The elements of life mapped across the Milky Way by SDSS/APOGEE

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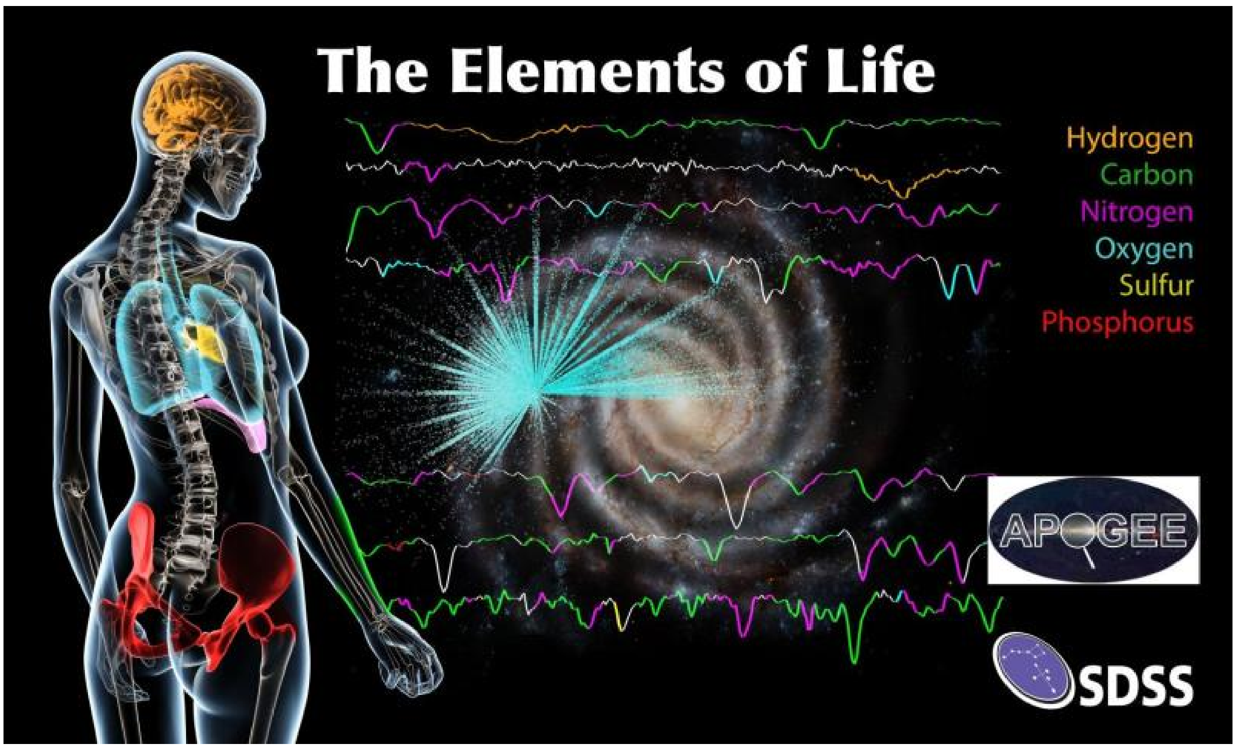

The six most common elements of life on Earth (including more than 97% of the mass of a human body) are carbon, hydrogen, nitrogen, oxygen, sulphur and phosphorus. The colors in the spectra show dips, the size of which reveal the amount of these elements in the atmosphere of a star. The human body on the left uses the same color coding to evoke the important role these elements play in different parts of our bodies, from oxygen in our lungs to phosphorous in our bones (although in reality all elements are found all across the body). In the background is an artist's impression of the Galaxy, with cyan dots to show the APOGEE measurements of the oxygen abundance in different stars; brighter dots indicate higher oxygen abundance. Credit: Dana Berry/SkyWorks Digital

Inc.; SDSS collaboration

To say "we are stardust" may be a cliche, but it's an undeniable fact that most of the essential elements of life are made in stars.

"For the first time, we can now study the distribution of elements across our Galaxy," says Sten Hasselquist of New Mexico State University. "The elements we measure include the atoms that make up 97% of the mass of the human body."

