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Molecular and Physiological Aspects of Intracellular Symbiosis of Aphid with Bacterium

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Most aphid species harbor prokaryotic intracellular symbionts, *Buchnera*, in their bacteriocyte or mycetocyte, a specialized cell in the fat body. This symbiosis probably dates back to as far as 250 million years ago, and represents one of the most intimate interactions between a bacterium and the eukaryotic cell. Since the initial infection, symbionts have been vertically transmitted through generations of aphid hosts and the two partners appear to have diversified in parallel, resulting in the present species of *Buchnera* which is associated with the present species of aphid.

One significant finding by us with *Buchnera* is that, when housed in the bacteriocyte, it selectively synthesizes symbionin, a stress protein homologous to *E. coli* GroEL. Symbionin functions not only as molecular chaperone, just as GroEL, but also as histidine kinase that transfers the phosphate group from ATP to substrates through its autophophorylation in an energy coupling manner. It is likely that this GroEL homolog has undergone unique evolution, and serves as sensor in the two-component pathway of signal transduction which specifically required by this intracellular symbiosis.

A long-lived mystery about aphids had been why they are so fecund despite their feeding on the plant phloem sap notoriously poor in nitrogenous compounds. A clue to unravel this mystery resides in the insect's symbiosis with *Buchnera*. Our studies have demonstrated that an interplay between bacteriocytes and *Buchnera* provides host insects with essential amino acids through the ultilization of glutamine and aspargine. These amino acids are not only abundant in the phloem sap, but also aphids' own nitrogen waste products, unlike in most other insects. Our recent study by the differential cDNA display and RT-PCR technique successfully demonstrated that genes encoding the enzymes responsible for the amino acid recycling above described are active only when the symbiotic system is

well organized in the young insect. The study also evidenced that *Buchnera* symbionts profit metabolically from the symbiotic system, providing the first indication that this symbiotic system is literally mutualistic to both partners.