

Book Review: *The Symbiotic Habit*

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Angela E. Douglas. 2010. *The Symbiotic Habit*. Princeton University Press, Princeton, New Jersey. ISBN 978-0-691-11341-8, 202 pp, \$45.

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Intimate relationship has always existed with our triune Father, Son, and Holy Spirit. Long term and intimate relationships with his created beings are ubiquitous on planet earth and are of great interest to creation biologists who are focused on building a creation model of biological origins and diversification (Francis 2009, p. 163). Because our God is relational, the creation model predicts these ubiquitous multi-partner relationships. The term *symbiosis* was coined in 1879 by Anton de Bary and meant any association between different species (p. 5). Historically they have been characterized as mutual, parasitic, or commensal. Mutual symbiosis occurs when both organisms benefit, parasitic relations happen when one is harmed, and commensalism occurs when one partner seems benefited by the relationship while the other seems unaffected. However, this picture is not cut and dried because of the extreme complexity and variability of these interactions.

As the Daljit S. and Elaine Sarkaria Professor of Insect Physiology and Toxicology at Cornell University, Angela Douglas has provided a comprehensive overview of the current status of symbiosis in her book, *The Symbiotic Habit*. Her central purpose in writing was to “explore the symbiotic habit and how symbioses are formed and persist in both evolutionary and physiological time” (p. 22). The current thinking about symbioses as mutual, parasitic and commensal, according to Douglas, has two problems. First, this definition is no longer accepted by most general biologists today, and second, the relationships are so varied and complicated that general principles, except for a few situations, cannot be inferred. Therefore, the most widely accepted definition of *symbiosis* by current general biologists and dictionary lexicographers refers to “a long term association between different species from which all participating members benefit” (pp. 5-6). More specifically, it is felt that the mutual benefits between partners are those in which a controlling partner manages any conflicts that might arise in the association.

According to Douglas, these definitional parameters allow researchers to gain insights into the exchange of benefits between

partners and how these symbioses become established and persist. This definition is not without its problems because researchers must quantify the mutual benefits derived by each symbiont. For example, Douglas points to the chemosynthetic bacteria found in pogonophoran worms at deep sea hydrothermal vents and the luminescent bacteria found in deep sea angler fish. It is hard to envision designing an experiment where bacteria-free angler fish and pogonophorans could be generated and monitored in such inaccessible deep sea habitats in order to quantify the mutual benefits with their bacterial symbionts.

The book structure is divided into six chapters. Chapter 1 focuses on the reality that we live in a “symbiosis-rich world” and that defining and describing the significance of symbiosis is crucial because it is a “biological phenomenon of first-order importance” (p. 22). She argues that new traits can be produced by neo-Darwinian mechanisms and lateral gene transfer from phylogenetically different taxa. Symbioses may be an important mechanism of lateral gene transfer in the evolution of organisms. She believes that descent with modification alone is inadequate for explaining new traits, but quickly assures the reader that this does not necessarily contradict the current understanding of evolutionary processes. For example, she presents with great confidence that eukaryotic cells acquired ancestral cyanobacterial cells that eventually became the plastids found in plants (endosymbiotic theory). However, she doesn’t even begin to address the complex mechanisms of obtaining the correctly expressed genes involved with oxygenic photosynthesis, the needed integration of cellular machinery involved in photosynthesis, and the formation of enzymatic machinery needed for carbon fixation.

She goes on to describe many fascinating relationships in which she concludes that the “symbiotic habit is a significant source of evolutionary innovation” (p.24). For example, there are instances where one symbiont synthesizes a chemical compound that can protect the other from natural enemies. The bee wolf (Family Crabanidae) has a highly specific association with the bacterium *Streptomyces philantii*. The adult female bee has glands in her

antennae that contain colonies of these bacteria. When she lays her eggs, she transfers an inoculum to the brood cell. When the larvae are born, they take the bacteria from the brood cell and apply them to the silk of their cocoon (p. 17). Bioassay data indicate that the bacteria produce antibiotics which protect the pupa from fungal attacks.

Chapter 2 explores evolutionary origins and fates of organisms in symbiosis. Douglas spends a great deal of time discussing how possible evolutionary histories may have brought about these mutual relations. For example, there are ant/aphid symbioses in which ant species herd and protect aphids and in return the aphids provide high quality sugary egesta for the ant. Could the relationship between ants and aphids have begun as a predator-prey relationship? Ants tend to be generalist predators and one hypothesis is that before they took care of aphids, aphids became a poor source of nutrition and over time the sugary egesta were more important to protect than the aphid itself. It has been observed that ants will occasionally consume the aphids when they get more abundant or when other foods are not available. She hypothesizes that the preexistent behavior of the ants may have had something to do with their transition to tending. Some “ants solicit honeydew from hemipterans in essentially the same way as they induce nest mates to regurgitate food” (p. 28).

Chapter 3 investigates creature relational conflict and conflict resolution. If organisms enter into a reciprocal relationship, “reciprocity assumes that the cost of providing a service is lower than the benefit of receiving the reciprocated service from the partner” (p. 56). But the problem with such relationships is “why not eliminate the cost by accepting the service from the partner and provide nothing in return?” Historically, the above dilemma has been the model used to explain conflict in symbioses called the “Prisoner’s Dilemma”, developed by Dreschler and Flood in 1950 (p. 56). On the one hand, costs required by organisms to enter into a reciprocal relationship must produce equal net benefits for both. On the other hand what is preventing one of the partners from “cheating” by not providing a service and thereby obtaining all benefits to the detriment of the other? Douglas concludes that this model assumes that cost is inherent in order to produce a benefit and that the model should not be treated as an accurate representation of all conflict in the natural world (p.57). For example, in some reciprocal symbioses there may be two steps where one step is costly for one or both symbionts and another step may be cost-free for both. In nitrogen recycling symbioses, microorganisms consume the nitrogenous wastes of the animal and act as sinks for these potentially toxic compounds. In return, the microorganism uses the nitrogen compounds toward their growth. This part of the relationship seems to be cost-free. In the second step, microorganisms synthesize these nitrogenous compounds that the animals cannot produce and release them back to the animal. This is costly for the microorganism (p.63).

