NORTHERN CALIFORNIA GEOLOGICAL SOCIETY

MEETING ANNOUNCEMENT

DATE: **January 28, 2015**

LOCATION: **Orinda Masonic Center, 9 Altarinda Rd., Orinda**

TIME: **6:30 p.m. social; 7:00 p.m. talk (no dinner) Cost: $5 per regular member; $1 per student or K – 12 teachers**

SPEAKER: **Dr. Lisa White, Director of Education UC Museum of Paleontology**

Understanding Global Change: Increasing public engagement in science through a new web resource at the University of California Museum of Paleontology

For more than 125 years, fossil vertebrates, invertebrates, microfossils, and plants from more than 10,000 localities worldwide have been housed at the University of California Museum of Paleontology (UCMP), a museum uniquely situated on the campus of UC Berkeley. The extensive fossil holdings (approximately 5 million specimens) and significant online resources are linked to UCMP educational websites, databases, specimen photographs, and digital archival materials and support the needs of both the research and teaching communities. Recent projects initiated by the UCMP support greater archiving and digitization of fossils and field materials and are providing new avenues and opportunities for public engagement.

The UCMP was an early proponent of the web and began to create online exhibits on paleontology and important events in the fossil record when the UCMP website was unveiled in 1992. More than 20 years of delivering paleontological information online produced two award-winning UCMP websites, *Understanding Evolution* (www.understandingevolution.org) and *Understanding Science* (www.understandingscience.org) that provide novel ways to engage the K-16 education community in scientifically valid, real-life portrayals of how evolution and science works. Together these websites receive 20 million pages views annually.

The success of these websites confirms that the education community values a "one-stop shop" for science resources and the next planned

UCMP

Understanding Global Change

…Continued on Page 2…

NCGS 2014 – 2015 Calendar

February 25, 2015 **7:00 pm**
Dr. Bradley Erskine, Kleinfelder, PG, CEG, CHG, Principal Geologist
Building a Dam out of Naturally Occurring Asbestos: Challenges and Solutions at the Calaveras Dam Replacement Project, Sunol, CA

March 25, 2015 **7:00 pm**
Dr. Jake Lowenstern, USGS
The Yellowstone Volcano: Past, Present and Future - Monitoring the sleeping giant beneath Yellowstone National Park

April 29, 2015 **7:00 pm**
Dr. Robert B. Miller, Professor and Chair of Geology, San Jose State University
Interpretations of Magmatic Fabrics and Structures: Insights from the Sierra Nevada and North Cascades

May 27, 2015 **DINNER MEETING; 6:00 pm**
B. Lynn Ingram, UC Berkeley
The West without Water

June 24, 2015 **7:00 pm**
Dr. Will Schweller, NCGS President and Consultant
Injected Sands – Mother Nature's Giant Frac Job?

NCGS Field Trips

Saturday April 25, 2015
An undefined Petroleum system along the Santa Cruz County coast, California
Dr. Allegra Hasford Scheirer and Dr. Leslie B. Magoon, Stanford University, Stanford

Peninsula Geologic Society

For an updated list of meetings, abstracts, and field trips go to http://www.diggles.com/pgs/. The PGS has also posted guidebooks for downloading, as well as photographs from recent field trips at this web address. Please check the website for current details.

Bay Area Science

This website provides a free weekly emailed newsletter consisting of an extensive listing of local science based activities (evening lectures, classes, field trips, hikes, and etc). Go to: http://www.bayareascience.org/

Association of Engineering Geologists San Francisco Section

Upcoming Events

Meeting locations rotate between San Francisco, the East Bay, and the South Bay. Please check the website for current details. To download meeting details and registration form go to: http://www.aegsf.org/.

…Abstract Continued….

UCMP web resource, *Understanding Global Change*, will meet the need for resources on the complex topic of global change. Users will be able to explore changes in climate, multiple interactions and feedbacks between the climate systems, biodiversity, ocean composition, and sea level, while drawing relevance to societal impacts and how human activities have become a "force of nature." The site will build on direct feedback from educators, align with elements of Next Generation Science Standards, and provide new avenues and opportunities for public engagement on the biotic impacts of global change - from deep time to the Anthropocene. Through this resource, we hope to foster good communication about the nature of global change and demonstrate the connections between drivers and impacts of change.

NCGS Welcome To New and Returning Members!

The NCGS welcomes the following new or returning members. When you are at a meeting, please introduce yourself! We'd like to meet you!

Michael Barnes, Elizabeth Brooking, Cleman Buffa, Jeffery Carvalho, Robert Coskey, Stephen Edwards, Bill Damon, Kirk Ehmsen, Mari Gilmore, Stacey Gross, Cin Man Mok, James Monroe, Crystal Replogle, and Alex Rosenthal!

Seeking Member Write-Ups

Have you recently gone to, or seen an interesting geologic feature, event, or…? Let us know! NCGS would like to diversify the content of the newsletter and we want to make sure you know that your articles are welcome. There may be some editing for length, content, or grammar, but we want to welcome your articles! Send them to Mark Detterman at mdetter1@gmail.com. Our members will thank you!

New NCGS Outreach Committee!

At the January 2015 Board Meeting NCGS member **John Christian** was elected as Chair of the NCGS Outreach Committee, also formed at the January Board Meeting. Please welcome him! Over the last several years John has been instrumental in obtaining a booth and staffing the booths on behalf of NCGS at many local shows including annual Gem and Mineral Society shows and at booths at the American Geophysical Union (AGU) public open day events. These events have brought in a number of new members and have raised the profile of the NCGS locally as a source of geologic information. If you have an interest in discussing geology, rocks, gems and minerals, and educating the general interested public in all matters geologic, please let John know and he will likely find an interesting event

for your consideration! You can reach him at jmc62@sbcglobal.net.

Help NCGS at the Mineral and Gem Society of Castro Valley Show March 6-8th

Already **John Christian** reports that the NCGS needs help to staff our tables at the Mineral and Gem Society of Castro Valley show March 6-8 (Friday through Sunday). We will need help from 9 AM to 3/4 hours after event ends in evening. However this is not a commitment for the entire day! Plan to spend on 2 to 4 hours on the day you can help out, more if you enjoy talking and educating others! John plans to arrange to bring photos of our field trips and dozens of local California rocks. He also plans on arranging to bring rocks and minerals to give away to the kids. If you have rocks and minerals that you want to donate to this cause please bring them to the NCGS meeting. Please coordinate with John and let him know if you plan to do so at jmc62@sbcglobal.net. For information on the show see: http://www.mgscv.org/show.html.

