*Symbiosis*, 24 (1998) 173-178
Balaban, Philadelphia/Rehovot



**Meeting Report**

# Not all Symbioses are Microbial: Newfoundland's Whales and Fossils

## Trinity Bay, Newfoundland, Canada, July 11-15, 1997

LYNN MARGULIS[1]* and MICHAEL DOLAN[2]
*University of Massachusetts, [1]Department of Geosciences, USA.*
*Tel. +1 413 545 3244, Fax +1 413 545 3243; and [2]Department of Organismal and Evolutionary Biology, USA.*

With the help of UMass-Amherst's Donna Reppard in October of 1996 Lynn Margulis and Michael Dolan circulated a preliminary invitation to a small group of symbiologists and a whale expert. They encouraged their colleagues to join a tiny scientific workshop and openly discuss the importance of symbiosis in evolution. The idea was to combine firsthand experience with one huge symbiotic complex: the >500 organisms that comprise the symbioses easily recognized as the barnacle-studded New England humpback whale (*Megaptera novaeangliae-Coronula diadema* Darwin) with talk of mutual interest. They intended serious consideration of the concepts of the biologist Ivan Wallin and his magnum opus: Symbionticism and the Origins of Species, Williams and Wilkins, 1927) however ignored and unknown they may be today. They slated the meeting was scheduled to take place north of St. John at The Village Inn, Trinity Bay, Newfoundland Canada July 11-15, 1997.

As many readers of Symbiosis know Wallin, who died in 1961 just after the discovery of DNA in plastids and mitochondria, argued persuasively for the origin of these organelles as symbiotic bacteria. He developed the principle of "prototaxis", the innate tendency of one kind of organism to respond in a given way to another. To Wallin all organisms are prototactic, all react in predictable ways to others, members of different species. For Wallin some prototaxes (e.g., the ingestion of algae by ciliates) led to some symbionticism (e.g., permanent symbiotic associations, such as *Paramecium bursaria*). This series of processes of symbiont integration he considered to be the underlying

*The author to whom correspondence should be sent.

0334-5114/98/$05.50 

cause of both ontogenetic (embryological development) and phylogenetic (evolutionary) change.

Mature male humpbacks, all of them in nature, are clearly symbiotic with up to hundreds of barnacles on their long pectorals and their throats.

Boat trips during the day were planned: visits to the habitats not only of *Megaptera* to see them but other species of cetaceans (fin and minke whales).

Furthermore at a distance of only a few hours drive south of Newfoundland's capital, the city of St. John, lies a protected area of coastline, about 5 km long and only some 650 meters inland from the ocean's edge. Located at the southeastern tip of the Avalon peninsula, indeed the very southeastern tip of the Newfoundland and Labrador Province this area is formally protected by the Canadian *Wilderness and Ecological Reserves Acts*. A visit to this rugged fossiliferous coast, called Mistaken Point Ecological Reserve, was part of the original scheme.

For eleven of the workshop participants the entire plan was accomplished: we saw first-hand the site of deep water marine prePhanerozoic fossils on a clear cool windy day along a gorgeous stretch of coast. Bathed in gleeful sunshine so rare in this part of the world we joined caribou as we scrambled past the sphagnum and over the heath on our 6 hour hike. Whether the fossils are remains of extinct animals or giant colonial protoctists dependent on their symbiotic autotrophs is still an unsettled scientific problem, in our view. In either case they represent the power of ancient symbioses to leave their mark in the fossil record. Mistaken Point is not only a World Heritage Site because of its outstanding "natural significance on an international scale" but in 1988 it was proclaimed the type locality for the prePhanerozoic/Phanerozoic boundary, a time-rock division dividing the preCambrian (Vendian) from the Cambrian Era.That Vendian-Tommotian boundary is now set at 541 million years ago.

In the end (and only when the Richard Lounsbery Foundation of New York City funded most of the expenses) the meeting was called: *Symbiosis: Rhythms, Morphogenesis and Speciation, or Whale Watching for a Reason.*

Speakers included graduate student Michael Dolan (University of Massachusetts, USA), Prof. Ricardo Guerrero (University of Barcelona, Spain), Prof. Radhey Gupta (McMaster University, Canada), Prof. Lynn Margulis (University of Massachusetts, USA), Dr. Roger Payne (Long Term Research Institute, USA and UK), Dorion Sagan (Sciencewriters, USA), Prof. Jan Sapp (York University, Ontario, Canada) and Prof. James Shapiro (University of Chicago, USA).

James Shapiro showed the naiveté of the assumption that bacteria, even in a clone on a petri plate, behave as independent entities. Swimming behavior, growth and other responses clearly are a function of neighbor proximity, colony age and other factors determining the social lives of gliding myxobacteria, *Pseudomonas, E. coli* and others.

Jan Sapp reviewed the general social ambience and certain events in the history of both symbiosis and cytoplasmic genetics research. He made it easy to

see how the importance to science of the findings in both fields were (and still are) eclipsed by the marginalization of most of the practitioners partly because of the requirement for expertise in more than a single taxon.

Radhey Gupta, on the basis of sequences of amino acids in many proteins, showed conclusively that "Archaea", far from being a third lineage of life, belong to that ancient group of bacteria that includes the gram positive rods (his "monoderms"). He emphasized that the classical difference between gram positive and gram negative bacteria (his "diderms") is supported by molecular biological analysis and that the archaebacteria fall into at least two groups with monoderms. Most importantly for the meeting, his data strongly support a chimeric (i.e., symbiogenetic) origin for all eukaryotes, even the protists living in anoxic environments, the motile amitochondriates. His assertion is that the symbiogenetic origin of eukaryotic cells occured between a diderm (gram negative bacterium but not any closer to spirochetes than to many other groups) and an archaebacterium, probably of the thermoacidophilic sort.