Chapter 4 discusses the mechanisms that allow organisms to identify cooperative partners and persist together in apparent harmony, while at the same time discriminate against ineffective partners. Symbiosis and host defense are one of the key areas of research in the attempt to understand “how the chosen are controlled” (p. 118). The old idea that the symbiont living in a particular creature is there because it is circumventing the host’s defense is too simplistic as more research comes to light. It is to

the host’s benefit that symbiotic relationships with their symbionts remain robust. Therefore, is it surprising to note that some data suggest that immune/defense systems can both discriminate between deleterious and beneficial partners and be involved with microorganism management? Douglas concludes that

one striking theme emerging from studies on a variety of associations is that the mechanisms underlying symbioses commonly involve preexisting capabilities, including the recruitment of gene products with nonsymbiotic functions to novel symbioses-specific functions. These results raise the question of how the expression of these many and diverse genes is regulated in the context of the symbiosis. Should we be looking to a single master gene that coordinates the network of relevant genes in the symbiotic context, or is control distributed across many preexisting regulatory circuits? (p. 124).

Chapter 5 emphasizes the success of symbiosis in both evolutionary history and its effects on changing whole ecological communities. She discusses the importance of how symbiotic relationships may have been the driving force behind ant and coral diversification, cospeciation and coevolution of various taxa, and the structure of ecological communities. In the middle part of the chapter she explores the five major anthropogenic factors of large-scale extinction, biotic homogenization through invasive species, habitat fragmentation, climate change, and modification of biogeochemical cycles and how they are affecting the fate of symbiotic partnerships. She concludes chapter 5 by investigating how humans can harness symbioses for our benefit as sources of bioactive compounds (antimicrobials and cancer drugs), pest control strategies, and human health.

Chapter 6 summarizes Douglas’s perspectives on the future of symbiosis research and the many questions still outstanding. She highlights six key questions for symbiosis research:

- 1) Can we predict the traits of symbioses from the ancestral lifestyles of the participating organisms?
- 2) When is a symbiont a symbiont-derived organelle?
- 3) How significant are “cheaters” as determinants of the traits of symbiosis?
- 4) Why is symbiosis obligate for some organisms?
- 5) How do symbiotic organisms interact with the immune/defense system of their partners?
- 6) Can organisms benefit from symbiosis without receiving a service from their partner?

Some of these questions assume that life arose by random chance processes and may not be questions creation biologists ask. Nevertheless, the ubiquity of symbioses for creation biologists pose many fascinating questions regarding how the designed mechanisms work in God’s creatures, how the mechanisms between very different symbionts coordinate with one another, how the Curse deleteriously affected mutually beneficial symbioses, and how these relationships contribute to the overall health and functioning of the biosphere, that we may steward more effectively.

Explaining the origin of complex mechanisms and machinery needed for life before entering into relationships, and then to have those mechanisms and machines in complex, yet to be understood coordination with creatures from highly different taxa smacks of complex design and is more consistent with the biblical worldview. Francis (2009, p.188) also highlights creationist

interest in symbiogenesis as a possible mechanism for rapid speciation after the Flood because of the several documented instances of symbiont-induced rapid speciation.

Complicating matters, and not included in the book, is the recent discovery of algae (*Oophila amblystomatis*) within the cells of spotted salamander embryos (*Ambystoma maculatum*) (Petherick 2010). The association between the two has been known for a long time, but this is the first time the alga has been discovered within the cells of the salamander. This kind of algal relationship has never been documented in a vertebrate before. The data suggest that the intracellular algae are receiving CO₂ from the respiring embryos and the embryos are being provided with the photosynthetic end products of oxygen and carbohydrates by the algae. It is consistent with the data that refutes the historical hypothesis of symbionts not being able to live within creatures with complex and adaptable immune/defense systems that were thought to destroy all but self. The inference is that the two systems are working together in such a way that both organisms benefit. This requires an immense amount of systems coordination between two completely different organisms and is consistent with design.

Symbiotic relationships between totally different taxa are fascinating and important to both evolutionists and creationists. *The Symbiotic Habit* is written for those with an undergraduate understanding of biological concepts and terminology and contains a detailed index and reference section. Though Douglas interprets these symbiotic interactions through the philosophic lens of naturalism, the book does a good job highlighting the current status of symbioses research and is a keeper for anyone interested in a relatively brief treatment of the topic and who enjoy analyzing the many fascinating symbiotic relationships around the world.

References

- Francis, J.W. 2009. Symbiosis, relationship, and the origin of species. In: Wood, T.C. and P.A. Garner, eds. *Genesis Kinds: Creationism and the Origin of Species. Center for Origins Research Issues in Creation* No. 5. Wipf and Stock Pub., Eugene, OR., pp. 163-192.
- Petherick, A. 2010. A Solar Salamander. *Nature News*, accessed May 14, 2011 from <http://www.nature.com/news/2010/100730/full/news.2010.384.html>.