Research and Scholarly Activities

My current research interests include: (1) the microbial geochemistry of the subseafloor biosphere; (2) the production, transport, and export of organic carbon within and from MOR hydrothermal systems; (3) the geomicrobiology of hydrothermal plume systems; (4) particle dynamics, especially the process of aggregation and the role of aggregates in material transport; and (5) arsenic removal from contaminated drinking water. Essentially all of my present and planned future research projects involve strong interdisciplinary collaboration. I am also particularly interested in the development of in situ sensors and related instrumentation for the detection and quantification of chemical proxies of biological activity. This interest in interdisciplinary research into life in extreme environments and the development of instrumentation to enable such research has led to my involvement in astrobiology (6).

Many colleagues, former and present postdocs (Mimi Bertram, Laura Pietro Galvez, Brian Glazer) and graduate (Mimi Bertram, Chuck Holloway, Xiyuan Wen, Rachel Shackelford, Phyllis Lam, Yves Plancherel, Courtney Fritz, Cyrus Khambatta) and undergraduate (Naomi Okazaki, Sherell Watanabe, Howard Chan, Harvey Llantero, Wendy Smith, Carolyn Berger, Diana Quatch, Kristin Mailheau, Eddie Nassar and others) students and technicians (Andy Berger, Don McGee, and) and specialist Dale Hebel have made all of the research possible and their contributions are deeply appreciated.

(1) Subseafloor Life: The existence of an extensive subseafloor biosphere associated with the hydrothermal circulation occurring within sediment-buried basement on ridge flanks is contentious; yet because the magnitude and implications of such a community is potentially so dramatic it is currently subject to intense discussion and growing research. Efforts to test subseafloor biosphere hypotheses are obviously problematic due to the severe inaccessibility of this environment. Consequently, my research in this area involves three closely related areas: i) advancements in the quality of access to this environment, including instrumentation development; ii) microbial (tracer) transport; and iii) microbial geochemical studies. This is a relatively new research direction for me and much of my effort to date has been devoted to ‘i’; the phases represented by ‘ii’ and ‘iii’ are just now funded and ready to start.

i) I have been actively working with a team of excellent hydrogeologists from UCSC (Andy Fisher), RSMAS (Keir Becker) and the Geological Survey of Canada (Earl Davis) who pioneered the development of **ODP** borehole Circulation Obviation Retrofit Kit (CORK) observatories. These CORK observatories offer an unprecedented opportunity to study biogeochemical properties and microbial diversity in fluids circulating within aging ocean basement. In the late 1990s, I led an NSF-supported team that demonstrated that fluids escaping from the top of the over-pressured ODP borehole (CORK) 1026B, on the flanks of the Juan de Fuca Ridge (JFR), are derived from the oceanic basement and that the chemical characteristics and temperature (65^{o}C) of these fluids are conducive to microbial growth (Cowen et al. 2003). However, questions remained in our minds as to the integrity of the samples with respect to contamination from CORK materials (e.g., iron casings). Subsequently, our previous work (and active lobbying) resulted in the incorporation of new, biogeochemically-friendly materials and dedicated microbiological fluid delivery lines in the new generation of CORK observatories installed.

In addition, I obtained separate funding for (1) the development of a down-hole instrument for uncontaminated sampling and incubation of basement fluids for microbial diversity and metabolism studies (NSF-Microbial Observatories SGER grant; PI Cowen; coPI Craig Taylor, WHOI) and (2) for the development, construction and field testing of the ‘GeoMICROBE sled’ (GeoMicrobial In situ CORK Research Observatory for Biosphere Experiments sled) (NOAA-Ocean Exploration grant; PI Cowen;

coPI B. Glazer). The GeoMICROBE is capable of making in situ geochemical measurements concurrent to in situ filtrations at the seafloor by utilizing the CORK observatory fluid delivery lines.

