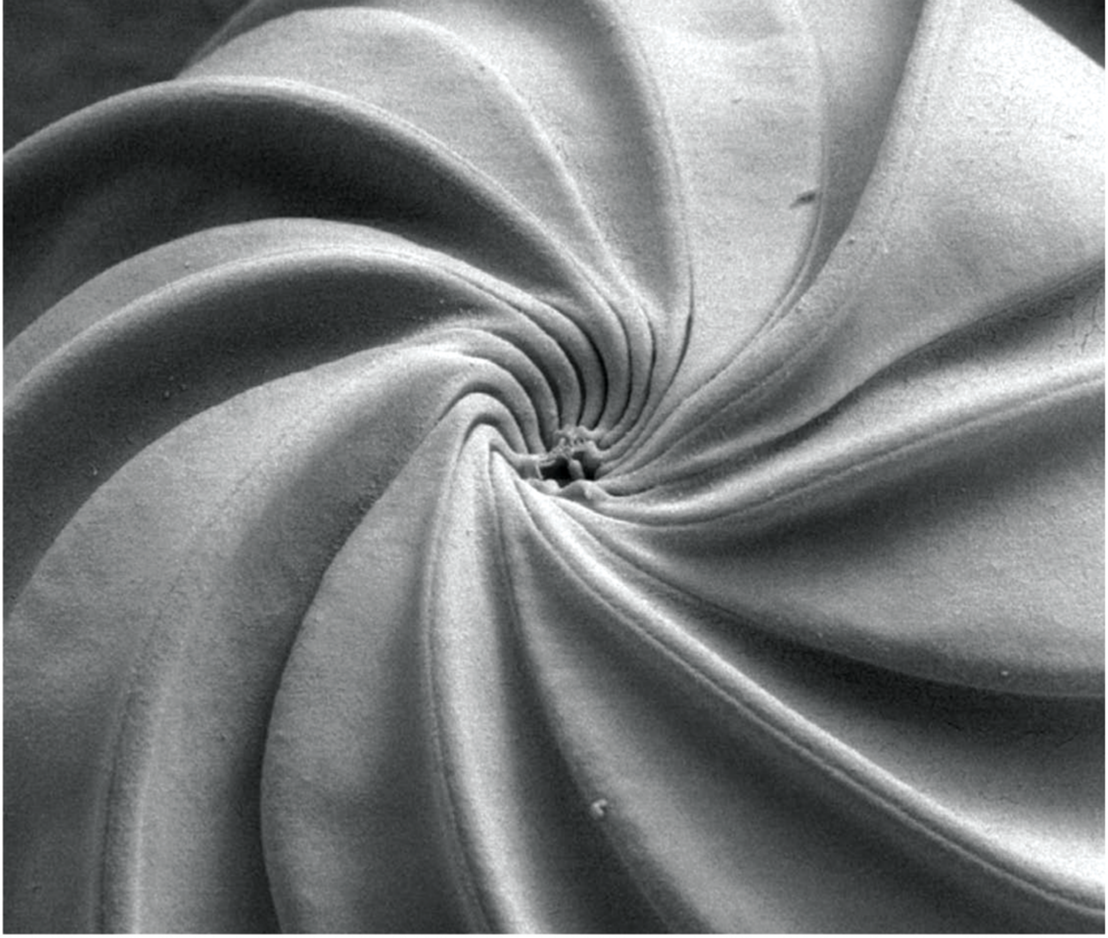


Photos> Brian Leander

BRIAN LEANDER IS EXPLORING THE HIDDEN WORLD OF MICROBIAL LIFE AND REDEFINING TRADITIONAL SCIENTIFIC TAXONOMY IN THE PROCESS

evolution revolution

Peering down his microscope, Dr. Brian Leander, Assistant Professor of Zoology and Botany at UBC Vancouver, eavesdrops intently on a hidden and foreign world – one that defies ordinary human experiences. This is the world inhabited by microscopic, primarily single-celled organisms, which are easily the most diverse and abundant life forms on the planet. Although microbial organisms are generally assumed to be fairly simple in form, the microbes that Leander works on tend to have extremely complicated shapes and sizes.

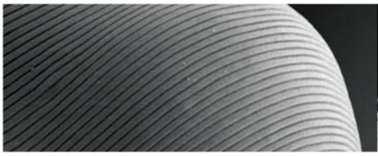
"We're at the edge of knowledge because we're looking at organisms people have never even dreamed of or couldn't even dream of. If you look at a movie like *Monsters Inc.,* you see all sorts of creatures built from familiar things pieced together in strange ways – a variety of eyes, arms and maybe an octopus tentacle or two. The things we're describing go beyond that limited field of human imagination."

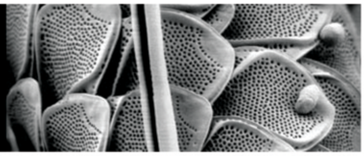
Working at the microscopic level gives Leander a sense of the structures and processes that are fundamental to all life, ranging from relatively complex forms to simpler, more streamlined forms. By identifying shared characteristics that unify diverse groups of species, like the wings of insects or the feathers of birds for example, Leander works to untangle the complicated, and often convoluted, evolutionary histories that gave rise to those characteristics in an effort to understand some of the deepest relationships of life. But while fascinating to observe, Leander is usually confronted with the puzzling conundrum of how to classify organisms that appear, by all accounts, to defy all traditional scientific taxonomy.

