



FASCINATING CONNECTIONS  
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Life is a web of connections. Networks occur across all biological levels, from sets of interacting genes to cells, organisms, social groups, species, communities of species, and ecosystems. How do these networks evolve and what are the roles of cooperation and conflict in shaping them? This was the topic of my Wiko exploration. Much of my career has involved the study of interactions among genes and between microbes and their hosts. Unbeknownst to many, our genes (and those of nearly all organisms) are not simply a happy family cooperating to create the successful organism. The DNA of nearly all organisms contains “parasites”, which can be harmful to the organism but gain an advantage in replication. In fact, it can be appropriate to think of an organism as an ecological community of genes, some cooperating while others exploit the system. It should be

pointed out that I am not assuming any cognition or intent here. All systems are vulnerable to exploitation, and even strands of DNA that are harmful to the organism can arise and increase when circumstances favor their proliferation. We know this to be the case because such genetic parasites are ubiquitous. Yet, the conflicts within the genome caused by these DNA parasites can lead to innovations over evolutionary time. This is one of the topics I decided to investigate while at Wiko. Among my projects, a paper was completed on how DNA modifications affect expression and evolution of gene networks. A second paper completed at Wiko reveals that an ancient transfer of DNA from bacteria to butterflies has resulted in the evolution of a new functional gene. What this gene does we do not yet know, but it has clearly been favored by natural selection to encode a functional protein. During his visit to Wiko, John Colbourne (University of Birmingham, UK) and I worked on a complex and fascinating data set revealing how networks of genes change expression over time and differ between the sexes – two manuscripts are underway that we hope to soon publish.

Processes of cooperation and conflict also occur among interacting organisms. My previous work has involved detailed studies of intracellular bacteria and how they interact with the host. Some of these bacteria are actually passed across generations when their hosts reproduce. One would assume that they would become benign passengers, or actively help the host, which is their vessel into the future. Yet many such bacteria are harmful parasites that alter the reproduction of their hosts – such as inducing sperm-egg difficulties, converting males into females, or killing the male offspring. Again, although these can be harmful to their interacting “partners”, a byproduct of this interaction may be the evolution of new species. Colleagues Peter Hammerstein (Humboldt University and Wiko Alumnus) and Arndt Telschow (University of Münster) and I completed a theoretical paper that shows how these bacteria can promote genetic divergence between populations, and perhaps lead to the evolution of new species. Peter and I also gave a joint talk on our collaborations entitled “When the guest becomes the pest: Conflicts between symbionts and their hosts” at a public symposium in Berlin on “Synthesizing Theoretical and Experimental Biology Today”. Another example of species interactions occur between “parasitoids” and their hosts. Parasitoids lay their eggs within the juvenile stages of other insects, which become nurseries for their developing young. This sounds gruesome and it is. Yet, parasitoids play an important role in keeping pest- and disease-transmitting insects at bay. Further, they can be quite beautiful – my favorite study organism is aptly called the “jewel wasp”. A female jewel wasp lays batches of eggs upon the pupae of flies

(the pupa in flies is equivalent to the chrysalis of butterflies, a transitional stage between larva and adult), and her young grow to adults upon this food. Although we may find her lifestyle unsavory, the jewel wasp is actually a reasonably good mother. She does not tend her young directly, but before laying her eggs she injects “venoms” into the fly that alter its physiology in remarkable ways, inducing the fly to make more amino acids, fats and sugars, and stopping its development, presumably so that the fly will not use up these resources. During a visit by Yacintha Ellers (Free University, Amsterdam) to Wiko, we discussed her research showing that parasitoids have lost the ability to make their own complex fatty acids. It now seems that this may be partly compensated for by their ability to use venoms to manipulate the host to do this for them.

Studies of parasitoid venoms may sound esoteric to some, but one of the fascinations of scientific research is that unexpected connections can emerge. As it turns out, our studies of how the jewel wasp’s venoms alter the fly’s metabolism revealed something unexpected – that alterations in the fly are similar to some metabolic complications caused by diabetes in people. Because we share many of the same metabolic pathways and similar genes with flies (during evolution, nature has been conservative with the basic toolkit of life), this implies that parasitoid venoms could yield some useful pharmaceuticals, or at least tools to study these pathways. During her visit to Wiko, Aisha Siebert (a graduate student at the University of Rochester) and I wrote a small grant proposal for early exploration of this possibility. We shall see whether this avenue bears fruit.