Ricardo Guerrero, using a small karstic lake in northeastern Spain (Lake Cisó, Gerona) as an example, showed how an entire community of prokaryotes acts as an entity in the physiological recycling of elements, especially sulfur and nitrogen. This lake displays predictable growth and death of its component cells, and with boundaries determined geomorphologically, comprises a loosely symbiogenetic organism.

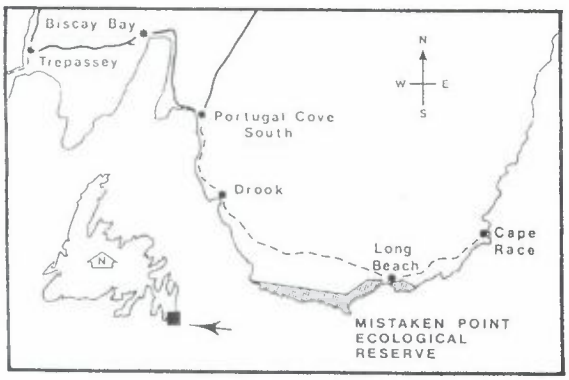
Michael Dolan showed possible "body farming" in a termite protist *Staurojoenina assimilis* where epibiotic bacteria seem to grow inside and migrate (perhaps along microtubules) to the surface of the hypermastigote where they are aligned in a regular longitudinal pattern. He also presented the status of his work on the search for kinetosome-centriole DNA in multinucleate parabasalids (calonymphids). His cytological preparations of fluorescent DNA were complimented by videographs of live protists.

Roger Payne documented a remarkable symbiosis between the Right whale (one type we did not see) and cohesive smaller epibiotic communities that include at least two species of decapod crustaceans (two kinds of "whale lice"). Like the body farming in *Staurojoenina,* the epibionts live only on certain portions of the whale's head and other surfaces. These reflective (white) communities generate a distinct pattern of individuality for the complex. Whale tissue in these certain portions hypertrophies and the hypertrophied protrusions serve as food sources for the decapod symbionts. The dark uninhabited skin contrasts markedly with the inhabited white patches.

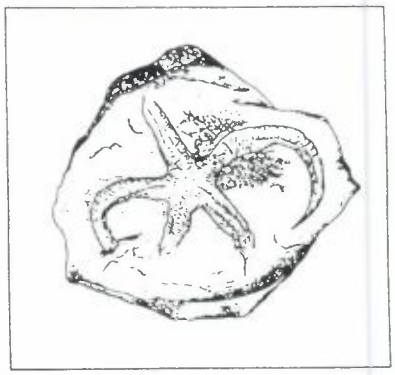
Lynn Margulis provided evidence for the symbiogenetic first appearance of amitochondriate eukaryotes, "archaeprotists". She showed that steps hypothesized for the origin of eukaryotes from motile gram negative bacteria by symbiosis with archaebacteria still can be observed in living microbes. Although her evidence comes from work entirely independent of the protein sequence analysis of Gupta, their views are complementary in most details.

Dorion Sagan analyzed "living matter" as a long-lasting set of energy-dissipative structures with a peculiar history. Placing life in the context of a universe that follows the rules of thermodynamics, he suggested that symbioses, in cases that become stable, are more capable than the unassociated partners in efficiently breaking down the solar gradient.

The trip was funded in part by the Lounsbery Foundation (Martha Norman, President) and by the UMASS Graduate School. Without Lounsbery support the accompanying members of the trip: UMASS graduate students Ugo D'Ambrosio and Andrew Wier, Smith College Ada Comstock scholar Annie Thompson, Clark University Ph.D. candidate Sona Dolan, and three boys (Eric Mathews, Tonio Sagan and Simon Thompson) could never have attended. The remaining expenses were paid personally by the participants, especially by Professor Margulis.




Southeast Newfoundland



Unidentified late Precambrian fossil

**Fig. 1 Mistaken Point** is at the southeastern tip of Newfoundland's Avalon Peninsula about 16 km southwest of Portugal Cove South. The protected area covers a strip of coastline about 5 km long and about 650 meters inland from the ocean's edge.

**Fig. 2 The Fossils.**
Most animal fossils show only the hard parts of the previously living animal. The soft parts usually disappear as they are crushed by the buildup of mud and sand. One of the features of Mistaken Point that makes it so unique is that many of the creatures were softbodied. They died when fine volcanic ash gently settled over them. The present fossils are impressions of the bodies made in the ash before they decayed. Some of them look rather like ferns that clung to the bottom with a structure called a "holdfast". Others may have floated free. They range in size from a few cm to 25 or 30 cm.
Fossils of similar age are found in few other locations — notably Russia and Australia. But the Mistaken Point site is unique because it is the only site that contains about 20 different kinds of organelles that lived in deep water. Mistaken Point is so important that it is also being considered as World Heritage Site. World Heritage Sites are areas that have been identified as having "outstanding" cultural or natural significance on an international scale.

Mistaken point


Dorion Sagan (left) and Simon Thompson (right)

Left to right:
James Shapiro, Annie Thompson, Sona Dolan, Lynn Margulis, Michael Dolan, Roger Payne, Radhey Gupta, Andrew Wier, Christine Beamish (innkeeper) and Ricardo Guerrero.

Tonio Sagan (left) and Ugo d'Ambrosio (right)

Eric Mathews

Ted Winter. Guide, science teacher, librarian, local sage. Trepassey, Newfoundland.

Joan Shapiro