John also reports that the NCGS will have a display case at the show that NCGS can use to promote our society. He is looking for a member to take the lead to design a display to fill that case. We thought that it would be interesting to use our rocks and minerals to educate the public about an important Bay Area geological subject. Suggested topics include: minerals and rocks associated with subduction; mercury mining in the Bay Area. All ideas are welcomed.

Wanted - Newsletter Editor!

At the January 2015 Board Meeting NCGS newsletter editor **Mark Detterman** announced that he is seeking fresh eyes and new blood to pick up the editing of the NCGS newsletter beginning in September 2015. He will have been editing the newsletter for 14 years at that point! Please note that he plans to continue managing the NCGS website, unless better laid plans are put forward! **If you have wanted to contribute to the NCGS, please step up and let him know!**

Goldilocks and the Three Zones

(Part 3); *By NCGS Member* ***Dr. Bill Motzer***

This article originally appeared in The Vortex from the California Section of the American Chemical Society (CALACS). Go to www.calvaryslz.org/calacs/ where you can download pdfs of the original articles and/or peruse past issues of The Vortex.

In Part 1, the Goldilocks Zone, also known as the habitable zone (HZ-1), was defined as the distance from a star that a terrestrial-like planet could maintain liquid water on its surface and consequently contain terrestrial-like life. The next HZ is believed to be one occurring within a galaxy and therefore is called the galactic habitable zone (GHZ) or HZ-2.

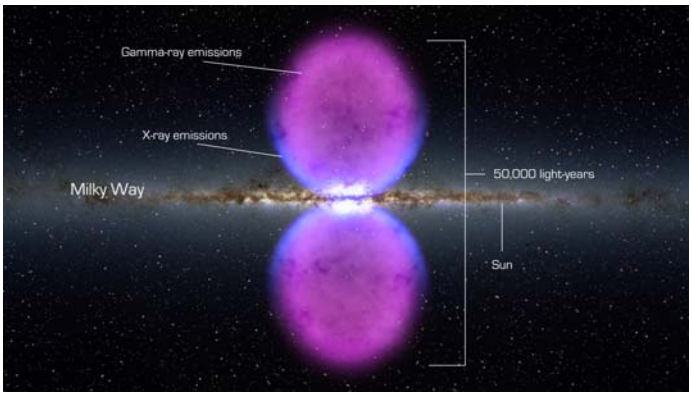
The classic GHZ (HZ-2) has been hypothetically defined as a galactic region with conditions best suited to development and survival of terrestrial-type life. For a barred spiral galaxy, the Milky Way's diameter ranges from approximately 100,000 to 120,000 light years (LY), about 1,000 LY in thickness, and contains 200 to 400 billion stars. Its GHZ is believed to extend from 23,000 to 29,000 LY from the galactic center. (The Sun is about 26,000 to 28,000 LY from the galactic center.) Additionally, it appears that the Milky Way's GHZ is slowly expanding or widening with time with its width controlled by two factors. The inner limit, closer to the galaxy's center, has a high stellar density (about 100 stars per 3.26 LY^3 when compared to a stellar density of 1.0 star per 3.26 LY^3 in our Sun's vicinity). Such high stellar densities could potentially threaten formation of complex carbon-based life with nearby ionizing radiation sources including those from supernovas and gamma ray bursts (GRB). Most stars in this region are O-type blue giants, 10 to 50 times more massive than the Sun. These young (a few million years old) stars emit UV radiation generally strong enough to fry most – if not all – life. A safe distance from an O-type star is at least 10 LY. An outer limit, generally occurring in the spiral arms imposed by galactic chemical evolution, is detected by the abundance of heavier elements produced by super novae, resulting in metal-rich stars and planets, which are required to harbor life. Therefore, a planetary system should be close enough to the metal-rich galactic center where a sufficient quantity of heavy elements (e.g., carbon, oxygen, silicon, iron, etc.) exist favoring rocky or terrestrial-type planet formation. Heavier elements are also required to form the complex molecules of life (e.g., DNA) and energy sources (e.g., chlorophyll) needed to keep life going.

Very recent astronomical observations have supported the classical GHZ hypothesis but the Milky Way's GHZ may actually be governed more by the presence of a central black hole (BH) than by stellar density alone. Observations of stars orbiting closest to the galactic center and an intense radio source in this region indicate a massive, compact object, currently explained as a super massive BH designated as Sagitarrius A* or Sag A*. Stars and interstellar gas orbiting Sag A* suggest it has a radius of about 3.0 billion km and mass of 4.1 to 4.5 million Suns. This agrees with other observations indicating that super massive BHs are located near most galactic centers. Such active galactic nuclei (AGN) have been designated as Seyfert Galaxies which are characterized by extremely bright nuclei and spectra with very bright hydrogen, helium, nitrogen, and oxygen emission lines.

AGNs may also switch "on" and "off" over time (known as a duty cycle, where active accretion occurs or ceases) and it's believed that the Milky Way's BH is presently inactive and actually much smaller than other galaxies

(e.g., the Andromeda Galaxy may have an AGN that is 100 times larger). But, when active, the Milky Way's BH has grown over time by accreting gas and disrupted stars. While active, the BH's accretion disk is believed to emit intense electromagnetic and particle radiation radiating perpendicular to the galactic plane. Recently, astronomers reported "bubbles" of emitting energy resulting from star formation at the galactic center. Discovered in 2010 by NASA's Fermi Gamma-ray Space Telescope, these Fermi bubbles are each 25,000 LY in length and are indeed perpendicular to the galactic plane indicating that the BH has been active only about 40% of the time in the recent past, perhaps within the past 500 million years.

Energy calculated from the luminosity of other AGNs suggest that when the duty cycle is switched on, the Milky Way's AGN energy output would be about 10^{44} ergs per second or 2 to 10 keV in the X-ray band, which is about a typical supernova's energy output in less than a year. Planets located in the GHZ would be most protected from ionizing photons produced by an AGN. For example, such X-ray impact to Earth would be about 130 ergs per m^2 per second, without any intervening absorption (i.e., interstellar dust and gas). This energy output is about 20 times that of the Sun in the same energy band, which is comparable to a typical X-ray solar flare. If intervening absorption is taken into account, the X-ray impact would be comparable to that of the Sun's average X-ray value. Thus, X-ray emissions from an AGN outburst would probably not significantly impact life on Earth, but it would for planets within 3,200 to ~6,000 LY of the Galactic center. The fact the Milky Way has a smaller and less active BH than many other galaxies may make it atypical to other galaxies and perhaps this is also conducive to the formation of life.