ii) NSF-ODP has recently provided initial science funding for a large scale tracer transport study ["*Collaborative Research: A three-dimensional, subseafloor, IODP observatory network in the northeastern Pacific Ocean, and initiation of large-scale, cross-hole experiments Tracer transport study" (PI: Andy Fisher, UCSC; coPIs Becker, Clarke, Cowen, Davis, Jannasch and Wheat).* This project complements the two-leg IODP drilling expedition led by Andy Fisher, to the flanks of JFR (Leg 1 completed in 2004; Leg 2 scheduled for 2008), for which I am also an active proponent. I am intimately involved as the resident microbial geochemist. My interests in this transfer transport project are multifold: a) I will be studying the transport of 'microbial cell' tracers (e.g., fluorescent microspheres and stained microorganisms) through the basement environment over spatial scales of 10s of meters to several km, and temporal scales of hours to years; b) the results of the experiment will shed light on flow rates and substrate exchange rates, with important implications for microbial activity; c) the multi-year project is high profile within IODP and requires long-term monitoring and yearly submersible visits, and therefore offers many opportunities for parallel studies.

iii) I am also leading a team of colleagues from UH (Cowen, B. Glazer, M. Rappe), OSU (S. Giovannoni), and Washington U. (J. Amend) that has recently been awarded with 5 years of NSF funding (NSF-Microbial Observatories; PI Cowen) to fully exploit the unprecedented opportunities provided by the new generation of long-term IODP borehole-CORK observatories installed on the flanks of the Juan de Fuca Ridge. We will be studying the sediment-buried basement microbial community structure in the context of its geochemical and physical conditions by utilizing the new generation Fluid Delivery Systems (FDS) and our newly developed/tested 'GeoMICROBE Sled'. We will employ in situ geochemical instrumentation, energetics modeling and a range of molecular biology/culture, and inorganic and organic geochemical analytical techniques while maintaining close collaboration with ongoing hydrogeological and geochemical studies. This study will formally start in March 2007.

Representative related publications:

Fisher, Andrew T., Tetsuro Urabe, Adam Klaus, C. Geoff Wheat, Keir Becker, Earl Davis, Hans Jannasch, Sam Hulme, Mark Nielsen, Derryl Schroeder, Richard Dixon, Tom Pettigrew, Robert Macdonald, Robert Meldrum, Martin Fisk, James Cowen, Wolfgang Bach, Katrina Edwards, and the IODP Expedition 301 Scientific Party (2005). IODP Expedition 301 installs three Borehole crustal observatories, prepares for three-dimensional, cross-hole experiments in the Northeastern Pacific Ocean. **Scientific Drilling, 1**:6-11.

Fisher, A. T., Wheat, C. G., Becker, K., Davis, E. E., Jannasch, H., Schroeder, D., Dixon, R., Pettigrew, T. L., Meldrum, R., Macdonald, R., Nielsen, M., Fisk, M., Cowen, J., Bach, W. and Edwards, K. (2005) Scientific and technical design and deployment of Long-term, subseafloor observatories for hydrogeologic and related experiments, IODP Expedition 301, eastern flank of Juan de Fuca Ridge, *In* A.T. Fisher, T. Urabe, and A. Klaus et al., **Proc. ODP, Expedition 301, College Station, TX (Integrated Ocean Drilling Program).**

Kenig F., Simons D.-J.H., Ventura G.T. , Crich D., Cowen J.P., Rehbein-Khalily T. (2005) Structure and distribution of branched-alkanes with quaternary carbon atoms in Cenomanian and Turonian black shales of Pasquia Hill (Saskatchewan, Canada). **Organic Geochemistry 36, 1**, 117-138

Cowen, J.P. (2004) The Microbial Biosphere of Sediment-Buried Oceanic Basement. **Research in Microbiology 155/7**: 497-506

Kenig, F., Simons, D.-J. K., Crich, D., Cowen, J.P., Ventura, G.T., Rehbein-Khalily, T., Brown, T.C. (2003). Branched aliphatic alkanes with quaternary substituted carbon atoms in modern and ancient geologic samples. **Proceedings of the National Academy of Sciences** (PNAS) **100**, no. 22, 12554-12558.

Cowen, J.P., S. Giovannoni, F. Kenig, H.P. Johnson, D. Butterfield, M. Rappe, M. Hutnak, and P. Lam (2003). Microorganisms in Fluids from 3.5 m.y. Ocean Crust. **Science** 299, 120-123.

Johnson, H.P., M. Hutnak, R.P. Dziak, C. Fox, I. Urcuyo, J. Cowen, J. Nabelek, and C. Fisher, . (2000). Earthquake-induced changes in a hydrothermal system on the Juan de Fuca mid-ocean ridge. **Nature** 407: 174-177.

