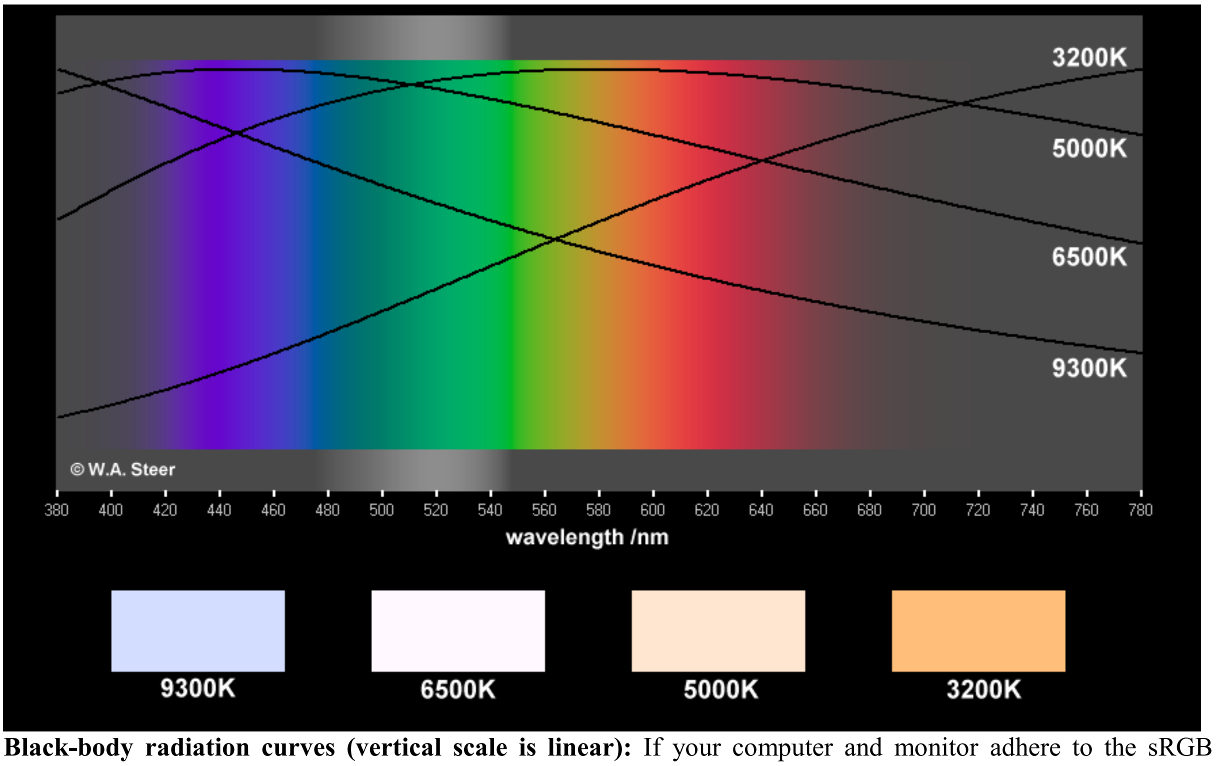
Color temperature

Source: http://www.techmind.org/color/coltemp.html

It is well known that when an object, such as a lump of metal, is heated, it glows; first a dull red, then as it becomes hotter, a brighter red, then bright orange, then a brilliant white. Although the brightness varies from one material to another, the color (strictly spectral distribution) of the glow is essentially universal for all materials, and depends only on the temperature. In the idealized case, this is known as 'black body' or 'cavity' radiation.

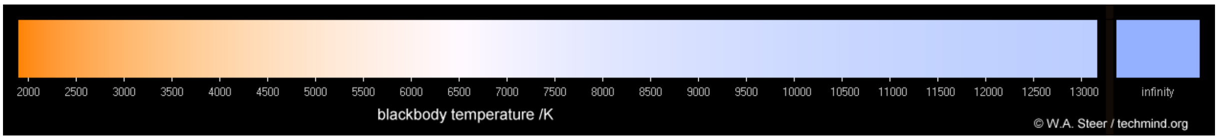
The figure below illustrates the relative amounts of energy at each wavelength across the visible spectrum, for a 'black body' at 3200K, 5000K, 6500K, and 9300K. Spectral distribution (including color) of the light from a quartz-halogen light bulb is similar to a black body source at 3200K. Light from the sun, measured in space, is close to black body radiation characteristic of temperatures around 5000-6500K.



Black-body radiation curves (vertical scale is linear): If your computer and monitor adhere to the sRGB specification (your monitor color-point should be set to 'sRGB' or '6500K') then the sample colors should be colorimetrically-accurate.

Due to absorption and scattering in the Earth's atmosphere, the solar spectrum at the earth's surface is modified somewhat depending on the time of day and weather conditions. On a clear day direct light from the sun will contribute the primary, highly directional, illumination, while the whole dome of the sky will contribute a diffuse blue ambient illumination. During a cold, frosty morning the scattered bluer components may be more dominant in defining the ambient illumination; perhaps counter-intuitively, this bluer light has a color approximating to a black-body at a higher temperature (e.g. 10000K).

Our eyes readily adapt not only to different levels of illumination (daylight vs. moonlight), but also to different tints in the color of light. A non-luminous object (such as a piece of paper) is objectively agreed to be 'white' if it reflects all colors (visible wavelengths) approximately equally, which means it takes on the color appearance of the ambient illumination. But unless we consciously think about it (or are photographers or color-scientists), most people are happy to regard illumination from regular filament light bulbs, sunlight (under varying conditions) and even fluorescent light as being 'white'! Colors which are generally 'acceptable' as 'white' are usually quite close to black body colors upwards of around 2500K. Consequently 'whites' for the purposes of graphics and photography are often specified in terms of a color-temperature.



Colors of black body sources: Note that it is not physically possible to accurately mimic blackbody colors cooler than 1900K on a standard sRGB (or Rec.709) monitor; the red primary of the display is not a deep enough red! As the temperature is increased beyond 10000K the color gradually converges towards a pale sky-blue, shown at the far right of the graphic as "infinity". I've included this color for completeness; it's of little practical significance since anything of such high temperature would be so blindingly bright as to make its color fairly irrelevant, also you'd be scorched by the ultraviolet radiation and X-rays.

Illuminants and color-constancy

Black body sources (approximately any filament bulb or sunlight - *but not fluorescent lamps, in general*) emit a smooth distribution of wavelengths across the visible spectrum, which means that our eyes and visual system can reliably distinguish colors of non-luminous objects. Subconsciously we adapt to differing bias in the illuminant color, and manage to perceive consistent colors in the artifacts we handle every day (food, clothes, etc) - despite wide variations in their absolute color.

Artificial sources of light, in particular discharge lamps (sodium, mercury, xenon) and fluorescent lamps can have extremely spiky spectral distributions, and this means that their **color rendering** properties are very poor (*even if* the overall perceived illuminant color is close to a blackbody color).

In professional lighting, a **Color Rendering Index, CRI** (sometimes written **Ra**) is often quoted to indicate how accurately that light will portray colors *relative to a blackbody source at the same nominal color temperature*. By definition, all blackbody sources have a CRI of 100. Fluorescent lamps typically have CRIs in the range 55-85, with 80-85 being classed by the manufacturers as 'good' or 'very good' color-rendering. I beg to differ! To my critical eyes, light from 'triphosphor' fluorescents with a CRI of 80-85 is ghastly; extremely flat and lifeless. By comparison, a nice incandescent quartz-halogen spotlight really gives vitality to whatever it shines on!