The Earth has supported life for most of its 4.5 billion year history, but the first macroscopic organisms only appeared some 600 million years ago, during the Ediacaran. The enigmatic inhabitants of this time are referred to as the Ediacara biota, and are most famously known from Newfoundland, Australia, Namibia, and the UK. Their world was fundamentally different from our own, and many aspects of their biology and ecology remain a mystery. Ediacaran organisms are inherently problematic: they have no known extant or fossil relatives, and bear only a passing resemblance to anything alive today or throughout geological history. The late Ediacaran fossil assemblages of Avalonia represent some of the oldest evidence for complex macroscopic life, and are dominated by the frond-like rangeomorphs, an iconic group from the period characterised by their self-similar branching architecture.

The sea-floor on which these organisms lived was covered with microbial matgrounds, and burrowing behaviours had only just begun to evolve. This contributed to conditions that allowed the entirely soft-bodied Ediacaran organisms to be preserved in numbers unprecedented in the fossil record. Even without knowing their place on the tree of life, it is possible to resolve key aspects of the ecology of these enigmatic organisms. By adopting a holistic approach combining study of the populations with the environment in which they lived, I have identified distinct ecological strategies within this group, including adaptation to competition and, conversely, adaptation to withstand sediment disturbance. Environmental disturbance plays a major role in structuring modern communities, and this held true for these oldest complex communities in the fossil record. The sum of this work is the first environmentally-sensitive model for ecological succession in Avalonian rangeomorphs. These ancient communities will ultimately help us to understand how modern-style ecosystems gained their first footholds during this critical interval in the history of life.