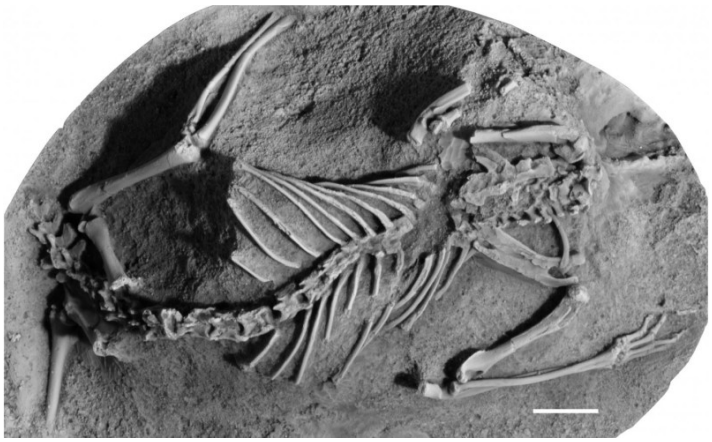
Milky Way Fermi (gamma ray) bubble simulation from NASA(http://www.nasa.gov/mission_pages/GLAST/news/new-structure.html)

On January 7, 2013, NASA reported that the Kepler Space Telescope had detected 461 new possible exoplanets resulting in a total of 2,740 exoplanets detected by Kepler in 22 months of operation. Although only 105 have been confirmed, four of the new planets are 1.25 to 2.0 times as large as Earth and are believed to occur within their star's HZ. Additionally, a recent stellar statistical study indicated that there might be as many a 17 billion planets in the Milky Way. If this is true and only 10% reside in the GHZ, then the possibility of life on a terrestrial-type planet becomes increasingly feasible.

Asteroid that wiped out dinosaurs may have nearly knocked off mammals, too

The extinction of the dinosaurs 66 million years ago is thought to have paved the way for mammals to dominate, but a new study shows that many mammals died off alongside the dinosaurs.

Metatherian mammals -- the extinct relatives of living marsupials ("mammals with pouches," such as opossums) -- thrived in the shadow of the dinosaurs during the Cretaceous period. The new study, by an international team of experts on mammal evolution and mass extinctions, shows that these once-abundant mammals nearly followed the dinosaurs into oblivion.



This image shows a cast of the fossil remnants of Asiatherium reshetovi, one of the metatherian species that used to live on the planet millions of years ago. (scale bar: 1cm)

Credit: Dr Thomas Williamson; CC-BY 4.0

When a 10-km-wide asteroid struck what is now Mexico at the end of the Cretaceous and unleashed a global cataclysm of environmental destruction, some two-thirds of all metatherians living in North America perished. This includes more than 90% of species living in the northern Great Plains of the USA, the best area in the world for preserving latest Cretaceous mammal fossils.

In the aftermath of the mass extinction, metatherians would never recover their previous diversity, which is why marsupial mammals are rare today and largely restricted to unusual environments in Australia and South America.

Taking advantage of the metatherian demise were the placental mammals: species that give live birth to well-developed young. They are ubiquitous across the globe today and include everything from mice to men.

Dr. Thomas Williamson of the New Mexico Museum of Natural History and Science, lead author on the study, said: "This is a new twist on a classic story. It wasn't only that dinosaurs died out, providing an opportunity for mammals to reign, but that many types of mammals, such as most metatherians, died out too -- this allowed advanced placental mammals to rise to dominance."

Dr. Steve Brusatte of the University of Edinburgh's School of GeoSciences, an author on the report, said: "The classic tale is that dinosaurs died out and mammals, which had been waiting in the wings for over 100 million years, then finally had their chance. But our study shows that many mammals came perilously close to extinction. If a few lucky species didn't make it through, then mammals may have gone the way of the dinosaurs and we wouldn't be here."

The new study is published in the open access journal *ZooKeys*. It reviews the Cretaceous evolutionary history of metatherians and provides the most up-to-date family tree for these mammals based on the latest fossil records, which allowed researchers to study extinction patterns in unprecedented detail.

Dr. Gregory Wilson of the University of Washington also took part in the study.

The work was supported by the US National Science Foundation and the European Commission.

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Journal Reference: Thomas E. Williamson, Stephen L. Brusatte, Gregory P. Wilson. **The origin and early evolution of metatherian mammals: the Cretaceous record**. *ZooKeys*, 2014; 465

Cheap asphalt provides 'green' carbon capture

The best material to keep carbon dioxide from natural gas wells from fouling the atmosphere may be a derivative of asphalt, according to Rice University scientists.

The Rice laboratory of chemist James Tour followed up on last year's discovery of a "green" carbon capture material for wellhead sequestration with the news that an even better compound could be made cheaply in a few steps from asphalt, the black, petroleum-based substance primarily used to build roads.

The research appears in the American Chemical Society journal *Applied Materials and Interfaces*.

The best version of several made by the Tour lab is a powder that holds 114 percent of its weight in carbon dioxide. Like last year's material, these new porous carbon materials capture carbon dioxide molecules at room temperature while letting the desired methane natural gas flow through.

The basic compound known as asphalt-porous carbon (A-PC) captures carbon dioxide as it leaves a wellhead under pressure supplied by the rising gas itself (about 30 atmospheres, or 30 times atmospheric pressure at sea level). When the pressure is relieved, A-PC spontaneously releases the carbon dioxide, which can be piped off to storage, pumped back downhole or repurposed for such uses as enhanced oil recovery.

"This provides an ultra-inexpensive route to a high-value material for the capture of carbon dioxide from natural gas streams," Tour said. "Not only did we increase its capacity, we lowered the price substantially." He said they tried many grades of asphalt, some costing as little as 30 cents per pound.

Tour's goal is to simplify the process of capturing carbon from wellheads at sea, where there's limited room for bulky equipment. The ability of A-PC to capture and release carbon over many cycles without degrading makes it practical, he said.

