

# Astrobiology

at the University of Washington



## Planets & Life

*A Newsletter of the Center for Astrobiology and Early Evolution*

*Issue #13 December 2008*

### *Welcome!*

Welcome to our newsletter of information and ideas in the fast-growing field of Astrobiology. We are committed to ensuring that our broad community of interested people is kept informed about our research and education into life in extreme environments on Earth, and potentially on other solar system bodies and beyond. For more information, check out the video featuring our 2006 annual Astrobiology Program field trip to Yellowstone National Park (available on our home page at <http://depts.washington.edu/astrobio>). This four-minute presentation also describes research and curriculum highlights of our Astrobiology Program.

#### **PLEASE SUPPORT OUR UW ASTROBIOLOGY PROGRAM**

Our Graduate Certificate Program in Astrobiology is training a new breed of scientist, grounded in a traditional discipline, yet with knowledge and experience transcending the boundaries of traditional discipline-based investigation.

Look inside this newsletter to read about some of the exciting research being conducted by our graduate students.

Your generous donations will directly benefit our graduate students through fellowship and research support. Please consider making a tax-deductible donation through our secure on-line giving site.

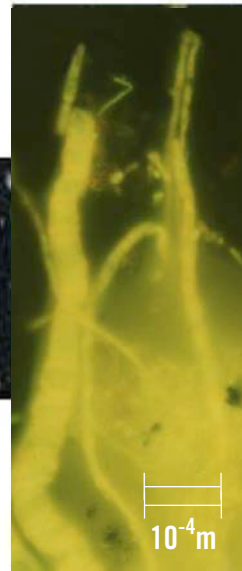
For more information, visit <http://depts.washington.edu/astrobio/give/>



*Star formation from interstellar gas and dust*



*Submarine hydrothermal vent*



*Microorganisms from hydrothermal vent*

## Looking for Answers to a 385-million-year-old Mystery

*Kelly Hillbun, Graduate Student (1st yr), Earth & Space Sciences/Astrobiology*

Extinction is a natural and inevitable part of evolution; it makes way for new species, and it also reminds us that life is vulnerable. Throughout the history of Earth, life has in fact endured several extinction events, five of which are termed mass extinctions due to their causing drastic decreases in biodiversity. Scientists understand the cause for one of these events (the asteroid that wiped out the dinosaurs and about half of all other species 65 million years ago), but four mass extinctions remain a mystery. These events have clearly played a major role in the history of life on Earth. By understanding them better, we astrobiologists can search more knowledgeably for possible life that may have endured similar catastrophes on Earth-like planets orbiting other stars.

The so-called late Devonian Mass Extinction of about 370 million years ago is one of the mass extinctions with no consensus amongst the experts as to its cause. It was unusual in that it spanned ~15 million years and may have eliminated as many as 75% of all marine species. Organisms such as corals and sponges were particularly devastated. Proposed hypotheses include rapid changes in atmospheric carbon dioxide, global warming, sea level rise, meteor impact, a combination of these mechanisms...or perhaps something else entirely. No hypothesis, however, accounts well for the sharp decline in biodiversity, the preferential loss in shallow marine organisms, and the relatively long duration of the extinction event.

But what if our mass extinction actually had two distinct parts, with a precursor extinction that took place 15 million years before the other? This hypothesis proposes a one-two-punch scenario: first, a rise in sea level and

associated rise of toxic bottom waters killed the majority of marine life; then, the surviving but weakened species became doomed by events such as rapid climate change, meteor impact, or extensive volcanism. Recent worldwide fossil data does show that extinction rates for many species were actually higher 385 million years ago than they were 370 million years ago.

This past summer I was fortunate to begin field work searching for answers to this unexplained disaster. In the Western Australian outback I collected samples and mapped the geology of well exposed and highly preserved Devonian rocks, which we could identify as an ancient reef system comparable to the modern-day Great Barrier Reef, but today ~200 miles inland. At one of our field sites, my advisor Professor Peter Ward and I discovered 385-million-year-old fossil corals and rocks that showed signs of harsh, low-oxygen conditions in shallow marine waters. Together with similar evidence during this time period found elsewhere in the world, our one-two-punch idea is strengthened.

