Astrobiology News January 2014:
"Superhabitable" Worlds

Last July, we explored the question, what makes a planet habitable? Much of the discussion focused on the concept of a *Habitable Zone* (HZ) around a star, where a planet could sustain liquid water on its surface. We considered various factors that suggest this concept might be too narrow for many reasons, including the fact that life pervades extreme environments on Earth. This month, there's been a lot of discussion on the Internet over a recent controversial article that appeared in the journal *Astrobiology*[1]. The authors of this article suggest that scientists have been too focused on Earth-like planets as the basis for considering habitability, and that Earth itself may be only marginally habitable by the standards of the Universe. Coining the term *superhabitable* to describe environments more benign to life than Earth, they come up with an extensive list of characteristics that might make a world superhabitable. The paper was published as a Hypothesis Article, since the intent of the authors is to spark conversations and investigation rather than to reach solid conclusions (rather like the purpose of the CLP).

Whether or not a planet that has more of what is needed for life is actually more likely to harbor life, is an open question of course, but several of the conditions the authors propose as conducive to supporting life are currently amenable to observational scrutiny, or will be in the near future. We can't examine all the factors they explore here, but we'll focus on a few of them. The authors conclude that worlds which are 2-3 times more massive than Earth, slightly older than Earth, and which orbit stars known as K dwarfs[2], are the best candidates for superhabitability. They suggest these should be prime targets for future follow-up observations for signs of extraterrestrial life.

Terrestrial planets that are 2-3 times more massive than Earth are thought to have longer tectonic activity and a carbon-silicate cycle that is active on a longer timescale. These planets could retain more massive atmospheres, which would provide better shielding against cosmic and stellar high-energy radiation, and decrease the temperature contrast between night and day. They would possess larger, smoother surfaces (due to higher gravity), allowing for more shallow seas. Because the greatest biodiversity is seen in shallow seas and along coastlines on Earth, the authors suggest that a world with less water, which is distributed in many seas and lakes rather than a single large ocean, would be superhabitable. Additionally, although the presence of liquid water is crucial, dryer planets will have a wider HZ because they are more resistant to experiencing a moist or runaway greenhouse effect at the inner edge of the HZ, and they can absorb more heat from their stars and stay warmer at the outer edge of the HZ. Earth itself is thought to be located on the inner edge of the HZ in our Solar System.

Curiously, statistics provided by NASA's Kepler mission indicate that *super-Earths* may be more common than Earth-sized worlds. Super-Earths are worlds that are 1.25 – 2

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[1] Heller, R. & Armstrong, J. 2014, *Astrobiology*, Vol. 14, #1, 50-66

[2] K dwarfs are stars that have longer lifetimes than the Sun, and are slightly less massive, dimmer and cooler.

times larger than Earth --- there are no analogs for worlds this size in our Solar System. If super-Earths have densities similar to the Earth, many would fall in the mass range suggested by the authors.

When NASA launches the James Webb Space Telescope[3] in 2018, it will help scientists characterize the atmospheres and compositions of planets orbiting other stars. As it happens, the closest stellar system to our Solar System harbors a K dwarf star known as Alpha Centauri B. At a distance of just over 4 light years, Alpha Centauri B is part of a binary star system. Alpha Centauri A and B orbit a common center of mass at an average distance that's comparable to the separation between the Sun and Uranus. A third star, Proxima Centauri, may or may not be gravitationally bound to this system. An Earth-sized planet orbits Alpha Centauri B with a period of just a few days – far too close to the star to be habitable, but not precluding the existence of other planets further away from the star that might be more hospitable!

Update on the February 18, 2014 *Clergy Contributions to Science* event at the Adler Planetarium in Chicago: Our not-quite-coincident-with *Evolution Weekend* event is shaping up wonderfully! Participants will enjoy several behind-the-scenes tours, including artifacts from the Webster Institute for the History of Astronomy collections and the Space Visualization Lab, where we have the known Universe at our fingertips (at least virtually). Afternoon presentations will include *Doing Science as a Member of the Clergy* (Br./Dr. Guy Consolmagno SJ, Vatican Observatory), *Standing in Awe* (Rev. Bruce Booher, Pastor, First Lutheran Church of Plano, IL), *Teaching Astronomy Off the Grid* (Revs. Chuck & Sue Ruehle, founders of Telescopes to Tanzania), *Teaching Religion and Science across the Seminary Curriculum* (Dr. Lea Schweitz, Lutheran School of Theology in Chicago) and *Leading Science and Religion Study Groups in Churches* (Rev. Dr. Phil Blackwell, Senior Minister, First United Methodist Church at the Chicago Temple). Due to limited space in our event venues and the need to reserve tickets, we have to set a cap on the number of participants. Spaces are filling quickly, but as of now, I am still able to take registrations. Please email me directly for more information or to register (gwolfchase@adlerplanetarium.org).

Regardless of whether you can join us at the Adler Planetarium, I encourage you to check out Adler's social media outlets near the time of the event. These can be accessed directly from our home page (www.adlerplanetarium.org). In particular, look for a podcast with Drs. Lea Schweitz and Terrance Baeder, faculty members at the Lutheran School of Theology in Chicago, who will discuss the mission of the Zygon Center for Religion and Science, explore the impetus behind *Teaching Religion and Science across a Seminary Curriculum*, and address the impact of these efforts on asking "larger questions" and finding common ground between religion and science.

Until next month,

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[3] http://www.jwst.nasa.gov/