Polydnaviruses and Parasitoids:
The Ultimate Virus-Host Relationship

by Don Stoltz

In the article "When Butterflies get Bugs" by Sonia Altizer and Jaap de Roode, on page 16 of this issue of *American Butterflies*, you learned about the many diseases of butterflies. It might be a surprise for most people to learn that for every lepidopteran species, there exists one or more species of parasitic wasp (parasitoid) which attacks it. Here, we take a look at a very unusual relationship between viruses belonging to the family, *Polydnaviridae*, and certain species of wasp belonging to the well-known wasp families, *Braconidae* and *Ichneumonidae*.

Those of you who keep a garden, and avoid the use of chemical pesticides, are likely to have observed Cabbage White caterpillars festooned with small white cocoons — these will have been spun by larvae of the braconid parasitoid, *Cotesia rubeculae*. Wasps in the genus *Cotesia* belong to a lineage (termed the microgastrine lineage), comprising more than 10,000 species worldwide. As far as we can tell, every species within this very large and successful lineage of wasps carries a polydnavirus. Polydnaviruses are also associated with at least two ichneumonid subfamilies. Polydnaviruses carried by braconid wasps are called bracoviruses while those carried by ichneumonids are called ichnoviruses. In terms of morphology, the bracoviruses and the ichnoviruses are very different (see photos, pages 28 and 29), however their life cycles are essentially identical and remarkable!

Here is a somewhat simplified description of the entwined life histories of the wasp and the virus. Much of this story was worked out over the past 40 years in my laboratory and in the laboratories of other scientists who became interested in this fascinating system.

When a braconid wasp encounters the right kind of caterpillar, it tries to inject its eggs into the caterpillar using a specialized structure called an ovipositor (many of you will have experienced the effects of a certain modification of the ovipositor, namely the stinger!). If it succeeds, it also injects some fluid, and this fluid contains polydnavirus particles. The recognition that virus particles were injected along with the eggs was made in the mid 1970s in my laboratory.

In a strange twist, however, the virus particles that have been examined don't seem to contain any viral DNA; rather they contain wasp DNA. Once the polydnavirus particles are within the caterpillar, the wasp genes contained within them spring into action and prevent the caterpillar's immune system from destroying the wasp eggs. But, the DNA released into the caterpillar cells from the polydnavirus particles doesn't replicate. In the 1990s, the DNA packaged into certain polydnavirus particles was completely sequenced. One of the results of this work was the realization that the genes required to make progeny virus particles were not packaged into said particles! So, the polydnaviruses are in the unique position of being unlike any other kind of virus, to the point that some questioned whether they should legitimately be called viruses.

Inevitably, the debate centered on the question of origins, for which there were two possibilities: one, certain wasps had evolved