2. The Production, Transport, and Export of Organic Carbon Within and From Hydrothermal Plumes: Nowhere is the connection between the geophysics of earth's interior and the geochemical, biological, and physical processes of the ocean more direct than at mid-ocean ridge crests and sites of mid-plate volcanism. Hydrothermal venting and resultant hydrothermal plumes provide the most dramatic linkages between the geophysical processes controlling crustal accretion and the flux of energy and mass to the overlying waters. A graphic example of cross-plume boundary transport of energy was strongly suggested by R. Thomson's multi-year observations of an intense non-benthic zooplankton concentration in an acoustic scattering layer immediately above the top of the laterally spreading hydrothermal plume at Endeavour Ridge. This and other independent observations led to our hypothesis that epi-plume zooplankton were exploiting organic-carbon sources derived from hydrothermal systems; and because there is a deficit of zooplankton abundance within the plume we proposed that access to the organic-C source is provided in part via an ascending particle flux. Project objectives included the measurement of the relative flux and composition of ascending versus descending particles, the distribution of aggregate-sized particles in relation to conventional hydrographic plume data (CTD-transmissometry), and in inventorying the organic-carbon production potential within the Endeavour Segment hydrothermal plume waters.

I have been funded by several NSF grants to study these and related phenomena at the intermediate spreading Endeavour Segment (Juan de Fuca Ridge-Northeast Pacific), the superfast spreading rate Southern East Pacific Rise (~17-21^{o}S) and the sedimented ridge system in Guaymas Basin. These studies were in collaboration with colleagues at IOS (Canada; R. Thomson), PMEL-NOAA (E. Baker, B. Lavelle), Skidaway Institute of Oceanography (S. Wakeham), Florida International University (R. Jones, now U. of Portland), the Japanese RidgeFlux Project (T. Urabe, J. Ishibashi), and UH (B. Popp). Future work in this area will hopefully include more detailed, simultaneous time-series measurements of dissolved and particulate organic carbon flux and plume physical parameters.

Representative publications

Bertram, M.A., J.P. Cowen, R.E. Thomson, and R.A. Feely (2002). Compositional variability in the ascending and descending fluxes from a hydrothermal plume. **J. Geophys. Res-Oceans 107: 3181-3190**.

Wakeham, S.G., J.P. Cowen, B.J. Burd, and R.E. Thomson (2001) Lipid-rich ascending particles from the hydrothermal plume at Endeavour Segment, Juan de Fuca Ridge. **Geochim. Cosmochim. Acta**. 65: 923-939

Cowen, J.P., M. Bertram, S. Wakeham, R.E. Thomson, J.W. Lavelle, E.T. Baker, and R.A. Feely (2001). Ascending particle flux from a hydrothermal plume: biogeochemical linkages with the upper water column. **Deep Sea Research I 48(4):1093-1120**.

(3) Geomicrobiology of Hydrothermal Plumes/ MOR Event Detection and Response: The roots of this research actually go back more than 20 years. My early work in this area emphasized the role of bacteria in the scavenging of dissolved manganese from seawater from the perspective of the impact of this microbial activity on the Mn geochemical cycle. This led to my focus on hydrothermal plumes. Deep-sea hydrothermal vents inject enormous amounts of reduced chemical species, including Mn^{II}, into the bottom water, where background levels of these constituents are generally low and constant, providing an excellent natural laboratory. My interests have naturally expanded to include other potentially important functional groups of microorganisms, especially regarding in situ organic-C production (e.g., ammonia and methane oxidation). It has also progressed in the direction of microbial population dynamics. The nature of hydrothermal plume formation and their subsequent development in relative isolation from further intense inputs, results in a unique opportunity to study the response of microbial populations to rapidly changing conditions in a deep-sea environment. Systematic changes in microbial geochemical processes and population structure are observable as young neutrally-buoyant hydrothermal plumes mature. Over the past 20 years I have been funded, primarily by NSF, but also NOAA (PMEL and NURP) to study various aspects of these parameters at the Juan de Fuca and Gorda Ridges, the Southern East Pacific Rise and Guaymas Basin.