Thanks to the support of the Astrobiology Program and the Department of Earth and Space Sciences, this past October I was able to present this research at the annual Geological Society of America conference in Houston, Texas. There I talked with coral reef experts and developed partnerships for future research projects. I'm hoping to return to Australia next summer to further test our one-two-punch hypothesis and eventually unravel why so many species disappeared in such a relatively short time, and what this extinction tells us more generally about how life evolves over billions of years.



*Kelly Hillbun and Prof. Peter Ward  
on the hot and dry, 385-million-year-old  
“Great Barrier Reef” in Western Australia.  
Image credit: Kelly Hillbun*

## Viewing Earth as if it were a Planet Orbiting Another Star

Nick Cowan, Graduate Student (5th yr), Astronomy/Astrobiology  
Ty Robinson, Graduate Student (3rd yr), Astronomy/Astrobiology

NASA's Terrestrial Planet Finder (TPF) is an astrobiology mission designed to search for Earth-like planets orbiting other stars, so-called extrasolar planets, and then analyze the composition of their atmospheres. Planned for a decade from now, it will allow us to find vital clues as to whether the atmospheric gases look propitious for life or not. For example, if we were to find both methane and oxygen in a planetary atmosphere, as occurs on Earth, it would be very difficult to explain this without the presence of biological processes on the planet. We know of no geological processes that alone can continuously produce both of these gases, whereas in Earth's atmosphere the oxygen comes from photosynthesis by plants and the methane primarily from microbial life (as in "swamp gas").

TPF's great technical problem, however, is that an Earth-like extrasolar planet is so small and so distant that it appears as only as a faint, single pixel next to its bright star (Fig. 1). Thus TPF employs a large telescope in space that can gather the weak light from the planet while blocking out the far brighter starlight. Once it has done this, it can record a spectrum of that light, splitting it into its constituent wavelengths and searching for specific wavelengths that are indicative of oxygen, methane, water vapor, carbon dioxide, etc.

In order to design TPF, why not look at the spectrum of Earth from a great distance and use it as a possible template? This has just been done with the EPOXI mission, which has cleverly "borrowed" normally idle instruments on a spacecraft whose destination in two years is Comet Hartley 2. While most of EPOXI's time is being devoted to monitoring known extrasolar planets that cross in front of their host stars, on three occasions its small telescope looked back at Earth for a full day at a time (Fig. 2).

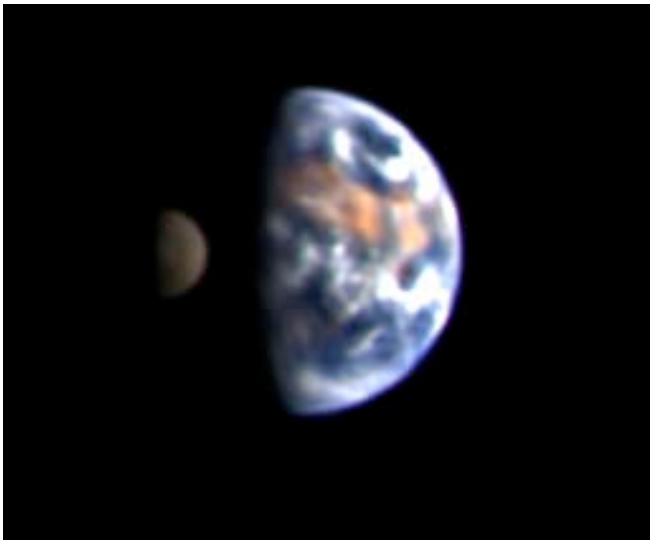


Figure 1: The famous "Pale Blue Dot" photograph taken by the Voyager 1 spacecraft looking back at Earth in 1990 from a distance of about 6 billion kilometers. We see Earth as would an observer on a distant planet orbiting another star; a single blue pixel obscured by a swath of scattered sunlight. Voyager, however, was not able to record the detailed spectrum of Earth as did the EPOXI mission. [Image Credit: NASA]

