Astrobiology News for May 2013: Planets, Planets, Everywhere!

Our Sun is one of roughly 400 billion stars in the Milky Way Galaxy. The Milky Way Galaxy, in turn, is one of hundreds of billions of galaxies, many with comparable numbers of stars, in the observable part of the Universe (the Universe itself may be infinite in extent). How many of these stars might have orbiting planets as our Sun does? Might any of these planets harbor life? The question of whether life exists elsewhere in the cosmos is not new to philosophy or religion, and it has certainly been a popular topic of science fiction; however, during the past few decades, it has become ever more possible to explore this question through science. Increasingly, it looks like planets may accompany most stars! The implications of what we're learning about these *extrasolar planets* (aka *exoplanets*) for finding worlds that are, like Earth, abodes of life, are enormous.

For over 25 years, my own research has focused on how stars form. During this time, we have gathered a wealth of observational evidence to support what theory has predicted for many years – that planets form as a natural consequence of the star-formation process. Hypotheses regarding the formation and evolution of our Solar System date back to the 18th century. Although these hypotheses differ in important details, they share some common elements. In these scenarios, the Sun and its planets formed from a spinning gaseous cloud that flattened out as it was pulled together by gravity. The Sun formed at the center of the cloud, and the planets and other small bodies formed in an extended "disk". This basic model explains various observational features of the Solar System, particularly why the planets and Sun are nearly coplanar, why the planets all orbit the Sun in the same direction, and why the planets mostly rotate in the same direction.

Of course, at the time these hypotheses were first proposed, there was no way to test them. Even today, we can't run time backwards to observe the formation of our Solar System, although we can get clues from studying its composition and dynamics. We can also use technology to search for examples of ongoing star and planet formation elsewhere in the cosmos. Thanks to the development of sensitive infrared detectors and radio telescopes, we have discovered many complex organic molecules – the building blocks of life -- in the vast clouds of gas and dust (*nebulae*) in which new stars and planetary systems form, and we have been able to peer into the dusty cocoons that enshroud the early stages of star formation to piece together important details of the star- and planet-building processes.

As we've learned many of the details of how stars and planets form, we have also used a variety of different methods to discover hundreds of planets orbiting relatively "nearby" stars. NASA's *Kepler* mission has been particularly prolific in this regard. *Kepler* is a space observatory that has been monitoring the brightnesses of hundreds of thousands of stars located in a rich part of the Milky Way to search for and record small dips in the light output of stars when orbiting exoplanets transit (pass across our line of sight to their stars). In addition to the hundreds of exoplanets that have been discovered, *Kepler* has established a list of thousands of

candidate exoplanets that are being subjected to a rigorous vetting process and follow-up observations to confirm them as bona fide exoplanets. Over the next few months, we'll explore the diversity of exoplanetary systems, what statistics are telling us about the frequency of different types of exoplanets, and the exciting question, what makes a planet habitable?

Finally, I'd like to invite all of you – regardless of your background in science – to help us search for exoplanets and learn more about how stars form. Check out *Planethunters* and *The Milky Way Project* in the *Zooniverse* suite of online citizen science projects (www.zooniverse.org). These projects facilitate "big science" that can be accomplished only through crowdsourcing many human eyes (or, in some cases, ears). *Zooniverse* is developed and maintained by the *Citizen Science Alliance*, which includes Oxford University and the Adler Planetarium as two of the leading institutions (www.citizensciencealliance.org). You can find projects in many different areas of science and social science in *Zooniverse* – there should be something of interest for everyone!

Until next month,

Grace Wolf-Chase, Ph.D.

SUGGESTED RESOURCES:

(1) The Extrasolar Planets Encyclopaedia: exoplanet.eu
This is the most comprehensive database of exoplanets, including research groups, techniques and methods of detection, and information on all confirmed exoplanets and their stars.

(2) NASA's Kepler mission: kepler.nasa.gov

(3) The *Astrobiology Primer* presents an overview of the diverse research topics in Astrobiology. You can access it under "SPOTLIGHT" on the NASA Astrobiology page: astrobiology.nasa.gov
Although this document is intended primarily for scientists who work in different fields, it is also a good resource for those who have a general science background and want to learn more about Astrobiology.