Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.31737

On the Origin of Information Dynamics in Early Life

ROBERT A GATENBY[1], JILL GALLAHER[1], HEMACHANDER SUBRAMANIAN[2], EMMA U HAMMARLUND[3] AND **CHRISTOPHER J WHELAN**[1]

[1]Moffitt Cancer Center
[2]National Institute of Technology
[3]Lund University

We hypothesize that predictable variations in environmental conditions caused by night/day cycles created opportunities and hazards that initiated information dynamics central to life's origin. Increased daytime temperatures accelerated key chemical reactions but also caused the separation of double-stranded polynucleotides, leading to hydrolysis, particularly of single-stranded RNA. Daytime solar UV radiation promoted the synthesis of organic molecules but caused broad damage to protocell macromolecules. We hypothesize that inter-related simultaneous adaptations to these hazards produced molecular dynamics necessary to store and use information. Self-replicating RNA heritably reduced the hydrolysis of single strands after separation during warmer daytime periods by promoting sequences that formed hairpin loops, generating precursors to transfer RNA (tRNA), and initiating tRNA-directed evolutionary dynamics. Protocell survival during daytime promoted sequences in self-replicating RNA within protocells that formed RNA–peptide hybrids capable of scavenging UV-induced free radicals or catalyzing melanin synthesis from tyrosine. The RNA–peptide hybrids are precursors to ribosomes and the triplet codes for RNA-directed protein synthesis. The protective effects of melanin production persist as melanosomes are found throughout the tree of life. Similarly, adaptations mitigating UV damage led to the replacement of Na^+ by K^+ as the dominant mobile cytoplasmic cation to promote diel vertical migration and selected for homochirality. We conclude that information dynamics emerged in early life through adaptations to predictably fluctuating opportunities and hazards during night/day cycles, and its legacy remains observable in extant life.