

UC SANTA BARBARA

# THE *Current*

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## **Genomic Sequencing of Marine Sponge Published; Revealed Early Genetic Complexity and Roots of Cancer**

This week's publication of the complete genomic sequence of a living marine sponge reveals genes dating back hundreds of millions of years -- a result far exceeding the expectations of the scientific world.

Four scientists from UC Santa Barbara contributed to the sequencing of the genome of a Great Barrier Reef marine sponge, from a 650 million-year-old group of organisms -- a project that indicates there were astonishingly rich genetic resources available at the dawn of the animal kingdom. The sequencing also reveals some basic information about cancer. The findings are published in the August 5th issue of the scientific journal *Nature*.

"This is a milestone sequence," said Kenneth S. Kosik, co-director of UCSB's Neuroscience Research Institute (NRI) and Harriman Chair in Neuroscience Research. "This sponge is the most basal animal for which we have a genome."

A genome represents all biological information required to create and maintain an organism. DNA is the language of the genome, and DNA is separated into genes that give directions for the creation of discrete parts of any organism. The entire genome

of the sponge *Amphimedon queenslandica* is available at:

<http://www.ncbi.nlm.nih.gov/sites/entrez?db=genomeprj&cmd=Retrieve&dopt...>

Kosik explained that the evolutionary origin of animals was marked by the ability of individual cells to assume specialized properties and work together for the greater good of the entire organism. "The sponge represents a window on this ancient and momentous event," he said. "Curiously, the cells of a sponge bear little resemblance to cells found in the rest of the animal kingdom. For example, sponges lack neurons; however, the sponge genome reveals the presence of many genes found in neurons." (The Kosik and Oakley research teams published this finding in 2007, in the journal PLOS One. See: <http://www.ia.ucsb.edu/pa/display.aspx?pkey=1612>)

The sponge genome reveals that, along the way toward the emergence of animals, genes for an entire network of specialized cells evolved. "This network laid the basis for the core gene logic of organisms that no longer functioned as single cells, but as a cooperative community of specialized cells -- all geared toward the survival of a complex multicellular creature," said Kosik.

Co-author Todd Oakley, professor in UCSB's Department of Ecology, Evolution & Marine Biology, explained that this work also helps scientists to understand cancer. "Once there is a transition from single cell to multicellular organisms, conflict is set up between the different cells of the multicellular organism," said Oakley. "It is in an individual cell's best interest to keep replicating, and this actually is what cancer is -- the uncontrolled replication of cells in the body."

Evolution had to solve the problem of how to police this uncontrolled replication, Oakley explained. Normally, body cells don't replicate out of control because there are policing mechanisms in place. When these policing mechanisms break down, cancer develops. "So in the history of animals, we can see this link with cancer, because the genes that are involved in the transition to multiple cells during evolution are also known to be linked to cancer," Oakley said.

As a neuroscientist, Kosik has great interest in synapses, which have a unique structure. The sponge has no neurons; however, it has the genes that encode for proteins which are used in other animals to build synapses. Synapses are a set of proteins that allow two neurons to talk to each other. They also allow a neuron to talk to a muscle and make it move. No other cells have synapses.

Kosik emphasized that scientists must go far back in evolutionary time in order to understand the origins of the brain, neurons, and synapses. "You really have to go back to the beginning of animals to understand what happened that led to the awakening of the human brain," he said.

"We had asked, 'Can we look at the evolutionary origins of the synapse?' " said Kosik. He explained that the marine sponge is called the most basal of all animals because the sponge ancestor probably branched off first from the original animal, before any other existent lineage.

"You had some ancestral animal that is long-since extinct, and its descendants became these modern-day sponges that we have, and there were other descendants that became the rest of the animal kingdom -- from jellyfish to baboons," said Kosik. "We speak of the sponge as being this earliest branching phylum, or group of animals. What distinguishes the sponge from all the other animals is that it does not have any nervous system or synapses."

He explained that the conclusion of that early work -- the finding that genes that encode a synapse are present in the sponge -- has important implications. "The conclusion of that paper said that what evolution did was exaptation," said Kosik. "This is a very important technical word. Evolution takes something that was evolved for one purpose and uses it for something else. Nature used this still-mysterious sponge structure to make the synapse, an exaptation of certain genes, which then became a key part of the nervous system."

Kosik said that another reason the discovery was important is that one of the ways that some anti-evolutionists have criticized evolution as an idea is by using the term "irreducible complexity." In other words, they say that the biology of certain organs is too complex to have developed through evolution. "How do you evolve an eye?" asked Kosik. "An eye is very complex, you can't have half an eye. You need a whole eye to function. If you are missing a piece, it is not an eye. How do you get the whole eye to evolve? This has been something that people who have criticized evolution have not understood."

Critics of evolution pose irreducible complexity as a problem. "The evolutionary biologists have very good answers to that question," said Kosik. "One of them is the following result: A synapse looks like it is a structure that you cannot take apart; if you did, it would lose its function. In the sponge, nature clearly took it apart. And a

piece of it is functioning very well in a species that has been quite successful for the last 650 million years."

Kosik explained further the importance of new information regarding evolution. Long before the current paper was developed, co-author Bernard M. Degman allowed the UCSB research teams to look at the preliminary sequence data. They were very surprised to find that, even though the sponges do not have synapses or neurons, they have the genes for synapses and neurons. The genes were there but they weren't making the structures -- which is the finding Kosik and Oakley published in 2007. "This work raised a lot of questions," he said. "One obvious question is: What are the genes even doing there if they don't have neurons or synapses? We still don't know the answer to that question."

A co-author who worked closely with Kosik at UCSB's NRI is postdoctoral fellow Cecilia Conaco. Additionally, co-author and graduate student David Plachetzki worked in Oakley's lab on this project; he has since moved on to a postdoctoral fellowship at UC Davis. Co-author Bernard M. Degnan is now based at the University of Queensland in Brisbane, Australia; he worked at UCSB several years ago.

All of the gene sequences were determined at the Joint Genome Institute (JGI) located in Walnut Creek, Calif., and operated by UC for the Department of Energy. In all, 33 scientists contributed to the paper. The lead author, Mansi Srivastava, is based at UC Berkeley's Center for Integrative Genomics and the Department of Molecular and Cell Biology, as well as the Whitehead Institute for Biomedical Research in Cambridge, Mass. The senior author, Daniel S. Rokhsar, is based at UC Berkeley and JGI.

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