Science Project: The Candle Illusion: Virtual Images

Mirrors are strange things. They're so common in our everyday lives that we often don't think of how interesting they really are. Somehow they take the three-dimensional world we live in and represent it so perfectly that we are fooled into thinking that another three-dimensional space exists behind the mirror! But why is this? Let's explore some of the special properties of mirrors and the light that makes them work.

Problem:

How do mirrors work? What is a virtual image?

Grade	**Middle School**
Subject	**Science** ◦ Physical Science

Materials:

- 2 Tea Candles
- Lighter
- Adult to light candles
- Transparent CD Jewel Case
- Dark Surface (black construction paper or a black t-shirt placed on a table works well)
- Dark Room

Procedure

1. With the lights on, prepare your dark surface.
2. Remove the album art from your CD case so that the hinged cover is now a transparent panel.
3. Using your dark surface, place the CD case on its side. Open the CD case at a 90 degree angle.
4. Take one tea candle and place it on one side of the CD case's transparent panel. Make sure you can see its reflection in the transparent part of the case. *In what position in space does the reflected image appear to be? Why do you think this is?*
5. Take the other tea candle and place it on the other side of the CD case's transparent cover. Line up this second candle so that it appears to be in the same apparent location as the reflected image of your first tea candle.
6. Move your head around while looking at the second tea candle through the CD case. *Can you see the reflection of the first tea candle? Does it ever not appear to be transposed over the real image of the second tea candle?*
7. Now, take a look at the orientation of the CD case and the tea candles from above. Note the position of the two tea candles. *What's special about their positions relative to the CD case's transparent panel? What's special about their positions relative to each other?*
8. Nudge the first Tea Candle away from the CD case slightly. *What happens to the reflection?*
9. Nudge the second Tea Candle to match the apparent location of the first tea candle's reflection.
10. Turn out the lights and light the tea candle located on the side of the transparent panel nearest you. Look at the reflected image. *What do you see?*
11. If you want to turn this into a great illusion for another observer, make sure they don't see how you set it up beforehand! Your observer should observe the illusion from the side of the transparent pane with the lit candle.

Touch the wick of the unlit candle on the opposite side of the panel with your hand. Your observer may be surprised that you don't burn yourself!

Results:

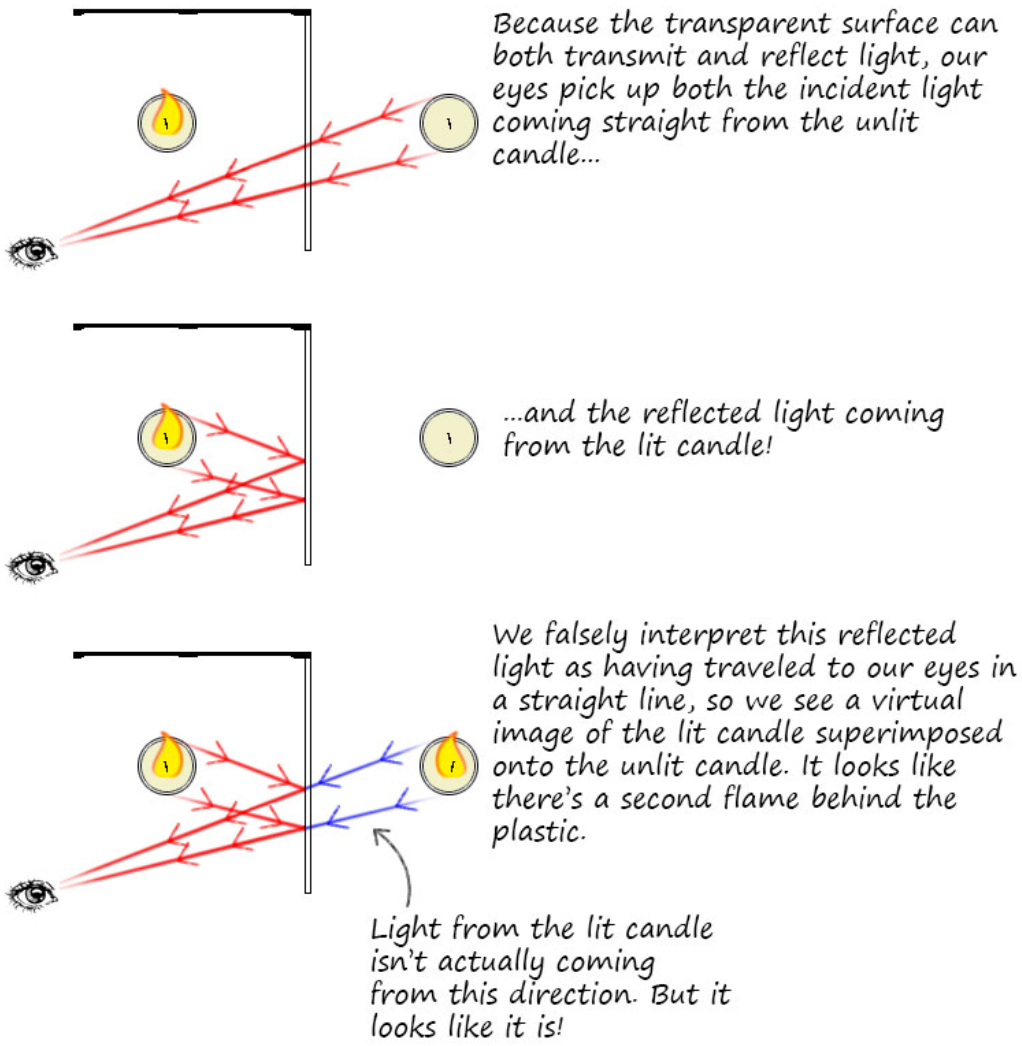
When you set up your experiment with the lights still on, the reflected image of your first tea candle looked like a second tea candle located somewhere behind the transparent panel.

When you placed a second tea candle behind the transparent panel to line up with the apparent location of the first tea candle's reflection, you should have noticed that both candles were in exactly the same place relative to the CD case's transparent panel. This phenomenon is known as **mirror symmetry**. When you change the position of your first candle relative to the CD case, its reflection changed its relative position as well, since the reflection you see is a **mirror image** of the real tea candle.

Now here's the fun part: when you lit the first tea candle, the second candle behind your transparent panel also looked like it was lit. So how come?

Why:

Transparent surfaces like the transparent panel on your CD case can both **transmit** light (allow light to pass through it) and **reflect** light (bounce light off of its surface).The illusion is created by a **virtual image** (created by reflected light) being transposed on top of a **real image** (created by transmitted light). Confused yet? Here's how it works:



Every surface exhibits some transmission and some reflection. For very transparent substances like glass, only about 10% of the light that hits it is reflected. The remaining 90% is transmitted—it passes right on through. When you light one

of the tea candles in a dark room, some of its light is transmitted through the CD case, and some of it is reflected. Even though the case can only reflect something like 10% of the flame's light, that reflected light is more than enough to create an illusion of two flames as opposed to one flame and one unlit wick.