

**PROCEEDINGS  
OF THE  
SIXTH SYMPOSIUM  
ON THE  
NATURAL HISTORY OF THE BAHAMAS**

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**Cover Photo: Dr. Lynn Margulis, Symposium Keynote Speaker, describes the structure and ecology of living stromatolites. Some, visible as grayish mounds near her feet, line the shore of Storrs Lake whereas others occur farther out in deep water. (See paper by D. C. Edwards, this volume).**

**Back Cover Photo: Group photo of the 6th Symposium participants and speakers.**

**Photos by Paul Godfrey (Computer processed prints by Lanny Miller).**

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## **FIVE KINDS OF LIFE OR IT IS TIME TO PUT LIFE BACK INTO BIOLOGY**

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My oral presentation on June 9, 1995, attempting to help the lively participants help their colleagues put the life back into biology, was simply the verbal video-illustrated version of two recent publications both of which have appeared since that meeting. The primary paper: "Archaeal-Eubacterial mergers in the origin of Eukarya: Phylogenetic classification of life" was published in the *Proceedings of the National Academy of Sciences* (PNAS) (Margulis, 1996). That paper presents a carefully defined, useful and complete evolutionary classification of life. The completeness refers to the fact that all known groups of organisms (autopoietic entities composed of cells) are unambiguously included. The major point of this scheme is the recognition that prokaryotic cells are single systems (monads); whereas, all eukaryotic cells are chimeras, i.e., they are products of microbial symbiogenesis (polygenomic dyads, triads, etc.; bearers of supernumerary genomes). In this new systematics, the anachronistic and imperialistic terms "Kingdom" and "Domain", delimiting the most inclusive (or largest) taxa, are replaced by biological groupings. The highest taxa recognized are the dichotomy: Prokarya, which include single-genome organisms consisting of prokaryotic cells, and Eukarya, which are all composite genome organisms that originated by bacterial symbiosis and consisting of eukaryotic cells. Eukarya are polyheterogenomic: single individuals incorporated (originally membrane-bounded genomic systems, cells, from individuals of at least two different types of microbes fused). The earliest Eukarya, heterotrophic anaerobic swimmers, hypothetically evolved from permanent whole-cell fusion between Archaea (such as *Thermoplasma*-like organisms) and Eubacteria (such as *Spirochaeta*-like organisms). In support of this classification,

which reunites all bacteria as Prokarya (Monera) and subdivides Eukarya into Protoctista, Animalia, Fungi and Plantae, are new molecular biological data. Especially pertinent are the several eubacterial genes along with an essentially archaeobacterial protein synthetic machinery in the cytoplasm of Archaeoprotists (anaerobic eukaryotes such as trichomonads and diplomads that never acquired mitochondria or plastids). Life-history, molecular genetic, biochemical and other analyses, as well as discoveries from the fossil records, especially those from the Proterozoic eon, I claim, far more appropriately support this two-tiered five kingdom classification scheme than they do the three domain (Archaea, Bacteria, Eukarya) of General Carl Woese, his captains, corporals, sergeants, other officers and their foot soldiers who so dominate today's microbiological hegemony. A key element of the cell symbiogenesis argument is the recent discovery of centriole-kinetosome DNA in some termite (*Cryptotermes brevis*) archaeoprotists known as *Calonympha grassii* (Dolan and Margulis, submitted to *Symbiosis*; Margulis and Dolan, submitted to the *Sciences*.) With this discovery, the ultimate chimeric nature of the nucleated cells is established.

Whereas the PNAS paper details the argument for professional biologists, especially molecular and cell biologists, our other publication is a profusely illustrated book answering the question "What is Life?" (Margulis and Sagan, 1995) as well as the question can be answered by science today. The book, presenting essentially the same argument as the PNAS paper but in prose approachable by all those interested, develops carefully the historical context for the current big trouble in biology. René Descartes, reflecting the Judeo-Christian culture in which all westerners have been embedded for

centuries, privileges the soul-bearing *Homo-sapiens*. We, it is claimed, are superior to all other forms of life. Cartesian thought provides us with a license to "reduce" all other forms of life to the mechanical. The language has changed: in today's world the reduction is to the programmed and the programmable. This cultural insistence on the search for "mechanisms" in live beings is only an unwarranted assumption, a legacy of poverty that is seldom confronted directly by professionals or discussed publicly. In "What Is Life?", we evade no issue. Furthermore, we never attempt even to avoid the unsettling problems of relationships among our 30 million or so planetmates. A more equitable and valid relationship in which we recognize that there is only a single diversified biota on Earth into which we are integrated as a relatively recent and rapidly growing part is intrinsic to our new teaching materials (Trash and Garbage, Five Kingdoms teacher's guide and poster, Gaia to Microcosm videos). We invite you to use them with your classes.

A third edition of "Five Kingdoms of Life" (Margulis and Schwartz, 1997) presents the details of the classification scheme, whereas "Symbiosis in Cell Evolution," 2nd edition (Margulis, 1993) describes in great detail, using primary literature, the science behind it. Experience with the splendor of nonhuman life is shared in our recently published "Gaia to Microcosm" video series (Margulis and Sagan, 1996). Lois Brynes facilitated the production and publication of these classroom videos with Kendall-Hunt Publishers. The pivotal importance of the unsung protagonists of the Proterozoic drama becomes clear in both the "Handbook of Protoctista" (Margulis et al., eds., 1990) and the Glossary of Protoctista (Margulis et al., eds, 1994) and their accompanying CD-ROMs (Margulis et al., 1996).

Michael Dolan, an advanced graduate student, and I were delighted by our discovery of *Staurojoenina* in San Salvador termites. We are preparing a fuller account of this gorgeous protist (Dolan and Margulis, submitted to *Symbiosis*).

I have dwelt here on our laboratory's own contributions only because I was requested to do so by Paul Godfrey and Craig Edwards. I am grateful to them and to you for

this opportunity not only to share our work, but also to have visited bird-laden, sunny (and buggy) San Salvador Island as well as the super stromatolites off Lee Stocking Island.

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