The paper's lead authors, postdoctoral associate Almaz Jalilov and graduate student Gedeng Ruan, and their Rice colleagues made A-PC by mixing asphalt with potassium hydroxide at high temperature; they turned it into a porous carbon with a lot of surface area: 2,780 square meters per gram. That material captured 93 percent of its weight in carbon dioxide. Further experiments showed processing A-PC with ammonia and then hydrogen increased its capacity to 114 percent.

Tour said the lab is continuing to tweak the material but noted that it's already better for carbon capture than other materials in current use. Amine-based materials now used by industrial facilities like power plants to absorb carbon dioxide are expensive and corrosive and can only capture about 13 percent carbon dioxide by weight. Materials in development based on metal organic frameworks are far more expensive to produce and don't show as great a selectivity for carbon dioxide over methane, he said.

Story Source: The above story is based on materials provided by Rice University.

Journal Reference: James M. Tour. **Asphalt-Derived High Surface Area Activated Porous Carbons for Carbon Dioxide Capture**. *ACS Applied Materials & Interfaces*, 2014.

Good News on Forests and Carbon Dioxide

A new NASA-led study shows that tropical forests may be absorbing far more carbon dioxide than many scientists thought, in response to rising atmospheric levels of the greenhouse gas. The study estimates that tropical forests absorb 1.4 billion metric tons of carbon dioxide out of a total global absorption of 2.5 billion -- more than is absorbed by forests in Canada, Siberia and other northern regions, called boreal forests.

"This is good news, because uptake in boreal forests is already slowing, while tropical forests may continue to take up carbon for many years," said David Schimel of NASA's Jet Propulsion Laboratory, Pasadena, California. Schimel is lead author of a paper on the new research, appearing

online in the Proceedings of National Academy of Sciences.

Forests and other land vegetation currently remove up to 30 percent of human carbon dioxide emissions from the atmosphere during photosynthesis. If the rate of absorption were to slow down, the rate of global warming would speed up in return.

A new NASA study suggests that tropical forests, like this one in Malaysia, absorb more atmospheric carbon dioxide than is absorbed by forests in Alaska, Canada and Siberia. Image Credit: Wikimedia Commons

The new study is the first to devise a way to make apples-to-apples comparisons of carbon dioxide estimates from many sources at different scales: computer models of ecosystem processes, atmospheric models run backward in time to deduce the sources of today's concentrations (called inverse models), satellite images, data from experimental forest plots and more. The researchers reconciled all types of analyses and assessed the accuracy of the results based on how well they reproduced independent, ground-based measurements. They obtained their new estimate of the tropical carbon absorption from the models they determined to be the most trusted and verified.

"Until our analysis, no one had successfully completed a global reconciliation of information about carbon dioxide effects from the atmospheric, forestry and modeling communities," said co-author Joshua Fisher of JPL. "It is incredible that all these different types of independent data sources start to converge on an answer."

The question of which type of forest is the bigger carbon absorber "is not just an accounting curiosity," said co-author Britton Stephens of the National Center for Atmospheric Research, Boulder, Colorado. "It has big implications for our understanding of whether global terrestrial ecosystems might continue to offset our carbon dioxide emissions or might begin to exacerbate climate change."

As human-caused emissions add more carbon dioxide to the atmosphere, forests worldwide are using it to grow faster, reducing the amount that stays airborne. This effect is called carbon fertilization. "All else being equal, the effect is stronger at higher temperatures, meaning it will be higher in the tropics than in the boreal forests," Schimel said.

But climate change also decreases water availability in some regions and makes Earth warmer, leading to more frequent and larger wildfires. In the tropics, humans compound the problem by burning wood during deforestation. Fires don't just stop carbon absorption by killing trees, they also spew huge amounts of carbon into the atmosphere as the wood burns.

For about 25 years, most computer climate models have been showing that mid-latitude forests in the Northern Hemisphere absorb more carbon than tropical forests. That result was initially based on the then-current understanding of global air flows and limited data suggesting that deforestation was causing tropical forests to release more carbon dioxide than they were absorbing.

In the mid-2000s, Stephens used measurements of carbon dioxide made from aircraft to show that many climate models were not correctly representing flows of carbon above ground level. Models that matched the aircraft measurements better showed more carbon absorption in the tropical forests. However, there were still not enough global data sets to validate the idea of a large tropical-forest absorption. Schimel said that their new study took advantage of a great deal of work other scientists have done since Stephens' paper to pull together national and regional data of various kinds into robust, global data sets.

Schimel noted that their paper reconciles results at every scale from the pores of a single leaf, where photosynthesis takes place, to the whole Earth, as air moves carbon dioxide around the globe. "What we've had up till this paper was a theory of carbon dioxide fertilization based on phenomena at the microscopic scale and observations at the global scale that appeared to contradict those phenomena. Here, at least, is a hypothesis that provides a consistent explanation that includes both how we know photosynthesis works and what's happening at the planetary scale."

Credits: Production editor: Dr. Tony Phillips | Credit: Science@NASA

More information: NASA monitors Earth's vital signs from land, air and space with a fleet of satellites and ambitious airborne and ground-based observation campaigns. NASA develops new ways to observe and study Earth's interconnected natural systems with long-term data records and computer analysis tools to better see how our planet is changing. The agency shares this unique knowledge with the global community and works with institutions in the United States and around the world that contribute to understanding and protecting our home planet.

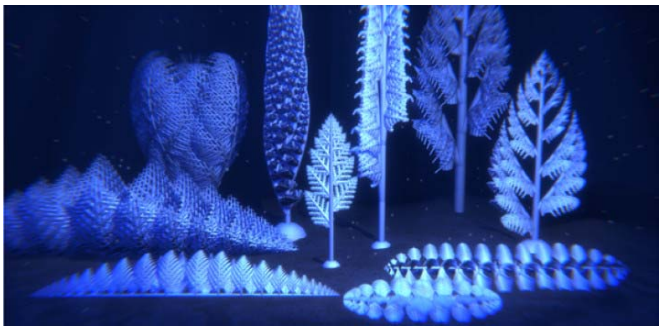
For more information about NASA's Earth science activities in the last year, visit: http://www.nasa.gov/earthrightnow

Reconstructions show how some of the earliest animals lived -- and died

New three-dimensional reconstructions show how some of the earliest animals on Earth developed, and provide some answers as to why they went extinct.

A bizarre group of uniquely-shaped organisms known as rangeomorphs may have been some of the earliest animals to appear on Earth, uniquely suited to ocean conditions 575 million years ago.

