The origin of animals and disease found on The Great Barrier Reef

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This is an adult sponge of the species *Amphimedon queenslandica* living with an octocoral off Australia's Great Barrier Reef. Credit: Maely Gauthier

(PhysOrg.com) -- Professor Bernard Degnan from University of Queensland's School of Biological Sciences has led an international team of scientists to sequence the genome of the first marine animal from Australian waters.

In another breakthrough, the sequencing of the sea sponge genome offers unprecedented insights in to the origin of the animal kingdom and how ancient genes contribute to human biology and health.

The study, published in *Nature* this week, illustrates how all contemporary animals, from sea sponges and corals to butterflies and humans, evolved from ancient and long-extinct ancestors - the very first multicellular animals.

"This incredibly old ancestor possessed the same core building blocks for multicellular form and function that still sits at the heart of all living animals, including humans," Professor Degnan said.

"We have found that sponges and humans, and their common ancient ancestor, share an amazing number of genes.

"Given how simple sea sponges are this was completely unexpected.

"It now appears that the evolution of these genes not only allowed the first animals to colonise the ancient oceans but underpinned the evolution of the full biodiversity of animals we see today."

As the deep animal fossil record is highly fragmented and essentially non-existent, Professor Degnan turned to the most modern of the biological sciences to uncover this ancestor: genomics.

"Searching for commonalities among the genomes of modern species whose lineages separated before the Cambrian period allowed me to develop a high-resolution picture of the ancestral animal genome," he said.

"Genes and genomic features that are shared between distant species, such as sponges and humans, are likely to be inherited from their common ancestor.

"Genomics essentially allowed us to time travel back at least 600 million years to have a glimpse at the very first multicellular creatures to roam our oceans."

In 2003, Professor Degnan, along with his primary collaborator, Professor Dan Rokhsar of University of California Berkeley, convinced the US Department of Energy Joint Genome Institute to sequence the Great Barrier Reef sponge genome Amphimedon queenslandica.

"Simple sea sponges have a genome of remarkable complexity," Professor Degnan said.

"It includes all of the gene families necessary for the development and functioning of complex animals, including humans and from this comparison we have been able to reconstruct the last common ancestor between humans and sponges."

The unanticipated and incredible sophistication of this 600+ million year ancestor rewrites all the textbooks and destroys long-held views that the very first animals were nothing but simple balls of cells.

Essentially all the genomic innovations that we deem necessary for intricate modern animal life have their origins far further back in time that anyone anticipated, predating the Cambrian explosion by tens, if not hundreds, of millions of years.

"These studies now allow us to provide a new and robust definition of the animal kingdom that includes a long list of genomic characters unique to animals," Professor Degnan said.

"These underpin the primary features of animal life: sex, development, cell growth and differentiation - including stem cells - and immunity.

"It is these genomic innovations that allowed animals to transcend their microbial ancestry, to grow big and to move into the macroscopic world they inhabit today.

"Incredibly we have be able to get particular sponge genes to function in the fruit fly, frog and even human cells, demonstrating the essential role of these genes in all animals."

In a cruel twist, it was the dysfunction of these very same mechanisms in modern animals that drove diseases such as cancer, in which controls on multicellularity failed, and autoimmune disorders in which distinctions between self and non-self were disrupted, he said.

"Astonishingly, this is clearly manifested in our 'first-animal' genome. We found that more than 90 percent of all the genes associated with human disease were present in animals living over 600 million years ago," Professor Degnan said.

"Another amazing feature sponges share with humans are stem cells.

"In fact, sponges have the ultimate stem cells with features of great interest to biomedical research.

"All adult sponge cells can become a stem cell that can convert back in to any cell type.

"By looking at sponge stem cells we can understand the absolute core requirements of their formation.

"This in turn could inform human stem cell biology and medicine.

"This marine genomic information sheds light on a range of other modern applications.

"Sponges produce an amazing array of chemicals of direct interest to the pharmaceutical industry.

"They also biofabricate silica fibres directly from sea water in an environmentally benign manner, which is of great interest in communications.

"With the genome in hand we can decipher the methods used by these simple animals to produce materials that far exceed our current engineering and chemistry capabilities."

Sponge Facts:

• Sponges are the oldest known lineage of animals still living on the planet today - they are 600+ million years old.

• Sea sponges have the ability to regenerate all cells and all body parts from a single adult stem cell.

• Sponges have the capacity to synthesise complex bioactive compounds that have made them major targets of pharmaceutical and other industries.

• Sponges can produce high-grade, ultra-strong glass fibres using nothing but sea water at room temperature and in an environmentally benign manner.

• This is the first marine genome sequenced from the Southern Hemisphere.

• The sponge genome project was funded by generous support from both the Australian Research Council and The US Department of Energy Joint Genome Institute.

• The US Department of Energy Joint Genome Institute was an important contributor to the human genome project.

• The Cambrian explosion occurred around 530 million years ago, and is when most major groups of complex animals first appeared in the fossil record.

Provided by University of Queensland