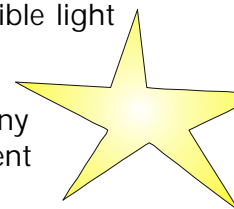


# SECONDARY ARTICLE: The Science Behind Glow-in-the-Dark Toys

You see them everywhere—glow-in-the-dark toys, decorations, even clothes. You probably know that they work by absorbing light and emitting it later. But what makes them different from other things that absorb light?

All glow-in-the-dark materials contain phosphors. A **phosphor** is a substance that radiates visible light after being energized. The two places where we usually see phosphors are in a television screen or computer monitor and in fluorescent light bulbs. In a TV screen, an electron beam strikes the phosphor to energize it. A color television screen actually contains thousands of tiny elements with phosphors that emit three different colors—red, green, and blue. In a fluorescent light, ultraviolet light energizes a mixture of phosphors that together create light that appears white to us.



Phosphors have three separate characteristics: the type of energy required to energize them, the color of the visible light they produce, and their **persistence**—the length of time they glow after being energized. A glow-in-the-dark product must have a phosphor that is energized by normal light and has a long persistence. Two phosphors that have these characteristics are zinc sulfide and strontium aluminate, which is the newer phosphor with a very long persistence.

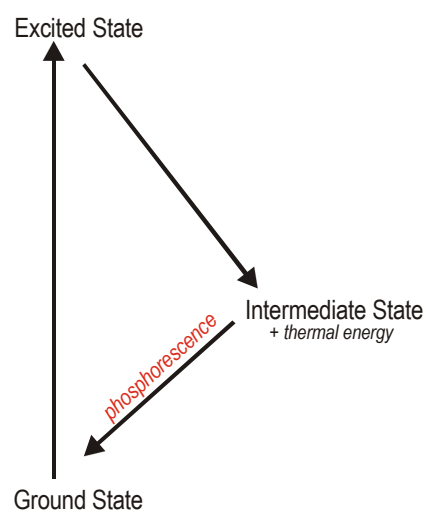


Glow-in-the-dark objects are **photoluminescent**—they are energized by light. Many materials are photoluminescent, but not all glow for a long period. Fluorescent materials glow as long as they are being energized, but stop glowing immediately when the energizing light is removed. **Phosphorescent** materials continue to glow after the energizing light is removed.

Substances that phosphoresce have electrons that are easily excited to higher energy levels when they absorb light energy. In phosphorescent materials—such as glow-in-the-dark objects—the excited electrons drop to a lower, but still excited intermediate level and stay there for a period of time before returning to their ground state (*original energy level*) and emitting the excess energy as visible light.

The return of the electrons to their ground state is temperature-dependent. A small amount of thermal energy (*heat*) is required to dislodge the electrons from the intermediate energy level and send them to their ground state. If the phosphorescent material is very cold—in liquid nitrogen, for example—the electrons cannot return to their ground state and the material will not glow.

Glow-in-the-dark objects are not excited only by visible light. Ultraviolet light, which is invisible to the human eye, is also within the range of wavelengths of light that is absorbed by the electrons of phosphors.



**EXPLORE:** Design and conduct experiments with a glow-in-the-dark object to answer the following questions:

1. Does the intensity of the light emitted by a glow-in-the-dark object depend on the intensity of the absorbed light?
2. Does the color of the light emitted by a glow-in-the-dark object depend on the color of the absorbed light?
3. Does the length of exposure to light have an effect on the length of time a glow-in-the-dark object emits light?
4. Which kind of light (incandescent, fluorescent, infrared, ultraviolet or black light) produces the highest intensity of emitted light from a glow-in-the-dark object?
5. Does the kind of light affect the persistence of the emitted light from a glow-in-the-dark object?
6. What effect does temperature have on the intensity and persistence of the emitted light (try using dry ice)?

(For a more in-depth exploration of the wave-particle nature of light and phosphorescence, see NSTA's April 2002 issue of *The Science Teacher*.)