A new model devised by researchers at the University of Cambridge has resolved many of the mysteries around the structure, evolution and extinction of these 'proto animals'. The findings are reported today (11 August) in the journal *Proceedings of the National Academy of Sciences.*



Palaeontological reconstruction of rangeomorph fronds from the Ediacaran Period (635-541 million years ago) built using computer models of rangeomorph growth and development.

Credit: Jennifer Hoyal Cuthill

Rangeomorphs were some of the earliest large organisms on Earth, existing during a time when most other forms of life were microscopic in size. Most rangeomorphs were about 10 centimetres high, although some were up to two metres in height.

These creatures were ocean dwellers which lived during the Ediacaran period, between 635 and 541 million years ago. Their bodies were made up of soft branches, each with many smaller side branches, forming a geometric shape known as a fractal, which can be seen in many familiar branching shapes such as fern leaves and even river networks.

Rangeomorphs were unlike any modern organism, which has made it difficult to determine how they fed, grew or reproduced, and therefore difficult to link them to any particular modern group. However, despite the fact that they looked like plants, evidence points to the fact that rangeomorphs were actually some of the earliest animals.

"We know that rangeomorphs lived too deep in the ocean for them to get their energy through photosynthesis as plants do," said Dr Jennifer Hoyal Cuthill of Cambridge's Department of Earth Sciences, who led the research. "It's more likely that they absorbed nutrients directly from the sea water through the surface of their body. It would be difficult in the modern world for such large animals to survive only on dissolved nutrients."

"The oceans during the Ediacaran period were more like a weak soup -- full of nutrients such as organic carbon, whereas today suspended food particles are swiftly harvested by a myriad of animals," said co-author Professor Simon Conway Morris.

Starting 541 million years ago, the conditions in the oceans changed quickly with the start of the Cambrian Explosion -- a period of rapid evolution when most major animal groups first emerge in the fossil record and competition for nutrients increased dramatically.

Rangeomorphs have often been considered a 'failed experiment' of evolution as they died out so quickly once the Cambrian Explosion began in earnest, but this new analysis shows just how successful they once were.

Rangeomorphs almost completely filled the space surrounding them, with a massive total surface area. This made them very efficient feeders that were able to extract the maximum amount of nutrients from the ocean water.

"These creatures were remarkably well-adapted to their environment, as the oceans at the time were high in nutrients and low in competition," said Dr Hoyal Cuthill. "Mathematically speaking, they filled their space in a nearly perfect way."

Dr Hoyal Cuthill examined rangeomorph fossils from a number of locations worldwide, and used them to make the first computer reconstructions of the development and three-dimensional structure of these organisms, showing just how well-suited they were to their Ediacaran environment.

As the Cambrian Explosion began however, the rangeomorphs became 'sitting ducks', as they had no known means of defence from predators which were starting to evolve, and the changing chemical composition of the ocean meant that they could no longer get the nutrients they required to feed.

"As the Cambrian began, these Ediacaran specialists could no longer survive, and nothing quite like them has been seen again," said Dr Hoyal Cuthill.

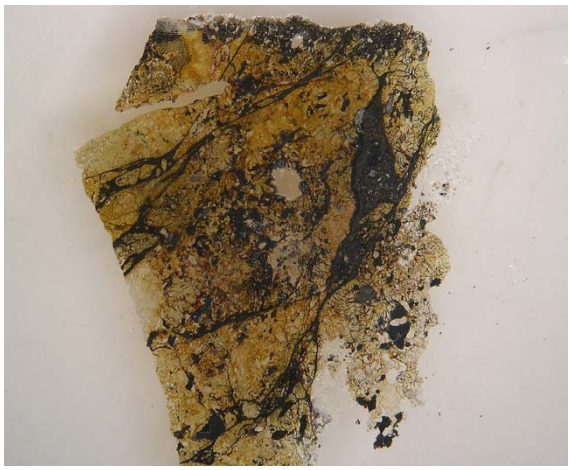
Story Source: The above story is based on materials provided by University of Cambridge. The original story is licensed under a Creative Commons Licence. *Note: Materials may be edited for content and length.*

Journal Reference: Jennifer F. Hoyal Cuthill and Simon Conway Morris. **Fractal branching organizations of Ediacaran rangeomorph fronds reveal a lost Proterozoic body plan**. *PNAS*, August 11, 2014.

Earth's most abundant mineral finally has a name

An ancient meteorite and high-energy X-rays have helped scientists conclude a half century of effort to find, identify and characterize a mineral that makes up 38 percent of the Earth.

And in doing so, a team of scientists led by Oliver Tschauner, a mineralogist at the University of Las Vegas, clarified the definition of the Earth's most abundant mineral -- a high-density form of magnesium iron silicate, now called Bridgmanite -- and defined estimated constraint ranges for its formation. Their research was performed at the Advanced Photon Source, a U.S. Department of Energy (DOE) Office of Science User Facility located at DOE's Argonne National Laboratory.



A section of meteorite that landed in Australia in 1879. Bridgmanite was formed and trapped in the dark veins from the intense, quick shock of asteroid collisions. A team of scientists clarified the definition of Bridgmanite, a high-density form of magnesium iron silicate and the Earth's most abundant mineral – using Argonne National Laboratory's Advanced Photon Source. Credit: Tschauneret et al, Science

The mineral was named after 1964 Nobel laureate and pioneer of high-pressure research Percy Bridgman. The naming does more than fix a vexing gap in scientific lingo; it also will aid our understanding of the deep Earth.

To determine the makeup of the inner layers of the Earth, scientists need to test materials under extreme pressure and temperatures. For decades, scientists have believed a dense perovskite structure makes up 38 percent of the Earth's volume, and that the chemical and physical properties of Bridgmanite have a large influence on how elements and heat flow through the Earth's mantle. But since the mineral failed to survive the trip to the surface, no one has been able to test and prove its existence -- a requirement for getting a name by the International Mineralogical Association.

Shock-compression that occurs in collisions of asteroid bodies in the solar system create the same hostile conditions of the deep Earth -- roughly 2,100 degrees Celsius (3,800 degrees Farenheit) and pressures of about 240,000 times greater than sea-level air pressure. The shock occurs fast enough to inhibit the Bridgmanite breakdown that takes place when it comes under lower pressure, such as the Earth's surface. Part of the debris from these collisions falls on Earth as meteorites, with the Bridgmanite "frozen" within a shock-melt vein. Previous tests on meteorites using transmission electron microscopy caused radiation damage to the samples and incomplete results.