"If you look at the history of scientific classification, most people are inclined to pigeonhole [eukaryotic] life into one of two familiar categories: plants or animals. But there are about thirty other groups of eukaryotes out there that are just as dissimilar as plants are to animals – and they're thriving at a microscopic scale that is far-removed from the human scale of ordinary experiences," says Leander. "By investigating these groups, we're finding out that our traditional notions are wrong. This is resulting in a complete dismantling of the plant-animal concept which will have a major ripple effect on our overall understanding of phylogenic relationships."

Fueling this breakdown of the traditional apicomplexan parasites that infect vertebrates are more closely related to each other than to marine gregarines. Accordingly, treatments of *Cryptosporidium* infections have usually involved drugs known to work on other apicomplexan parasites of vertebrates, namely, coccidians, but these drugs have shown to be totally ineffective. Our work is showing that between cells is not so strong in these species, we can reconstruct the intermediate stages that occurred as part of the process of evolving highly integrated structures."

By exploring organismal diversity and reconstructing how certain character states evolved over time through detailed comparative analyses of morphological features and gene sequences, Leander's





"Understanding how cells came together to form a larger individual organism gives us great insight into how our own bodies evolved and work now."

scientific naming system is Leander's work on convergent evolution, or how fundamentally different lineages of eukaryotic life have developed (superficially) similar features in response to similar environmental conditions over long periods of time. Understanding convergent evolution is critical for inferring broad patterns of organismal diversification (macroevolution) and for recognizing the fundamental biological problems that organisms face on Earth (natural selection) and the ways that different groups of organisms have solved them. Research in the Leander lab is uncovering several interesting examples of convergence at the cellular level in a variety of marine environments involving predatory, photosynthetic and parasitic organisms.

Work on marine parasites, for instance, is providing solid evidence for how different lineages of parasites took independent routes to the same hosts and converged on some similar characters. One particular example relates to the parasite *Cryptosporidium,* which infects the intestinal systems of livestock and humans, has the potential to kill hosts with compromised immune systems and is infamous as a causative agent of disease outbreaks associated with contaminated public water supplies.

Leander explains: "A large group of eukaryotes – called the Apicomplexa – contains both gregarines, which are parasites of marine invertebrates and insects, and several important parasites of terrestrial vertebrates, including humans (e.g. *Plasmodium* and *Cryptosporidium*). The general paradigm is that the *Cryptosporidium* is only very distantly related to other terrestrial parasites and appears to be an independent offshoot of marine gregarines. Therefore, this emerging phylogenetic context indicates that there are bigger biological differences between *Cryptosporidium* and other terrestrial apicomplexans than what has been previously assumed, and this helps explain why the anti-coccidial drugs used to try and kill *Cryptosporidium* aren't working."

Leander stresses that the primary aim of his lab is not to look at *Cryptosporidium* in the hopes of developing drug targets that would kill these parasites in humans. However, he acknowledges that his research on marine relatives could serve as a means to this end by giving biomedical researchers the context needed to pursue these targets independently.

Instead, Leander stays focused on the science of biodiversity and evolutionary biology and his work provides a wide range of insights that influence the way we think about our relationship to the rest of nature. "Our research sits in the nexus between the origin of the cell and the many different origins of multicellularity. As humans, we want to understand how our highly multi-cellular bodies came to be, how our cells interact with each other and how disorders in human bodies come and go. Understanding how cells came together to form a larger individual organism gives us great insight into how our own bodies evolved and work now. Several less differentiated organisms offer relatively straightforward models to address these questions. Because the degree of integration overall goal is to make significant contributions to an all-species *Encyclopedia of Life* (www.eol.org). This research is also intended to provide compelling evidence for historical transformations in morphological form that are associated with major transitions in the evolution of life.

Although his research often leads to many perplexing sources of data, it is Leander's curiosity that ultimately drives his exploration into the relatively hidden and foreign world dominated by microbes and that leads him to discover unconventional sources of knowledge.

"On one level, convergent evolution at the cellular level is a nuisance because it hinders our ability to interpret the fossil record and to understand who is related to whom, which then muddles with the accuracy of our scientific system of names. On the other hand, convergent evolution is fantastic because it informs us about the selective forces operating at microbial scales and broad patterns of macroevolution during the earliest stages of Earth's history."

Brian Leander is a CIFAR Scholar and Tula-CMDE Investigator. His work is also funded by the Natural Sciences and Engineering Research Council (NSERC), the National Science Foundation (USA), and the Canada Foundation for Innovation (CFI). Through programs like the Canadian Institute for Advanced Research (CIFAR – Integrated Microbial Biodiversity) and the Tula Foundation's Centre for Microbial Diversity and Evolution (CMDE), Canada is among the strongest groups of people in the world focused on microbial diversity.