
Candle	
Light emitting diode (LED)	
Incandescent light bulb	
Halogen light bulbs	
Compact fluorescent light bulb	
Fluorescent light tubes (check tube ends)	
Firefly	
Plasma TV-screen	
Sun	

Discuss your results with your classmates, and then compare them to the data your teacher gives you.

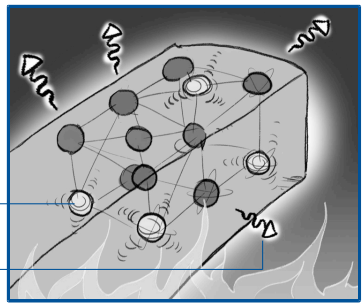
By the way, the same trick also works to test the energy efficiency of other technical devices like e.g. the charger for mobile phones, electric toothbrushes, computers, cars, etc… .

2 Have you ever heard people talking about 'warm' light, or 'cold' light? In most cases, when these terms are used, the references are not to the heat produced by the light source, but rather to the colour of the light. Red and orange are usually associated with warmth, while bluish light is considered to be 'cold'.

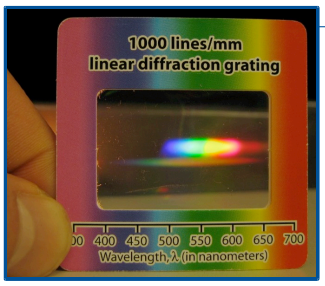
But what does the colour of the light tell us about the temperature of the light source? Is a piece of metal that glows red warmer or colder than a piece of metal that glows yellow or even bluish white? Look at a piece of metal that is heated over a Bunsen burner or a metallic wire heated by an electric current. Please describe how the colour changes while the metal heats up below.

Based on your observation, is the common understanding of 'warm' and 'cold' light *physically* correct?

3 You were probably not surprised to see the metal **glowing.** But why does metal start to emit light when it is heated up? Why does the colour change? Although this effect has been observed by humans for thousands of years, it was only a little over 100 years ago that Max Planck provided a satisfactory explanation for it: By heating metal we add **energy** to it: The more we heat it, the more the metal atoms vibrate in their positions in the latticework. To get rid of their excess energy – i.e., to cool down – atoms emit small packages of energy in the form of light. Such packages are called **photons.** How much energy a photon has depends solely on the frequency of the light.



4 Does a photon with higher frequency have more energy than a photon with lower frequency? Or is it the other way round?



You can answer this question by carefully examining the change in the emitted light while the metal is cooling down. A diffraction grating will help you to separate the different frequencies of light.
Please hold the diffraction grating close to your eyes so that the left part of the frame covers the glowing metal. The blue light has the highest frequency (and shortest wavelength) while red light--at the other end of the optical spectrum--has the lowest frequency (and longest wavelength). Carefully observe what happens to the spectrum while the metal cools down, until it stops glowing. Please note your observations below.

What do your observations lead you to conclude? Is there more energy in those photons with a higher or lower frequency? Can you provide evidence to support your conclusion?

5 Use the diffraction grating to study the spectra of an incandescent light source and the LEDs on the LED module. What difference in the spectra do you note? How do they compare to the spectra of the hot metal?

Obviously, the photons emitted by the red, green and blue LEDs have different energies. Touch the LEDs – can you notice any difference in temperature?

What do you conclude from your observations about the way in which light is generated by the various different light sources?