Time Critical Studies: Our serendipitous encounters with two "event plumes" (sudden massive releases of enormous amounts of hydrothermal fluid associated with mid-ocean ridge magmatic events) in 1986/87 opened up a dramatic new opportunity. 'Event plumes' provide a unique deep-sea geomicrobial experimental system, analogous to warm or cold-core rings of surface waters. "Event plumes" are formed quickly (hours to days) and appear to be identifiable for months to years. Since NOAA-PMEL first obtained real-time access (in 1993) to the US Navy's SOSUS data we have been able to remotely monitor seismicity along the Juan de Fuca and Gorda Ridges (NE Pacific). As a community we are still learning how to interpret the seismicity signals detected by SOSUS (see Dziak et al. 2006); however, this capability has allowed the community to detect and rapidly respond to 7 MOR tectonic and magmatic events in the last 13 years. I have been very close to the planning, development and promotion of what has become known within the 'RIDGE' community as 'Event Detection and Response', and is one of the primary Themes of the RIDGE2000 program ('Time Critical Studies'). I chair the TCS committee and have been the lead PI on the NSF-funded multi-institutional, interdisciplinary grants to achieve and maintain maximum readiness for immediate response to future unpredicted mid-ocean ridge events; among other key objectives the project exploits the SOSUS system and an interdisciplinary approach to study the geochemistry and microbiology of evolving event plumes. I have been Chief Scientist on 5 NSF-supported rapid response cruises to the Juan de Fuca Ridge, Gorda Ridge and East Pacific Rise. Most recently (May 2006), we responded to a likely seafloor eruption at the 9^{o} 51' North EPR where we were able to confirm a very recent seafloor eruption and extensively sample the new lava and the overlying water column. In addition to the exciting science this expedition stimulated the follow-up cruise (June 2006) with the deep submergence vehicle, *DSV Alvin*. The results from these response and follow-up cruises have been truly exciting and tremendously informative with respect to mid-ocean ridge processes; and have received much positive attention from the science community and NSF, as well as the general non-scientific community.

Representative Publications (Geomicrobiology of hydrothermal plumes and 'event-detection and response'

Cowen, J.P., D. J. Fornari, T. M. Shank, B. Love, B. Glazer, A. Treusch, C. Holmes, S.A. Soule, E. T. Baker, M. Tolstoy, K.R. Pomraning (Accepted pending final revision). Volcanic Eruption at the East Pacific Rise Near 9° 50'N. **EOS**

Dziak, R.P., D.R Bohnenstiehl, J.P. Cowen, E.T.Baker, , J.H. Haxel, M.J. Fowler, K. Rubin (In Review). Rapid dike emplacement leads to dramatic hydrothermal plume release during seafloor spreading events. Geology.

Tolstoy, M., J. P. Cowen, E. T. Baker, D.J. Fornari, K.H. Rubin, T.M. Shank, F. Waldhauser, D.R. Bohnenstiehl, D.W. Forsyth, R.C. Holmes , M.R. Perfit, R.T. Weekly, B. Glazer (2006). A Seafloor Spreading Event Captured by Seismometers. **Science**

Dziak, R., Cowen, J.P., Embley, R., Baker, E.T., Chadwick, W., Bohnenstiehl, D. (2006). Lessons learned from 12 yrs of detection and response. **EOS 87** no. 4, p. 37, 42; January 24, 2006.

Cowen, J.P., E.T. Baker, and R.W. Embley (2004). Detection of and Response to Mid-ocean ridge magmatic/tectonic events: implications for the subsurface biosphere. In: **RIDGE Theoretical Institute: The SubseaFloor Biosphere at Mid-Ocean Ridges**; Edited by: W. Wilcock, C. Cary, E. DeLong, D. Kelley, and J. Baross. Geophysical Monograph Series, Volume 144, 408 pages, ISBN 0-87590-409-2

Lam, P., Cowen, J.P., and Jones, R. (2004). Autotrophic ammonia oxidation in a hydrothermal plume. **FEMS Microbiology and Ecology 47**, 191-206**.**

Lam, P. and Cowen, J.P. (2004). Sampling deep-sea particle –rich water for fluorescence in situ hybridization. **Applied and Environ. Microb**. **70**, 25-33

Cowen, J.P., X. Wen, B.N. Popp (2002). Methane in Aging Hydrothermal Plumes. **Geochim. Cosmochim. Acta 66: 3563-3571**

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Johnson, H.P., M. Hutnak, R.P. Dziak, C. Fox, I. Urcuyo, J. Cowen, J. Nabelek, and C. Fisher, . (2000). Earthquake-induced changes in a hydrothermal system on the Juan de Fuca mid-ocean ridge. **Nature** 407: 174-177.