So the team decided to try a new tactic: non-destructive micro-focused X-rays for diffraction analysis and novel fast-readout area-detector techniques. Tschauner and his colleagues from Caltech and the GeoSoilEnviroCARS, a University of Chicago-operated X-ray beamline at the APS at Argonne National Laboratory, took advantage of the X-rays' high energy, which gives them the ability to penetrate the meteorite, and their intense brilliance, which leaves little of the radiation behind to cause damage.

The team examined a section of the highly shocked L-chondrite meteorite Tenham, which crashed in Australia in 1879. The GSECARS beamline was optimal for the study because it is one of the nation's leading locations for conducting high-pressure research.

Bridgmanite grains are rare in the Tenhma meteorite, and they are smaller than 1 micrometer in diameter. Thus the team had to use a strongly focused beam and conduct highly spatially resolved diffraction mapping until an aggregate of Bridgmanite was identified and characterized by structural and compositional analysis.

This first natural specimen of Bridgmanite came with some surprises: It contains an unexpectedly high amount of ferric iron, beyond that of synthetic samples. Natural Bridgmanite also contains much more sodium than most synthetic samples. Thus the crystal chemistry of natural Bridgmanite provides novel crystal chemical insights. This natural sample of Bridgmanite may serve as a complement to experimental studies of deep mantle rocks in the future.

Prior to this study, knowledge about Bridgmanite's properties has only been based on synthetic samples because it only remains stable below 660 kilometers (410 miles) depth at pressures of above 230 kbar (23 GPa). When it is brought out of the inner Earth, the lower pressures transform it back into less dense minerals. Some scientists believe that some inclusions on diamonds are the marks left by Bridgmanite that changed as the diamonds were unearthed.

The team's results were published in the November 28 issue of the journal *Science* as "Discovery of bridgmanite, the most abundant mineral in Earth, in a shocked meteorite," by O. Tschauner at University of Nevada in Las Vegas, N.V.; C. Ma; J.R. Beckett; G.R. Rossman at California Institute of Technology in Pasadena, Calif.; C. Prescher; V.B. Prakapenka at University of Chicago in Chicago, IL.

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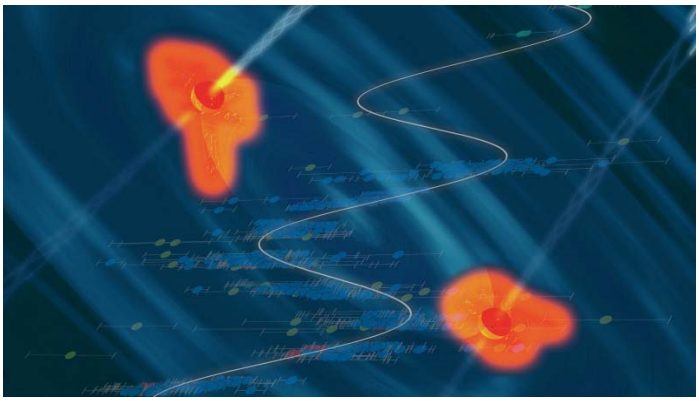
Unusual light signal yields clues about elusive black hole merger

The central regions of many glittering galaxies, our own Milky Way included, harbor cores of impenetrable darkness -- black holes with masses equivalent to millions, or even billions, of suns. What is more, these supermassive black holes and their host galaxies appear to develop together, or "co-evolve." Theory predicts that as galaxies collide and merge, growing ever more massive, so too do their dark hearts.



An artist's conception of a black hole binary in a heart of a quasar, with the data showing the periodic variability superposed. Credit: Santiago Lombeyda/Caltech Center for Data-Driven Discovery

Black holes by themselves are impossible to see, but their gravity can pull in surrounding gas to form a swirling band of material called an accretion disk. The spinning particles are accelerated to tremendous speeds and release vast amounts of energy in the form of heat and powerful X-rays and gamma rays. When this process happens to a supermassive black hole, the result is a quasar -- an extremely luminous object that outshines all of the stars in its host galaxy and that is visible from across the universe. "Quasars are valuable probes of the evolution of galaxies and their central black holes," says George Djorgovski, professor of astronomy and director of the Center for Data-Driven Discovery at Caltech.

In the January 7 issue of the journal *Nature*, Djorgovski and his collaborators report on an unusual repeating light signal from a distant quasar that they say is most likely the result of two supermassive black holes in the final phases of a merger -- something that is predicted from theory but which has never been observed before. The discovery could help shed light on a long-standing conundrum in astrophysics called the "final parsec problem," which refers to the failure of theoretical models to predict what the final stages of a black hole merger look like or even how long the process might take. "The end stages of the merger of these supermassive black hole systems are very poorly understood," says the study's first author, Matthew Graham, a senior computational scientist at Caltech. "The discovery of a system that seems to be at this late stage of its evolution means we now have an observational handle on what is going on."

Djorgovski and his team discovered the unusual light signal emanating from quasar PG 1302-102 after analyzing results from the Catalina Real-Time Transient Survey (CRTS), which uses three ground telescopes in the United States and Australia to continuously monitor some 500 million celestial light sources strewn across about 80 percent of the night sky. "There has never been a data set on quasar variability that approaches this scope before," says Djorgovski, who directs the CRTS. "In the past, scientists who study the variability of quasars might only be able to follow some tens, or at most hundreds, of objects with a limited number of measurements. In this case, we looked at a quarter million quasars and were able to gather a few hundred data points for each one."

"Until now, the only known examples of supermassive black holes on their way to a merger have been separated by tens or hundreds of thousands of light years," says study coauthor Daniel Stern, a scientist at NASA's Jet Propulsion Laboratory. "At such vast distances, it would take many millions, or even billions, of years for a collision and merger to occur. In contrast, the black holes in PG 1302-102 are, at most, a few hundredths of a light year apart and could merge in about a million years or less."

Djorgovski and his team did not set out to find a black hole merger. Rather, they initially embarked on a systematic study of quasar brightness variability in the hopes of finding new clues about their physics. But after screening the data using a pattern-seeking algorithm that Graham developed, the team found 20 quasars that seemed to be emitting periodic optical signals. This was surprising, because the light curves of most quasars are chaotic -- a reflection of the random nature by which material from the accretion disk spirals into a black hole. "You just don't expect to see a periodic signal from a quasar," Graham says. "When you do, it stands out."

