Center for Theoretical Biological Physics

SEMINAR

"Oxidative Stress and Antioxidant Protection Antedate the Great Oxidation Event"

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Abstract: It is widely assumed that antioxidant systems originated after the great oxidation event (GOE) 2.3 Ga ago. However, ultraviolet (UV) radiation at the ocean surface was more intense in the Archean (3.5-2.5 Ga ago, by the time photosynthetic organisms evolved) than today, owing to the absence of a protective ozone layer. Because this radiation generates reactive chemical species (RS), could the Archean ocean be rich enough in RS to favor the evolution of antioxidant defenses despite the low atmospheric oxygen? We addressed this question through kinetic modeling of RS formation in the ancient and present oceans, together with phylogenetic analyses of antioxidant enzymes. Simulations point to a substantial reactivity of the Archean environment towards proteins and nucleic acids. Further, the reactivity towards nucleic acids in the cytoplasm owing to UVC radiation near the surface of the Archean ocean was higher than that ensuing from superoxide and hydrogen peroxide concentrations during aerobic growth in present-day *E. coli* cytoplasm. These results suggest a selective pressure on ancient photosynthetic organisms favoring the development of defense mechanisms against oxidative damage to their genomes and proteomes. Phylogenetic analyses indicated that glutathione and ascorbate synthesis, glutaredoxin, Cu-Zn superoxide dismutase, A/G DNA glycosylase and the thioredoxin reductase/thioredoxin/peroxiredoxin system evolved in the Archean eon, prior to the GOE, whereas Fe/Mn superoxide dismutase, catalase, peptide methionine sulfoxide reductase, glutathione peroxidase and tocopherol synthesis evolved during the GOE. These estimated times of origin are in keeping with model-predicted RS concentrations over time and further support the notion that the antioxidant systems started to evolve before the GOE.