Bertram, M.A. and J.P. Cowen (2000) Diagenesis of ferromanganese crusts: chemical and biological alteration of artificial substrates on Cross Seamount. **SEPM (Society for Sedimentary Geology) Special Publication** No. 65: Marine Authigenesis: From Global to Microbial, C.R. Glenn, L. Prévôt-Lucas and J. Lucas, eds.

Cowen, J.P., R. Shackelford, D. McGee, E.T. Baker, P. Lam, E.J. Olson (1999) Microbial biomass in the hydrothermal plumes associated with the 1998 Axial Volcano eruption. **Geophys. Res. Letters**. 26: 3637-3641.

Feely, R.A., E.T. Baker, G.T. Lebon, J.F. Gendron, J.A. Resing, and J.P. Cowen (1999) Evidence for sulfur enrichment in hydrothermal particles at Axial Volcano. **Geophys. Res. Letters** 26: 3649-3653.

Baker, E.T., C.G. Fox, and J.P. Cowen (1999) In situ observations of the onset of hydrothermal discharge during the 1998 submarine eruption of Axial Volcano, Juan de Fuca Ridge. **Geophys. Res. Letters** 26: 3445-3449

McLaughlin-West, E.A., E.J. Olson, M.D. Lilley, J.A. Resing, J.E. Lupton, E. T. Baker, and J.P. Cowen (1999) Variations in hydrothermal methane and hydrogen concentrations following the 1998 eruption at Axial Volcano. **Geophys. Res. Letters**. 26:3453-3457.

Cowen, J.P. and E.T. Baker (1998). The 1996 Gorda Ridge event detection and response activities: historical perspective and future implications. **Deep-Sea Research** II. 45: 2503-2512.

Cowen, J.P., M.A. Bertram, E.T. Baker, G.J. Massoth, R.A. Feely, and M. Summit (1998) Geomicrobial Transformation of Manganese in Gorda Ridge Event Plumes. **Deep Sea Research** II 45: 2713-2738.

Cowen, J.P., X. Wen, R.D. Jones, and R.E. Thomson. (1998) Elevated NH4+ in neutrally-buoyant hydrothermal plume: Endeavour Segment, Juan de Fuca Ridge. **Deep-Sea Research** I 45: 1891-1902.

Lupton, J.E., E.T. Baker, N. Garfield, G. Massoth, R. Feely, J.P. Cowen, R. Greene, T. Rago (1998) Tracking the evolution of a hydrothermal event plume using a RAFOS neutrally-buoyant drifter. **Science** 280: 1052-1055.

Gendron, J.F., J.P. Cowen, R.A. Feely and E.T. Baker (1993). Age estimate for the 1987 Megaplume on the Southern Juan de Fuca Ridge using excess radon and manganese partitioning. **Deep-Sea Research** 40: 1559-1567.

Cowen, J.P. (1991). Individual particle analyses. In: Marine Particles: Analysis and Characterization; **Geophysical Monograph** 63: 429-436.

Cowen, J.P. and Y.-H. Li (1991). The influence of a changing bacterial community on trace metal scavenging in a deep-sea particle plume. J. **Marine Research** 49: 517-542.

Cowen, J.P., G.J. Massoth and R.A. Feely (1990). "Scavenging rates ofdissolved manganese in a hydrothermal vent plume". **Deep Sea Research** 37: 1619-1637.

Feely, R.A., G.J. Massoth, E.T. Baker, J.P. Cowen, M.F. Lamb and K.A. Krogslund (1990). Impact of hydrothermal emissions on phosphate distributions in the Northeast Pacific. **Earth and Planetary Science Letters** 96: 305-318.