Of the 20 periodic quasars that CRTS identified, PG 1302-102 was the best example. It had a strong, clean signal that appeared to repeat every five years or so. "It has a really nice smooth up-and-down signal, similar to a sine wave, and that just hasn't been seen before in a quasar," Graham says.

The team was cautious about jumping to conclusions. "We approached it with skepticism but excitement as well," says study coauthor Eilat Glikman, an assistant professor of physics at Middlebury College in Vermont. After all, it was possible that the periodicity the scientists were seeing was just a temporary ordered blip in an otherwise chaotic signal. To help rule out this possibility, the scientists pulled in data about the quasar from previous surveys to include in their analysis. After factoring in the historical observations (the scientists had nearly 20 years' worth of data about quasar PG 1302-102), the repeating signal was, encouragingly, still there.

The team's confidence increased further after Glikman analyzed the quasar's light spectrum. The black holes that scientists believe are powering quasars do not emit light, but the gases swirling around them in the accretion disks are traveling so quickly that they become heated into glowing plasma. "When you look at the emission lines in a spectrum from an object, what you're really seeing is information about speed -- whether something is moving toward you or away from you and how fast. It's the Doppler effect," Glikman says. "With quasars, you typically have one emission line, and that line is a symmetric curve. But with this quasar, it was necessary to add a second emission line with a slightly different speed than the first one in order to fit the data. That suggests something else, such as a second black hole, is perturbing this system."

Avi Loeb, who chairs the astronomy department at Harvard University, agreed with the team's assessment that a "tight" supermassive black hole binary is the most likely explanation for the periodic signal they are seeing. "The evidence suggests that the emission originates from a very

compact region around the black hole and that the speed of the emitting material in that region is at least a tenth of the speed of light," says Loeb, who did not participate in the research. "A secondary black hole would be the simplest way to induce a periodic variation in the emission from that region, because a less dense object, such as a star cluster, would be disrupted by the strong gravity of the primary black hole."

In addition to providing an unprecedented glimpse into the final stages of a black hole merger, the discovery is also a testament to the power of "big data" science, where the challenge lies not only in collecting high-quality information but also devising ways to mine it for useful information. "We're basically moving from having a few pictures of the whole sky or repeated observations of tiny patches of the sky to having a movie of the entire sky all the time," says Sterl Phinney, a professor of theoretical physics at Caltech, who was also not involved in the study. "Many of the objects in the movie will not be doing anything very exciting, but there will also be a lot of interesting ones that we missed before."

It is still unclear what physical mechanism is responsible for the quasar's repeating light signal. One possibility, Graham says, is that the quasar is funneling material from its accretion disk into luminous twin plasma jets that are rotating like beams from a lighthouse. "If the glowing jets are sweeping around in a regular fashion, then we would only see them when they're pointed directly at us. The end result is a regularly repeating signal," Graham says.

Another possibility is that the accretion disk that encircles both black holes is distorted. "If one region is thicker than the rest, then as the warped section travels around the accretion disk, it could be blocking light from the quasar at regular intervals. This would explain the periodicity of the signal that we're seeing," Graham says. Yet another possibility is that something is happening to the accretion disk that is causing it to dump material onto the black holes in a regular fashion, resulting in periodic bursts of energy.

"Even though there are a number of viable physical mechanisms behind the periodicity we're seeing -- either the precessing jet, warped accretion disk or periodic dumping -- these are all still fundamentally caused by a close binary system," Graham says.

Along with Djorgovski, Graham, Stern, and Glikman, additional authors on the paper, "A possible close supermassive black hole binary in a quasar with optical periodicity," include Andrew Drake, a computational scientist and co-principal investigator of the CRTS sky survey at Caltech; Ashish Mahabal, a staff scientist in computational astronomy at Caltech; Ciro Donalek, a computational staff scientist at Caltech; Steve Larson, a senior staff scientist at the University of Arizona; and Eric Christensen, an associate staff scientist at the University of Arizona. Funding for the study was provided by the National Science Foundation.

Story Source: The above story is based on materials provided by California Institute of Technology (Caltech). The original article was written by Ker Than.

Journal Reference: Matthew J. Graham, S. G. Djorgovski, Daniel Stern, Eilat Glikman, Andrew J. Drake, Ashish A. Mahabal, Ciro Donalek, Steve Larson, Eric Christensen. **A possible close supermassive black-hole binary in a quasar with optical periodicity**. *Nature*, 2015.

Human language's deep origins appear to have come directly from birds, primates

On the island of Java, in Indonesia, the silvery gibbon, an endangered primate, lives in the rainforests. In a behavior that's unusual for a primate, the silvery gibbon sings: It can vocalize long, complicated songs, using 14 different note types, that signal territory and send messages to potential mates and family.

Far from being a mere curiosity, the silvery gibbon may hold clues to the development of language in humans. In a newly published paper, two MIT professors assert that by re-examining contemporary human language, we can see indications of how human communication could have evolved from the systems underlying the older communication modes of birds and other primates.

"Yes, human language is unique, but if you take it apart in the right way, the two parts we identify are in fact of a finite state," Miyagawa says. "Those two components have antecedents in the animal world. According to our hypothesis, they came together uniquely in human language." Credit: Illustration by Christine Daniloff/MIT

From birds, the researchers say, we derived the melodic part of our language, and from other primates, the pragmatic, content-carrying parts of speech. Sometime within the last 100,000 years, those capacities fused into roughly the form of human language that we know today.

But how? Other animals, it appears, have finite sets of things they can express; human language is unique in allowing for an infinite set of new meanings. What allowed unbounded human language to evolve from bounded language systems?

"How did human language arise? It's far enough in the past that we can't just go back and figure it out directly," says linguist Shigeru Miyagawa, the Kochi-Manjiro Professor of Japanese Language and Culture at MIT. "The best we can do is come up with a theory that is broadly compatible with

what we know about human language and other similar systems in nature."

Specifically, Miyagawa and his co-authors think that some apparently infinite qualities of modern human language, when reanalyzed, actually display the finite qualities of languages of other animals -- meaning that human communication is more similar to that of other animals than we generally realized.

"Yes, human language is unique, but if you take it apart in the right way, the two parts we identify are in fact of a finite state," Miyagawa says. "Those two components have antecedents in the animal world. According to our hypothesis, they came together uniquely in human language."

