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The Symbiotic xD Strain of Amoeba proteus: A Model System for the Organismic Association and the Origin of Cell Organelle

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As symbiosis draws genomes from the entire biosphere, intracellular symbiosis is an important biological phenomenon in terms of genetic changes that may be greater in magnitude than those which may result from mutation, hybridization or ploidy changes. In order to establish endosymbiosis both the infecting organism and the host have to overcome several barriers. Bacterial infection and intracellular survival in eukaryotic cells have been extensively studied to understand the parasitism and the symbiosis leading to the origin of cell organelles, but much remains still unknown about the mechanisms underlying the phenomena.

The endosymbiotic association of X-bacteria (XB) in *A. proteus* is a unique and novel system in which the host and symbionts developed a stable symbiosis within a few years under continuous observations. It has known history of symbiosis, symbionts bring about the host's dependence for survival within 10 amoeba generations (4 weeks), and cellular changes caused by symbiosis can be reproduced under laboratory conditions. The symbiotic bacteria are different from other bacterial inclusions in the avoidance of lysosome fusion, and their relationship to the host nuclear genome.

The XB enclosed in symbiosomes accumulate large amount of GroELx stress protein, produce macrophage infectivity potentiator (Mip), and secrete S29x protein containing nuclear localizing signal. The symbiosomes contain spectrin, myosin, and actin provided by the host and avoid lysosome fusion by having lipopoly-saccharides (LPS) and S96 proteins synthesized by XB. The xD strain is deficient of S-adenosyl-L-methionine synthetase (SAMS), a housekeeping enzyme. Thus, we postulate the following scheme for the genetic interaction between the host and symbiont: XB initiate changes in the expression of amoeba's *sams* gene. Then, XB supplement the host's genetic defect by providing an alternative source of SAMS. Thus, when XB are removed, xD amoebae become deficient in SAMS, and hence methylating reactions using SAM as the methyl-group donor would be blocked. An

abnormal morphology of amoeba's nuclei actually observed was because such interference was occurred in the processing of pre-rRNA methylation. The xD amoebae did not recover unless live XB were reintroduced. Otherwise, the damaged nucleus would have to be transplanted into normal xD cytoplasm for recovery.

Symbiogenesis of XB in amoebae is a good model with which to study various steps involved in the establishment and maintenance of endosymbiosis. The system is well suited to study the process of integration between the symbiont and host cells, which would lead to the acquisition of new cell organelles.