BABATUNDE OGUNLADE: Hello, everyone. Today we're going to be working through Goodie Bag 5, which is on electronic materials, namely semiconductors. In order to follow along, you'll need a multimeter, a pair of alligator clips, some large LEDs-- I'll be using red, white, blue, and green-- and some regular sized LEDs. I'll be using red, blue, and purple.

Our main objectives today are to identify differently colored LEDs by irradiating them with light across the visible light spectrum. And in the process, to explore the relationship between the bandgap of a semiconductor and its critical absorption wavelength. As we work through the Goodie Bag, I'd like you to think about how the size of the bandgap of material may influence which wavelengths of light you can absorb. Let's get started.

First, connect your black or negative lead to the 10 amp port on the multimeter, and then your red or positive lead to the voltage ohm milliamp port. Then connect the probe end of each respective lead to one end of an alligator clip. After you do this, you should still have two free ends of the alligator clips.

Grab one of your small LEDs and connect the free end of the alligator clip connected to the red lead probe to the positive end of the LED. This is the longer leg of the LED. And then connect the other free end that's connected to the black lead probe to the negative end of the LED. That's the short leg of the LED.

Then turn on your multimeter and set the dial to 2,000 milli DC volts. This is the order of magnitude of voltage we'll measure across our small LEDs when we irradiate them with light from the larger LEDs. Finally, make sure to keep track of which small LED you're testing so that which LED to refer to when we start comparing data between small LEDs.

So now we have our small LED hooked up to our multimeter. And now we're going to shine each one of our large LEDs onto the small LED and record whether or not we have some non-zero voltage reading. If the large LED has enough energy to excite electrons across the bandgap of the small LED, we should see some non-zero voltage across the small LED.

So first I'm going to try and shine this blue light onto my small LED, and I'm going to look at the multimeter and try to see if there's some voltage drop. As you can see, our volt meter is now measuring some non-zero value, which means that this blue light has enough energy to excite electrons across its bandgap. After you've done this, repeat this for the other large LEDs, and then repeat the entire experiment for the other two small LEDs. This should generate a set of 12 data points. And using our knowledge of bandgaps and wavelength absorption, as well as the data that you've acquired, we're going to determine which small LED is what color.

So after running through your experiments, you should have some chart that looks like mine, where I have my small LEDs going down the side here and the large LEDs going across. So each square represents a time when a small LED he was irradiated by a large LED. And a check represents when a non-zero voltage was measured across the multimeter, and an x represents when there was a zero or very low voltage reading across the LED.

So in order to dig into what this means it's important to understand the balance of the visible light spectrum in terms of energy and wavelength. So if you remember the visible light spectrum, known wonderfully by the acronym ROYGBIV, where you have red on one end and you have violet on the other end, we know that red corresponds to around 700 nanometers in wavelength. And we know that violet or purple corresponds to around 40 nanometers of wavelength.

And if we think back to the relationship between the energy of light and its wavelength, we know that the formula is E equals hc over lambda. So as the wavelength of light decreases, the energy of light increases. So going across, as we go from red, green, blue, and white, we have increasing energy because we have decreasing wavelength.

And just as a reminder, white is a composite of red, blue, and green. So it has all three of these combined in it. So now let's start to identify which LED is what color.

So if you look at small LED 1, it was irradiated by red, green, blue, and white light. And there was a voltage drop across the LED for all of them. That means that at the very least, red had enough energy to excite electrons across the bandgap of that small LED. Because that's the case, and we know that we're dealing with LEDs which emit like in the visible light spectrum, we know that this small LED then must be red.

So if we look at small LED 2, we can see that both red and green light did not have enough energy to excite electrons across the bandgap of the second LED. But when we shined blue light onto the LED, we got a non-zero voltage drop. And the same thing when we shined white light, which also has blue light in it. Because, like I said at the beginning, we knew that our small these were red, blue, and purple, and we've already found our red LED, that means that this LED must be the blue.

So finally, if we look at small LED number 3, we can see that red, green, blue, and white light did not have sufficient energy to cause some voltage drop across the LED. If we look back to ROYGBIV, and we think about the energy of red to blue, that means that they didn't have enough energy to excite anything after it. And that means that our final LED must be violent or purple.

So by shining light across the visible light spectrum onto our small LEDs, we're able to identify which one of our small LEDs are what color. So right here I have small LED 1 hooked up to the multimeter. And we determined it was red. And so we can check that by just turning on the LED.

So as you can see, this LED is shining red, which means it's the red LED, and we're able to confirm that by using our data as well. You can check that the other two LEDs are the colors that we determined by doing the same thing. So today we looked at a direct application of semiconductors in LEDs.

We looked at the relationship between the bandgap of an LED, of a semiconductor, and the range of light that can absorb across its bandgap. We found that for semiconductors, there are some critical absorption wavelengths, some maximum wavelength, below which the LED will absorb all other wavelengths of light.