By observing the full disk of Earth for an entire rotation on several days, EPOXI was the first mission to measure daily and seasonal variations as they would appear to a distant extrasolar observer. The new visible and infrared data for Earth give us a model for what an extrasolar planet might look like with TPF. At the UW we are now studying the daily variations in total reflected light from Earth, in order to determine the positions of continents, clouds and oceans around the planet, as well as the variability of Earth weather systems. We are also analyzing the distribution of vegetation on Earth by mapping the "red edge" in Earth's spectrum, caused by an abrupt jump (at a wavelength of about 700 nm) in how well plants reflect light. EPOXI spectra of Earth's atmosphere also reveal both methane and oxygen, indicative of life. Furthermore, the larger area of land in Earth's northern hemisphere leads to a hemispherical imbalance of certain gases generated by life, which we hope to detect. The data from the EPOXI mission is just beginning to arrive, so keep your eyes out for more exciting results within the next six months!

Figure 2: An image of the Moon transiting the Earth as seen from the EPOXI spacecraft. For a great movie showing the rotating Earth and orbiting Moon, visit <http://epoxi.umd.edu>. [Image Credit: NASA]

## What's New in the UW Astrobiology Program

*Prof. Woody Sullivan, Astronomy/Chair, Astrobiology Steering Group*



Woody Sullivan

Many exciting things have happened in the Astrobiology Program over the past year. Our graduate students continue to be among the very best in their departments – see the two articles in this newsletter for examples of great research they're doing. Last spring, at the annual Astrobiology Conference near NASA Ames Research Center in California, our students Nate Kaib (Astronomy) and Aaron Goldman (Microbiology) received two of the top four prizes for best student papers; their papers investigated how an excess of comets in the early solar system may have pummelled Earth and Mars, and how proteins have evolved and led to different "family trees" of microorganisms over life's history. Altogether we have 27 students (and several postdoctoral researchers) now in the Program, based in the Departments of Astronomy, Biology, Earth & Space Sciences, Microbiology, and Oceanography. Upon receiving their Ph.D.'s with a Certificate in Astrobiology, our students are finding great jobs in academia and NASA – one example is Steve Vance, who just took a position at NASA's Jet Propulsion Lab in Pasadena. Steve's thesis work was on modelling possible hydrothermal vents on the floor of the ocean beneath the icy surface of Jupiter's moon Europa. If they exist, then by analogy with Earth's hydrothermal vents, microbial life might thrive there, too.

Our graduate-level textbook *Planets and Life* (2007), edited by Prof. John Baross (Biological Oceanography) and myself (Astronomy) and including many chapters by UW authors, is also selling well and spreading the UW philosophy of training graduate students to stretch well beyond their specialized disciplines in order to generate new interdisciplinary concepts and synthesize existing ideas. Finally, on the recruiting side, last year we held a week-long experience in astrobiology aimed at minority undergraduate science majors, with the goal of showing

them the world of graduate school studies.

On the faculty side, together with the Astronomy Department, we were able last year to hire from Caltech Professor Vikki Meadows. Vikki is one of the premiere astrobiologists in the country, known for her Virtual Planetary Lab (VPL) consortium. VPL, now headquartered at the UW, combines experts from atmospheric sciences, astronomy, geology, and biology with the goal of understanding exactly what the spectrum of an Earth-like planet would be as seen from, say, a hundred light-years away. The future NASA mission called Terrestrial Planet Finder aims to measure spectra of Earth-like planets orbiting other stars, and Prof. Meadows's lab is laying the groundwork for the design of this mission (see the related article in this Newsletter). And we're eagerly anticipating the arrival next March of Prof. David Catling, who left UW for a few years in his native England, but now returns to the Earth & Space Sciences Department and the Astrobiology Program. Prof. Catling has been one of the scientists working on NASA's Phoenix mission, which landed in the north polar region of Mars last May and for five months scooped up the soil and ice for detailed chemical analysis, analyzed the atmosphere, and photographed its surroundings. A primary goal of this mission is to understand the chemistry of the Martian soil now and in the past, so as to investigate the possibility that it could have been inhabited by Martian microbes. The next Martian rover, called Mars Science Lab, is to be launched in 2009, and will have specifically astrobiological experiments on board. Roger Buick (Earth & Space Sciences), another of our Astrobiology faculty, is on the landing site selection committee for this mission.