Following a visit by Arndt Telschow to Wiko and my follow-up visit to the University of Münster, Arndt and I are advancing our collaboration on disease dynamics and the evolution of generalist and specialist pathogens, using network modeling approaches. Jakob Strauß, a graduate student in Arndt’s laboratory group, is now visiting at the University of Rochester to work on the model.

As a geneticist and evolutionary biologist, the topics above are within my comfort zone. A major goal at Wiko was to step outside this comfort zone and conduct research for a book on how conflict and cooperation shape other networks of life, including ecosystems, and the social networks of microbes, plants, and animals (including humans). The diversity of academic interests found at Wiko, among both Fellows and frequent visitors, was an ideal environment for this effort. It is not possible to mention all the helpful discussions, but among them were lively exchanges with Cristina Lafont and Hubertus Buchstein on political theory, with Kelly Askew and Shakti Lamba on ways to measure cooperation in human social groups, with Sonia Sultan and Emily Jones on species-community

interactions, with Bruce Kogut on economic systems, and with Robert Trivers on evolutionary theory.

Many engaging interactions at Wiko came from periodic meetings of the Evolution Group. We were a diverse bunch, including a significant linguistic component of William Foley, Ben Fortson, and Johanna Nichols, as well as card-carrying evolutionary biologists such as Robert Trivers, Jim Costa, Joanna Masel, and Emily Jones. Bruce Kogut would infuse the conversation with economic insights and dry wit. Franco Moretti's interests in applying network modeling to literature brought him to see whether evolutionists had anything useful to say. Often we did not, but the conversations were lively and courteous, and I personally learned a lot about linguistics and cultural evolution in these discussions.

For me, though, among the best interactions occurred in unexpected "Wiko Moments". For example, Birgitta Whaley was at Wiko to explore connections between quantum theory and biology. I must admit to having been a bit skeptical about whether such connections would be meaningful, at least between quantum mechanics and my flavor of biology. However, when John Colbourne, Birgitta, and I conversed over a bottle of wine one evening, the ideas began to flow. Even in the sober light of the next day, the ideas retained merit. We found that population genetic theory had some relevance to questions of how photosynthesis could achieve levels of efficiency sufficient to reveal quantum processes; these thoughts are now part of a manuscript in preparation, with Birgitta at the helm.

Wiko moments often occurred during breakfast, when I would meet an unexpected visitor. One day I met a legal scholar on a short stay at Wiko. We proceeded to discuss topics of interest to each of us, and by the end of the meal I was convinced that a chapter on the Function and Evolution of Law would be crucial to my thesis. After all, what aspect of human culture could be more relevant to the resolution (or at least management) of human conflict than law? This has led to some intensive digging into a complex and dense literature, from which I have not yet emerged. Another Wiko moment came when Jim Costa and I decided that there is a linguistic puzzle in the word "fitness" and whether cross-fertilization between science and popular culture played a role in its evolution.

The meals at Wiko were such a pleasure, and my waistline is just now making a recovery. I would especially like to thank Lena Mauer and Daniela Gogel for marvelous meals and creating such a friendly atmosphere. The staff at Wiko is outstanding. I will mention a few who exemplify all those who make Wiko a success. Vera Schulze-Seeger answered our endless questions with charm and good humor – she was a patient mother

to the Wiko Fellows. Andrea Bergmann and Nina Kitsos guided us through administrative mazes, and Mari and I are especially grateful for help with Simon's school.

Mari and Simon and I made good friends at Wiko. We fondly remember brunches, dinners, and outings with the Costas, Gillian and Amy, Kelly, Ben and Cecilia, Elora, Ussama, Sinan, and Nur, and Bruce, Monika and Momo, and lively meals and conversations with Robert Trivers. Once Simon reaches the age of maturity (he is now 14), he may yet take Robert up on his offer for Simon to visit Jamaica, where Robert says Simon can find everything he needs in life. A unique part of my Wiko experience has been getting to know and becoming friends with Robert.

In closing, I should point out that not all connections work out. For example, there was a postal connection between Wiko and Rochester that involved a shipment of papers and notes on many of the topics I had developed at Wiko. When the box arrived at the University of Rochester, it contained theology books written in Greek and Polish, plus one of Mari's Japanese novels and a note from the postal service saying that the box had opened during shipment and been repacked with my loose materials. Fortunately, I will recover from this small debacle (some files were also generated electronically). Perhaps to complement my recent efforts in being a postal sleuth (so far without reward), I will now develop an interest in theology.