

IWM #25 Abstract [2461/2500 characters]

Monte Carlo simulation of somatic twist in ancient marine worms

A somatic twist was thought to occur during the invertebrate-to-vertebrate transition 550 million years ago, resulting in a dorsoventrally inverted body plan for all vertebrates leading to decussation in the corticospinal tracts (Kinsbourne, 2013). Our research explored the plausibility of an evolutionary pathway that connects ancient marine worms to the protochordate *Pikaia* (aka the 'first fish'). But what force(s) could possibly drive the biomechanical tissues of ancient marine worms to perform a somatic twist?

To recreate evolutionary events inside a computer, our experimental design requires Monte Carlo simulation of feast and famine cycles. Our research purpose is to observe how the first digital *C. elegans* worm from the OpenWorm Project evolves *in silico* to become the first fish, whose fossil was initially thought to be that of a "big fat annelid worm" when first discovered in the Burgess Shale, with a dorsoventrally inverted body plan after a somatic twist when given bountiful food sources over evolutionary time. Our hypothesis that underlies the simulation: underwater buoyancy from generations of feeding drove the somatic twist of ancient marine worms.

We downloaded an open source worm model from the OpenWorm Project and installed the Sibernetik software, which provides visualization of worm locomotion driven by a physics engine that simulates the hydrodynamics interaction between the environment and the body of the worm. We gathered model parameters for biomechanical matter within an aquatic environment and adjusted them according to cycles of feast and famine, in order to evolve successive generations of marine worms. We modeled feast and famine cycles stochastically using a Markov chain to drive proportionate changes of parameters characterizing each ring of the marine worm: body mass and volume, thus density and buoyancy based on the Archimedes' Principle. Our approach of integrating Monte Carlo simulation of feast and famine cycles over evolutionary time with a hydrodynamics engine for worm locomotion is a novel aspect of our research.

Monte Carlo simulation shows great promise as a practical new approach to conducting evolutionary biology experiments *in silico* when combined with Sibernetik and OpenWorm. Our research work is ongoing and we would like to share our interim progress in various design aspects of evolutionary modeling for a digital worm as well as practical computational challenges encountered along the way. We hope to ultimately be able to provide *in silico* validation for Kinsbourne's somatic twist theory, supported in turn by our hypothesis that underwater buoyancy force drove somatic twist in marine worms during evolutionary times when food was bountiful.

References:

Kinsbourne, M. (2013). Somatic twist: A model for the evolution of decussation. *Neuropsychology*, 27(5), 511–515. <https://doi.org/10.1037/a0033662>

Project Description: A somatic twist was thought to occur during the invertebrate-to-vertebrate transition 550 million years ago, resulting in a dorsoventrally inverted body plan for all vertebrates. My hypothesis is that underwater buoyancy force drove the biomechanical tissues of ancient marine worms to perform a somatic twist. My experimental design requires Monte Carlo simulation to recreate evolutionary events inside a computer, so that I can observe how the first digital worm organism evolves to become the first fish when given bountiful food sources.
