Fall 12-16-2017

Unseen Science: Modern Discoveries Too Far Away or Tiny for Human Eyes

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When two astrophysicists at the University of Geneva saw signs of an unknown planet the size of Jupiter in 1994, they weren't peering through a high-powered telescope, as generations before them had done. Michel Mayor and Didier Queloz were scouring through data from a spectrometer, a machine sensitive enough to pick up subtle light changes up to 150 light-years away.

For millennia, scholars have studied the night sky. The ancients picked out Mercury, Venus, Mars, Jupiter and Saturn. Galileo built the first telescope in 1608, and from then on, lens technology became ever more sophisticated, enabling German astronomer William Herschel to discover Uranus in 1781.

The French mathematician Urbain Le Verrier predicted that gravity from a further planet was tugging at Uranus, creating its unaccountably slow orbit. On September 18, 1846, he sent his calculations to the German astronomer Johann Galle and Galle's student Heinrich Louis d'Arrest, who used them, first to locate Neptune, and then to find it five days later through a telescope viewfinder.

That was the last time astronomers used a telescope to discover a planet--even now-discredited Pluto was identified with the help of math. In the early 1990s, when astronomers began looking for planets circling other stars (known as exoplanets because they exist outside our solar system) the most advanced telescopes were useless because the distances were just too vast.

Exoplanet hunters were like the wildlife photographers who track reclusive red pandas or jaguars, using signs the animals leave behind. Instead of droppings and footprints, though, these experts examined the light patterns that planets make.

Both planets and the stars they orbit have their own forces of gravity. These interact, changing the wavelengths of light emitted by the star. The push and pull of the orbiting planet produces a pattern of short and long wavelengths instead of the constant light that the star would otherwise emit.

The first exoplanet ever found was the one that Mayor and Queloz identified in 1994. It was 50 light-years away, in the Pegasus constellation, and they named it 51 Pegasi b. This discovery triggered a boom in planet hunting, and astronomers began developing additional non-visual methods for detecting exoplanets, including measuring the amount of light a star emits as an exoplanet eclipses it.

NASA soon decided to invest $550 million in its own exoplanet-hunting program. The agency's goal was to find exoplanets that are similar to Earth, in hopes of finding signs of extraterrestrial life. In 2009, NASA launched the Kepler spacecraft, equipped with a camera and spectrometer. Kepler has identified 5,118 potential exoplanets, hundreds in the past year alone.

This explainer video illustrates the two main ways in which astronomers look for planets too

distant to be seen through a telescope lens.

Computational biologist Ekta Khurana of Weill Cornell Medical College in New York also makes unseeable discoveries, though she doesn't focus on huge, faraway objects, as Mayor and Queloz do. Instead, she examines tiny molecules that are very close by--indeed, they're inside the human body.

Khurana studies segments of human DNA that until not long ago were considered worthless. Human genetic material is packaged into chromosomes, densely packed strings of DNA residing inside the nucleus of each of our cells. Parts of these DNA bundles are genes--the instructions to make the molecules our bodies need to function. However, in between the genes are long segments of DNA whose purpose is unknown. Scientists nicknamed these spans "junk DNA." But when, 17 years ago, geneticists learned that this so-called "junk DNA" makes up roughly 98 percent of chromosomes, they realized it must be good for something.

Scientists now refer to it as "noncoding DNA." Khurana and others believe that it can act as an on/off switch for genes, telling them when to be active and when to lay low. Khurana and her team have been investigating the noncoding DNA in cancer cells to see whether mutations there drive these cells to act abnormally. To do this, they compare identical sequences of noncoding DNA in cancer cells and healthy cells taken from the same person.

The individual molecules that make up DNA are known as nucleotides. There are four varieties --adenine, thymine, guanine, and cytosine--referred to in scientific shorthand as A, T, G and C. Each chromosome contains millions of these four nucleotides, strung together like beads in a necklace. The order of the nucleotides is critical, because it determines what that segment of DNA is able to do. Although the most powerful microscopes are capable of visualizing molecules, looking at each nucleotide through a microscope would be tedious. So scientists instead "read" the letters of DNA using a technique known as "sequencing."

To sequence DNA, scientists make copies of it using fluorescent nucleotides. Unlike normal nucleotides, the fluorescent ones have a tag that is designed to break off and cause a flash of light whenever that nucleotide joins the chain. Each of the four nucleotide types has a distinctive flash which can be detected by a machine called a sequencer. As the new DNA strands are assembled, flashes of light occur each time another nucleotide is added to the string of DNA. The sequencer records all the flashes and then produces a computer readout of the full code of the final sequence.

When Khurana and her team have sequenced noncoding DNA from both the cancerous and the healthy cells, they use a computer program to pick out every difference, of even a single nucleotide. These differences are known as mutations--changes to the healthy DNA. Next, the team considers which genes these mutations might affect.

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Listen to this podcast to learn about one type of non-coding DNA that might hold the key to future cancer treatments.