Overall, we see a bright future for Astrobiology as a new way of thinking and synthesizing the sciences in the twenty-first century. We are committed to maintaining our acknowledged leadership (number one in the country) in astrobiology graduate education.

### Astrobiology Program Participants

#### *Graduate Students (a = affiliate)*

Rika Anderson, Oceanography  
Loren Ballanti, Biology  
Jeff Bowman, Oceanography  
Billy Brazelton, Oceanography  
Regina Carns, Earth & Space Sciences (a)  
Michele Cash, Earth & Space Sciences  
Jesse Colangelo-Lillis, Oceanography  
Eric Collins, Oceanography  
Kyle Costa, Microbiology  
Nick Cowan, Astronomy  
Marcela Ewert, Oceanography  
Samantha Ewing, Earth & Space Sciences  
Clara Fuchsman, Oceanography  
Jessica Garvin, Earth & Space Sciences  
Aaron Goldman, Microbiology  
Jelte Hammeijer, Earth & Space Sciences  
Kelly Hillbun, Earth & Space Sciences  
Nathan Kaib, Astronomy  
John Kirkpatrick, Oceanography  
Praveen Kundurthy, Astronomy  
Andrew Opatkiewicz, Oceanography  
Nicholas Pinel, Microbiology  
Makenna Reeves, Earth & Space Sciences (a)  
Tyler Robinson, Astronomy  
Linda Sauter, Microbiology

David Smith, Biology  
Darci Snowden, Earth & Space Sciences  
Sanjoy Som, Earth & Space Sciences  
Eva Stueeken, Earth & Space Sciences

#### *Postdoctoral Associates*

Rory Barnes, Astronomy (January 09)  
Mark Claire, Astronomy  
Shawn Domagal-Goldman, Astronomy  
Julien Foriel, Earth & Space Sciences  
Robin Kodner, Oceanography  
Graciela Matrajt, Astronomy  
John Wisniewski, Astronomy

#### *Faculty (a = affiliate)*

Eric Agol, Astronomy  
Joshua Bandfield, Earth & Space Sciences (a)  
John Baross, Oceanography  
Mike Brown, Earth & Space Sciences  
Don Brownlee, Astronomy  
Adam Bruckner, Aeronautics & Astronautics  
Roger Buick, Earth & Space Sciences  
David Catling, Earth & Space Sciences (March 09)  
John Delaney, Oceanography (a)  
Jody Deming, Oceanography  
Joe Felsenstein, Genetics

Richard Gammon, Chemistry/Oceanography  
Allen Gillespie, Earth & Space Sciences  
Erika Harnett, Earth & Space Sciences (a)  
Debbie Kelley, Oceanography  
John Leigh, Microbiology  
Alex Mamishev, Electrical Engineering  
Vikki Meadows, Astronomy  
David Montgomery, Earth & Space Sciences  
Kristi Morgansen, Aeronautics & Astronautics  
Jim Murray, Oceanography (a)  
Bruce Nelson, Earth & Space Sciences  
Maresi Nerad, (IGERT) College of Education  
Tom Quinn, Astronomy  
Ram Samudrala, Microbiology (a)  
David Stahl, Civil & Environmental Engineering/Microbiology  
Jim Staley, Microbiology  
Woody Sullivan, Astronomy  
Laurenz Thomsen, Intl. Univ., Bremen, Germany (a)  
Peter Ward, Biology  
Steve Warren, Atmospheric Sciences/Earth & Space Sciences  
Dale Winebrenner, Earth & Space Sciences/APL (a)  
Robert Winglee, Earth & Space Sciences

#### *Staff*

Nancy Quense, The Graduate School