Introducing the 'integration hypothesis'

The current paper, "The Integration Hypothesis of Human Language Evolution and the Nature of Contemporary Languages," is published this week in *Frontiers in Psychology*. The authors are Miyagawa; Robert Berwick, a professor of computational linguistics and computer science and engineering in MIT's Laboratory for Information and Decision Systems; and Shiro Ojima and Kazuo Okanoya, scholars at the University of Tokyo.

The paper's conclusions build on past work by Miyagawa, which holds that human language consists of two distinct layers: the expressive layer, which relates to the mutable structure of sentences, and the lexical layer, where the core content of a sentence resides. That idea, in turn, is based on previous work by linguistics scholars including Noam Chomsky, Kenneth Hale, and Samuel Jay Keyser.

The expressive layer and lexical layer have antecedents, the researchers believe, in the languages of birds and other mammals, respectively. For instance, in another paper published last year, Miyagawa, Berwick, and Okanoya presented a broader case for the connection between the expressive layer of human language and birdsong, including similarities in melody and range of beat patterns.

Birds, however, have a limited number of melodies they can sing or recombine, and nonhuman primates have a limited number of sounds they make with particular meanings. That would seem to present a challenge to the idea that human language could have derived from those modes of communication, given the seemingly infinite expression possibilities of humans.

But the researchers think certain parts of human language actually reveal finite-state operations that may be linked to our ancestral past. Consider a linguistic phenomenon known as "discontiguous word formation," which involve sequences formed using the prefix "anti," such as "antimissile missile," or "anti-antimissile missile missile," and so on. Some linguists have argued that this kind of construction reveals the infinite nature of human language, since the term "antimissile" can continually be embedded in the middle of the phrase.

However, as the researchers state in the new paper, "This is not the correct analysis." The word "antimissile" is actually a modifier, meaning that as the phrase grows larger, "each successive expansion forms via strict adjacency." That means the construction consists of discrete units of language. In this case and others, Miyagawa says, humans use "finite-state" components to build out their communications.

The complexity of such language formations, Berwick observes, "doesn't occur in birdsong, and doesn't occur anywhere else, as far as we can tell, in the rest of the animal kingdom." Indeed, he adds, "As we find more evidence that other animals don't seem to posses this kind of system, it bolsters our case for saying these two elements were brought together in humans."

An inherent capacity

To be sure, the researchers acknowledge, their hypothesis is a work in progress. After all, Charles Darwin and others have explored the connection between birdsong and human language. Now, Miyagawa says, the researchers think that "the relationship is between birdsong and the expression system," with the lexical component of language having come from primates. Indeed, as the paper notes, the most recent common ancestor between birds and humans appears to have existed about 300 million years ago, so there would almost have to be an indirect connection via older primates -- even possibly the silvery gibbon.

As Berwick notes, researchers are still exploring how these two modes could have merged in humans, but the general concept of new functions developing from existing building blocks is a familiar one in evolution.

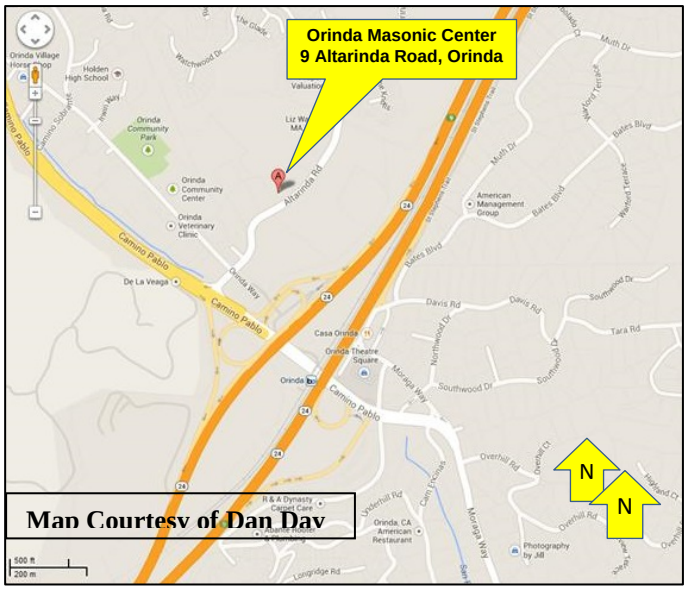
"You have these two pieces," Berwick says. "You put them together and something novel emerges. We can't go back with a time machine and see what happened, but we think that's the basic story we're seeing with language."

Miyagawa acknowledges that research and discussion in the field will continue, but says he hopes colleagues will engage with the integration hypothesis.

"It's worthy of being considered, and then potentially challenged," Miyagawa says.

Story Source: The above story is based on materials provided by Massachusetts Institute of Technology and ScienceDaily June 11, 2014.

Journal Reference: Shigeru Miyagawa, Shiro Ojima, Robert C. Berwick, Kazuo Okanoya. **The integration hypothesis of human language evolution and the nature of contemporary languages**. *Frontiers in Psychology*, 2014; 5.



Biography: Lisa D. White is Director of Education and Outreach at the University of California Museum of Paleontology and Adjunct Professor of Geology at San Francisco State University. Past positions held at SF State include Professor of Geology, Chair of Geosciences, and Associate Dean of the College of Science and Engineering. Lisa has extensive experience with science outreach programs for urban youth and she is active in efforts to increase diversity in the geosciences. A micropaleontologist by training specializing in fossil diatoms and the stratigraphy of the Monterey Formation and related siliceous units around the Pacific Rim, she is a Fellow of the California Academy of Sciences and the Geological Society of America. Lisa was the inaugural recipient of the GSA Bromery Award for Minorities in 2008, an honor bestowed upon a geoscientist who has been instrumental in opening the geoscience field to other minorities. As the Principal Investigator of the SF-ROCKS (Reaching Out to Communities and Kids with Science in San Francisco) and SF-METALS (Minority Education through Teaching and Learning in the Sciences) programs, Lisa trains and guides diverse groups of students in wide-ranging geoscience learning experiences. She recently served on a National Academy of Sciences working group on Trends and Opportunities in Federal Earth Science Education and Workforce Development. As the education director at the UCMP, Lisa develops and disseminates learning materials on evolution and the Earth's biota, global climate change, and the nature and process of science. Lisa earned degrees from San Francisco State University (B.A. in Geology) and the University of California at Santa Cruz (Ph.D. in Earth Sciences).

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