Science Forward—Tools of Seeing

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Summer Ash: Take a look around you. With just our eyes and the light that they receive, we can see so much. We can see things that are very large and very small, and we can see things that are far away or right in front of our noses. In fact, a lot of scientific observation can be done with the human eye, with careful looking and close attention.

But sometimes scientists need to look at and study things we can't actually see. They might be things that are too tiny or too distant, or they might even be things that don't interact with visible light.

In this video, we'll talk to scientists who are using tools to see at new scales and in new ways.

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Summer Ash: Scientists are often looking for ways to improve the resolution of their observations. When we talk about how scientists use the term "Resolution," we're talking about the ability to perceive detail.

Here's an example. If you look at a group of stargazers who are very far away, like a few miles, you might see just an indistinguishable blob. You wouldn't be able to tell who they are or even how many of them are there. If you got closer, you might be able to see that there were five of them. Closer still, and you can see that three of them are children, one is elderly, and the last one is your friend Ethel. Even closer, and you can see Ethel is smiling. If you could get right up close, you could see Ethel has a piece of spinach caught between her two front teeth.

Getting closer is one of the things that optical tools like microscopes and telescopes help us to do. They make faraway things appear closer and clear, and small things appear bigger and brighter. So you can see with a microscope that piece of spinach is actually made up of separate cells with separate parts. Or, going in the other direction with the telescope, you can see that one of the bright lights up in the sky is really two separate stars -- a binary system.

We visited Bill L'Amoreaux at the Advanced Imaging Facility at the College of Staten Island.

Summer Ash: What takes place here at the Advanced Imaging Facility?

Bill L'Amoreaux: We have a motto that is essentially we make small things big and bright. We have one transmission electron microscope, a scanning electron microscope, an atomic force microscope, and a confocal microscope, in addition to all sorts of other types of support equipment.

Summer Ash: What kinds of scientists end up using these machines?

Bill L'Amoreaux: It's easier to say "What kind of scientist does not," but we have chemists, we have biologists, we have physicists, we have geologists. If you're an -ist at the end, you pretty much can use these instruments.

Most people measure in inches and yards. We measure in not even millimeters, but microns and nanometers. Pretty small.

Summer Ash: Microns? Nanometers? How small are we talking about?

Bill L'Amoreaux: Meters, generally if you think about that, is a yard. If we take a thousandth of that, that's a millimeter. If you take a thousandth of that, that's a micrometer. If you take a thousandth of that, that's a nanometer. If you take a thousandth of that, that's a picometer. We got a bunch of zeroes at the end of our one over, so we're getting down really, really small.

Again, an angstrom, which is a tenth of a nanometer, is the size of a hydrogen molecule. My rule of thumb, if we're talking millimeter size, you can see it. If we're talking about micrometer size, you're not going to be able to see it with your eyes.

Summer Ash: Scientists sometimes find looking at things that are not visible with our eyes, we can learn much more than we thought.

Karin Block: I had absolutely no interest in mineralogy until I started to look at rocks in thin sections. When I started looking at rocks that were sliced into 30 micrometer thin sections that are mounted onto a microscope slide, I was very surprised to find out that you could derive the pressure and temperature history just from the mineral assemblages that exist in those rocks.

Summer Ash: It's not just rocks. What do you do when you need to not just look at but actually manipulate something very tiny, like the venom duct of a cone snail?

Mande Holford: We're magnifying what we see in the animal. In the dissecting microscope there's a plate, and you're looking through ocular lenses that you can adjust at different scales to work effectively and efficiently to dissect the gland as quickly as you can.

Juliette Gorson: Like I said, the venom duct in these snails is incredibly, incredibly small. We actually have to use microscopes in the field, and tiny scissors and tiny forceps to actually do the dissecting.

Summer Ash: With microscopes, scientists can study and even sometimes interact with things that are just too tiny to see. But they often use another kind of scope, the telescope, to study things that are hard to see for another reason -- because they're so far away.

Charles Liu: I study distant galaxies.

Summer Ash: How distant?

Charles Liu: My galaxies aren't that distant. They're only a few billion light years away. Since a light year's only six trillion miles or so, we're only talking a few billion, trillion miles away from Earth.

If you could imagine that with telescopes and observatories that are carefully designed and calibrated, along with their cameras and other instrumentation that's provided, we can look at things that have only 0.000000001 percent the amount of light reaching the earth as the faintest stars we can see with our unaided eye. We can see now the importance and the power of using telescope technology.

Summer Ash: It's not just about distance. Astronomers also use telescopes to see relatively close objects that are hard to see because they don't emit much light.

Emily Rice: The objects that I study, these low mass stars, these brown dwarves, and these exoplanets are...they're small in astrophysical terms. Because they're so faint, we can't actually see them very far away. Most of the objects that we can see are within a few hundred light years or so.

In order to get a spectrum of a brown dwarf, we need a telescope. The bigger the telescope the better, because with the bigger the telescope we can see a fainter object in a relatively small amount of time.

Summer Ash: When you go to telescopes to do observing, what do you actually do when you get there?

Emily Rice: Sometimes we actually get to go to the telescope, but sometimes we don't even have to go to the telescope. Sometimes you can log into Skype and operate the telescope remotely too. That's fun. You can really observe with a telescope anywhere that you have Internet access.

Summer Ash: These days, astronomers aren't just observing visible light anymore.

Emily Rice: We also want a telescope that works fairly well on infrared.

Summer Ash: What's so special about infrared light?

Emily Rice: The infrared light is longer wavelengths than our eye can see, so these brown dwarves are hardly visible at visible wavelengths. They hardly radiate at all. Then they're much brighter at infrared wavelengths.

Summer Ash: So there are infrared telescopes, but that's not all.

Charles Liu: When we started astronomy, we desperately clung to whatever photons we could get onto our photographic plates, and we hoped and prayed that the skies would allow us to do that.

Nowadays we can go up above the clouds with our space telescopes. We can use technology to look through clouds – radio telescopes. It's an amazing time to be an astronomer. We're learning about the universe at a rate that couldn't have been imagined even just a few years ago.

It's a perfect example of how using multi-wavelength technology, from the radio through visible light all the way through x-rays and gamma rays, gives us a more complete picture of how the universe works. Every single piece of information from all these different things collapse together, or cycle in and out, and they create something that we can really understand the physics, not just guess, but really know what is doing what at what time, when, where, and how.

Summer Ash: Microscopes and telescopes, among other tools of seeing, give scientists deeper understanding and more information to work with. But something else happens too. When scientists use tools to bring distant things closer and clear, or make small things bigger and brighter, they find…beauty.

Bill L'Amoreaux: I was an undergraduate student at Arkansas State University, and we had a guest speaker come in who was showing these absolutely gorgeous images from a transmission electron microscope. He was showing us tick salivary glands. As a result of that, I fell in love with the pictures, and then found out that I really loved doing the work.

Karin Block: A thin section of a rock actually reveals a tremendous amount of information and beauty that you would never expect. That was something that captured my interest and my imagination, and I couldn't get enough of it. I still can't.

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Transcription by CastingWords