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Planet Hunters: The Search for Earthlike Worlds

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Planet Hunters

The Search for Earthlike Worlds

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In late August 2016, the European Southern Observatory published a paper in the journal *Nature* announcing that they had discovered a new exoplanet. Under normal circumstances, this likely would have been written off as a mild footnote, as the successful Kepler missions had already confirmed more than 1,000 exoplanets over its nearly 8 year lifetime. However, this newly found exoplanet was discovered orbiting the star Proxima Centauri, the closest star to our solar system. This means that, at a mere 4 light years away, the exoplanet known as Proxima Centauri b, or Proxima b is the closest exoplanet to our Earth that has ever been found, and likely ever will be found. As if that weren't exciting enough, Proxima b is believed to lie within its host star's habitable zone, the orbital region around a star in which a planet could support liquid water on its surface. Could this mean that Earth's twin is residing within our own cosmic backyard?

To comprehend the significance of this discovery, it is important to understand what exoplanets are, how they are detected, and what we currently know about Proxima b and its star. In the official definition by the International Astronomical Union, a celestial body is a planet if it orbits the sun, is sufficiently massive such that gravity has molded it into a sphere, and its orbital path is clear of debris of comparable size. If we modify the first part of the definition to consider objects orbiting other stars, we arrive at the definition of an exoplanet.

Since planets are much dimmer and smaller than their host stars (our sun, for example, is approximately 1 billion times brighter than Jupiter and about the width of 10 Jupiters or 100 Earths laid end to end), it can be difficult or impossible to detect exoplanets through typical means of telescope observation. However, many exoplanet search efforts, including Kepler, have found ways to use both a star's brightness and mass to their advantage.

One of the most common observing methods, and the one used by Kepler, is known as the transit method. As the name suggests, this method relies on observing stars as exoplanets pass between them and our telescopes. As the transit occurs, the star will experience a dip in its overall brightness along our line of sight, which can then be used to infer the size of the transiting object we are observing. If the data reveals a long trend of such dips that occur at even intervals, then astronomers can be confident that their observations indicate the confirmation of an exoplanet. The accumulation of many observations of this dip in brightness can also help determine the period of the exoplanet's orbit. Another benefit of this method is that light passing through a transiting exoplanet's atmosphere can provide astronomers with a spectrum that details the atmosphere's composition and whether the exoplanet may be able to support life.

The method that was used to find Proxima b is known as the radial velocity (or wobble) method. In a many-bodied system like a solar system, the planets don't actually orbit the star, but rather both the star and the planets orbit the system's center of mass. In many cases it just so happens that the mass of the star is such a significant percentage of the system's total mass that the system's center of mass tends to be located somewhere within the star itself. Because of this effect, during the planet's orbit, the gravitational interactions between a planet and its host star will cause that star to wobble in its own orbit around the system's center of mass. Over time, the spectral lines that we observe in the star's light as it reaches our telescope will be shifted up and down the star's spectrum as the wobble precesses. This information can then be used to determine the change in the star's velocity relative to us over time and as a result, the approximate mass of the exoplanet and its distance from its star.

Based on the information astronomers have learned about Proxima Centauri through analyzing its spectrum, they were able to conclude that Proxima b was between one and three times the mass of Earth and was within Proxima Centauri's habitable zone. This means that the closest star to ours could have a life-supporting planet. As of the publication of this issue of *The Synapse*, Earth is the only planet in the observable universe that has been confirmed to harbor life of any kind. That being said, there are numerous other celestial bodies both inside and outside our solar system that likely have the capacity to do so as well. Even one of our closest neighbors, the planet Mars, despite its thin carbon dioxide atmosphere and scarce traces of potable water, may have harbored life in the past and could presently have microscopic organisms living a few feet beneath its surface.

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That being said, just because a planet orbits within a star's habitable zone, it does not mean that it is necessarily habitable. Venus is within our own sun's habitable zone, yet its atmosphere is almost completely composed of carbon dioxide and has a surface pressure more than 90 times that of Earth. There are likewise many factors that have led astronomers to conclude that it is unlikely that Proxima b has the capacity to sustain life.

The star that Proxima b orbits is a type of star known as a red dwarf. These stars are typically less than half the mass of the sun, much dimmer, and likely live for around a trillion years (over 100 times longer than our sun). It would seem like this would provide more than enough time for live to evolve and sustain itself. However, red dwarfs typically have very violent solar winds, meaning that any atmosphere Proxima b had would easily be stripped away, releasing gases that are crucial for life into space and exposing any life to deadly ionizing radiation. Additionally, Proxima b might orbit so close to Proxima Centauri that it could be tidally locked, meaning that the same side of the planet is always facing its star. In systems like this, the side facing the star would be perpetually hot and the opposite side would be perpetually cold, meaning that life might only be able to survive along a thin border between the two sides. For these reasons, it is unlikely that we would find life on Proxima b were we to explore it.

While the search for Earth's twin appears to not be over just yet, it may be sooner than we think. Thousands of exoplanets have already been confirmed and around 30 of those have been confirmed to be within their stars' habitable zones. Using available data, one can extrapolate that over 11 billion Earth-sized planets orbit within their stars' habitable zones in just our galaxy. With so many possible candidates, it's only a matter of time before we find our first home away from home.