Commentary to accompany slides in SEM for STEM outreach presentation

Slide 1: Solicit assistance and feedback from students: I'm very new at the game of presentations to students like you. Please give me feedback on which parts of the presentation are useful and which need to be deleted or improved.

Please ask questions about anything you don't understand: I'd rather we only get through five slides on which you understand content than 40 slides of which you understand nothing.

Slide 2: Microscopes are a common tool in science

Interact: Who has used a microscope?

What did you look at?

How small were the things you could see?

What limits how small something can be and you could still see it with a microscope?

Slide 4: Imagine you are watching football from high in the stadium

The players on the field look really small

The "players" you see on the Jumbotron look much larger, as do those on your TV if you are watching from home.

But the "players" you see on the Jumbotron or your TV are not really players; they are representations of players

The images you see on the Jumbotron or TV are representations of a real object.

Slide 5: Who cares?

Interact: Why do you think it's important to be able to look at objects we can't see with the naked eye?

Solicit responses; give examples (next slides)

Slide 9: In addition to being able to see really small things, as we shall see later, the SEM has a much larger depth of field than an optical microscope and, by detecting x-rays, can give information about chemical composition.

Slide 10: In an optical microscope the magnification is simply defined to be the ratio of the image height to the object height. This is changed by moving the object with respect to the lens. (Point to each with laser while describing.)

Slide 11-12: How does the SEM work and how does it magnify an image? (Both rhetorical questions!)

Electrons are "boiled off of" a heated cathode, then accelerated by a large positive voltage to a high energy: 100 to 30,000 Volts. (Note that for comparison normal household outlets are 110 V.)

Using a series of electromagnetic lenses, the beam of electrons is focused to a very small area where the beam intersects the sample.

Another set of electromagnets moves the beam across a rectangular area on the sample. The technical term is "rastering' but it just means scanning the beam horizontally across the object, pixel by pixel, they stepping vertically from line to line.

A detector measures the electrical current coming off the sample at each pixel.

The brightness of a pixel on the monitor is proportional to the current into the detector when the beam is focused on the corresponding pixel on the object.

If the pixel on the sample corresponds to a hole in the material from which electrons cannot escape, the corresponding pixel on the monitor is dark. If the pixel on the sample corresponds to a heavy, conductive element from which many electrons are emitted, the corresponding pixel on the monitor will be bright.

Interpreting the bright and dark areas of the image on the monitor and relating them to the actual sample is why the operator gets paid the big bucks.

Slide 13: Does anybody recognize what this is? The image on the left is a fly's head; the image on the right is an area of the eye over which a much smaller area is being scanned; since both areas get displayed on the same size screen, the image on the right has a higher magnification.

Changing the magnification is simply a matter of telling the computer to change the area on the sample over which the beam is scanned or rastered.

Slide 27: The Utah Neural Array is approximately 5 mm square; the electrodes are about 1.5 mm tall. A long time ago I learned that the researchers who developed the Array had taught monkeys to play Pong. Do students still know what Pong is? Monkey plays Pong (with a mouse); monkey wins Pong game; monkey gets banana. (They could have used middle school students, but monkeys work cheaper.) Then they implanted the array in the monkey's brain. Now the monkey can sit back with folded arms and just think about how he would move the mouse to win at Pong and get his banana. To which you say: "For this my parents pay their hard-earned money in taxes?"

Slide 28: The Utah Neural Array signal drives the Utah Arm. This is quite useful if your arm was blown off by an IED in Iraq or cut off in a piece of farm machinery. The current state of the art is that a wearer of a Utah Arm can drink a can of Coke without crushing the can or spilling Coke all over the user.

Slide 30: Researchers in the U Metallurgy Department have developed a technology for water purification based on a titanium dioxide catalyst. SEM images are used for process control to assure that the nanopores are of the proper size and geometry to actually purify water. This technology is being used by backpackers in the US and individuals and villages in India where central purification facilities do not exist.

Slide 31: Note that these particles are about 100 nm in size. This is smaller than the wavelength of visible light. They cannot be seen at all in an optical microscope, let alone with the high resolution of this image.

Slide 36: This is the CEO of the company referred to a few slides back who uses her SEM for development and quality control on her water purification product.

Slide 37: Paolo demonstrates that you can make a very nice salary without having to wear a coat and tie!