(4) Particle Dynamics: The Process of Aggregation and the Role of Aggregates in Material Transport: My studies on the geomicrobiology of hydrothermal plume systems have also coincided with my interest in particle dynamics, especially in regard to particle aggregation and the lateral and vertical transport of hydrothermally-derived mineral and organic particles. Biogeochemical conditions within a hydrothermal plume system evolve as discharged hydrothermal fluids undergo continuous dynamic changes while transiting through the buoyant and neutrally buoyant phases of the plume. There is effectively no steady state within the evolving plumes. The system changes as the effluent ages, a function of time elapsed since hydrothermal discharge, typically observed as the plume moves down-current from the discharge area. Depending on metal and H_2S concentrations and the relative solubility of respective mineral products, these particles undergo alteration by continued oxidative precipitation or dissolution, scavenging, and aggregation or disaggregation processes. Chronic style plumes offer the most accessible hydrothermal plume environment. They are “dependably” located and the whole temporal spectrum of the plume is expressed simultaneously as a function (ideally) of lateral distance from the plume origins (i.e., vent sites) [of course this “ideal” picture is complicated by variable currents and topographic forcing]. Episodic “event” plumes (see ‘Time Critical Events’ above) are also an exciting alternative to chronic-style plumes due to the discreet nature of their formation and their isolation from competing hydrothermal sources. We are addressing questions of particle transformation processes (and rates) in aging event plumes as part of the ‘Event detection and response’ project noted above, in part by a combination of nephelometry (conventional light scattering) and laser *in situ* scattering and transmissometry (LISST-Deep) for size distribution and true volume concentration measurements of particles in the <250 micron size range.

In addition, I have continuing interests in the linkages between microbial exopolymer production, TEP (transparent exopolymers), aggregate abundance and particle flux within ocean water columns generally, as well as hydrothermal plumes. We are also concerned with the impact of external factors

such as particle draw-down due to elevated surface-derived particle fluxes (e.g., following plankton blooms). Finally, my current laboratory (i.e., Dale Hebel and Courtney Fritz) are presently studying the role of abiological particle formation in marine waters. This is a technologically demanding study, especially from the contamination and analytical sensitivity perspectives. This latter study is funded by a grant from NSF (EAR-Integrated Carbon Cycle Research Program).

Representative Publications

Shackelford, R. and Cowen, J.P. (2006) Transparent exopolymers particles (TEP) as a component of hydrothermal plume particle dynamics: Juan de Fuca Ridge. **Deep-Sea Research 53,** 1677-1694**.**

Prieto, L. and Cowen, J.P. (2006) Transparent exopolymers particles in a deep-sea hydrothermal system: Guaymas Basin, Gulf of California. **Marine Biology 149 (6),** .[[ISSN: 0025-3162 (Print) 1432-1793 (Online): Presently "Online First": http://dx.doi.org/10.1007/s00227-006-0430-1

Cowen, J.P., M. Bertram, S. Wakeham, R.E. Thomson, J.W. Lavelle, E.T. Baker, and R.A. Feely (2001). Ascending particle flux from a hydrothermal plume: biogeochemical linkages with the upper water column. **Deep Sea Research I 48(4):1093-1120**.

Holloway, C. and J.P. Cowen (1997). Development of a laser scanning confocal microscopic technique to examine the structure and composition of marine snow. **Limnology and Oceanography** 42: 1340-1352.

Cowen, J.P. and C. Holloway (1996). Sequential imaging of marine aggregates by *in situ* macro-photography and laser confocal and electron microscopy. **Marine Biology** 126: 163-174.

(5) Arsenic Removal from Drinking Water: A new area of deep interest to me is the global crises of arsenic contamination of drinking water, which threatens >100 million people worldwide. A young colleague from the College of Tropical Agriculture and Human Resources (L. Dong) has developed an innovative media that appears to be very effective at removing As from fresh water. I am working with Dong and HIGP faculty LiChung Ming and Pavel Zinin to characterize the removal mechanism of this media and its performance under a wide range of environmentally (and culturally) biogeochemical conditions. The goal is to develop this As-removal technology into a very inexpensive, efficient and safe product for distribution to effected communities in both developed and, especially, developing countries.

(6) Astrobiology: Astrobiology encompasses studies of the origin and evolution of life on earth and the possibility and search for life on other planetary bodies within and outside of our solar system. Among other goals it is hoped that studies of life in earth's extreme environments may shed important information on how to look and where to look for extraterrestrial life. Deep-sea hydrothermal systems and the deep subsurface biosphere are two extreme environments that are highly relevant to astrobiology. My involvement in studies related to these environments led to an invitation to join a proposal to NASA's Astrobiology Program to establish a UH-NASA Astrobiology Institute. We are a multi-disciplinary, cross-institutional (Institute of Astronomy, Department of Oceanography, Hawaii Institute of Geophysics and Planetalogy, Department of Geology and Geophysics, Department of Information Sciences) team. Our proposal was successful and, consequently, I am one of 9 co-PIs, and the deputy director, of the 5 year UH-NAI. For me this

development has opened up a whole new and exciting area of intellectual stimulation and opportunity.