The new results come from a catalog of more than 150,000 stars; for each star, it includes the amount of each of almost two dozen chemical elements. The new catalog includes all of the so-called "CHNOPS elements" – carbon, hydrogen, nitrogen, oxygen, phosphorous, and sulfur – known to be the building blocks of all life on Earth. This is the first time that measurements of all of the CHNOPS elements have been made for such a large number of stars.

How do we know how much of each element a star contains? Of course, astronomers cannot visit stars to spoon up a sample of what they're made of, so they instead use a technique called spectroscopy to make these measurements. This technique splits light – in this case, light from distant stars – into detailed rainbows (called spectra). We can work out how much of each element a star contains by measuring the depths of the dark and bright patches in the spectra caused by different elements.

Astronomers in the Sloan Digital Sky Survey have made these observations using the APOGEE (Apache Point Observatory Galactic Evolution Experiment) spectrograph on the 2.5m Sloan Foundation Telescope at Apache Point Observatory in New Mexico. This instrument collects light in the near-infrared part of the electromagnetic spectrum and disperses it, like a prism, to reveal signatures of different elements in the atmospheres of stars. A fraction of the almost 200,000 stars surveyed by APOGEE overlap with the sample of stars targeted by the NASA Kepler mission, which was designed to find potentially Earth-like planets. The work presented today focuses on ninety Kepler stars that show evidence of hosting rocky planets, and which have also been surveyed by APOGEE.

While the Sloan Digital Sky Survey may be best known for its beautiful public images of the sky, since 2008 it has been entirely a spectroscopic survey. The current stellar chemistry measurements use a spectrograph that senses infrared light – the APOGEE (Apache Point Observatory Galactic Evolution Experiment) spectrograph, mounted on the 2.5-meter Sloan Foundation Telescope at Apache Point Observatory in New Mexico.

Jon Holtzman of New Mexico State University explains that "by working in the infrared part of the spectrum, APOGEE can see stars across much more of the Milky Way than if it were trying to observe in visible light. Infrared light passes through the interstellar dust, and APOGEE helps us observe a broad range of wavelengths in detail, so we can measure the patterns created by dozens of different elements."

The new catalog is already helping astronomers gain a new understanding of the history and structure of our Galaxy, but the catalog also demonstrates a clear human connection to the skies. As the famous astronomer Carl Sagan said, "we are made of starstuff." Many of the atoms which make up your body were created sometime in the distant past inside of stars, and those atoms have made long journeys from those ancient stars to you.

While humans are 65% oxygen by mass, oxygen makes up less than 1% of the mass of all of elements in space. Stars are mostly hydrogen, but small amounts of heavier elements such as oxygen can be detected in the spectra of stars. With these new results, APOGEE has found more of these heavier elements in the inner Galaxy. Stars in the inner galaxy are also older, so this means more of the elements of life were synthesized earlier in the inner parts of the Galaxy than in the outer parts.

While it's fun speculate what impact the inner Galaxy's composition might have on where life pops up, we are much better at understanding the formation of stars in our Galaxy. Because the processes producing each element occur in specific types of stars and proceed at different rates, they leave specific signatures in the chemical abundance patterns measured by SDSS/APOGEE. This means that SDSS/APOGEE's new elemental abundance catalog provides data to compare with the predictions made by models of galaxy formation.

Jon Bird of Vanderbilt University, who works on modelling the Milky Way, explains that "these data will be useful to make progress on understanding Galactic evolution, as more and more detailed simulations of the formation of our galaxy are being made, requiring more complex data for comparison."

"It's a great human interest story that we are now able to map the abundance of all of the major elements found in the human body across hundreds of thousands of stars in our Milky Way," said Jennifer Johnson of The Ohio State University. "This allows us to place constraints on when and where in our galaxy life had the required elements to evolve, a sort 'temporal Galactic habitable zone'".

The catalog of chemical abundances from which these maps were generated has been publicly released as part of the Thirteenth Data release of the SDSS, and is available freely online to anyone at www.sdss.org .

Provided by Sloan Digital Sky Survey