The Curious Case of *Dictyostelium discoideum*

How Slug Farming Bacteria Could Teach Us About Epigenetics

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Agriculture is well known as one of the most significant innovations to aid in the success of human development. However, the practice of preparing a food source for future use is not unique to humans. Organisms such as fungus-growing ants, termites, and ambrosia beetles have similarly adapted the ability to cultivate crops. Simpler agricultural methods, with fewer associated adaptations, have been found in microorganisms that show sophisticated social behaviors as well as symbiosis with their environment.

Indeed, the social amoeba, *Dictyostelium discoideum*, engages in primitive farming of bacteria, to allow for future consumption. The single-celled amoebas, which can aggregate together to form a multicellular slime mold, reveal a fascinating behavior when food becomes scarce. This strain of soil-dwelling amoeba normally grazes on bacteria, but as the collective slime mold exhausts its bacteria food source, the slime mold aggregates tightly into a motile slug. The cells of the *D. discoideum* slug then undergo a morphogenesis in which they sacrifice part of their own network of cells within the slug body to form a fruiting stalk. This fruiting body contains asexual, differentiated spores that the stalk disperses. The dispersed spores can then populate a new area. The agricultural aspect of this mechanism became evident when studies found that some of *D. discoideum's* fruiting bodies contain the bacteria they normally eat. Thus, not only do *D. discoideum* spores arrive in a new area, but they also carry a bacterial food source along with them. The bacteria will then be seeded and subsequently harvested by *D. discoideum*, their predacious carrier.

Some strains of *D. discoideum* can farm their food and others cannot. Under conditions of food scarcity, farmer strains of *D. discoideum* have been found to produce significantly more spores than the non-farmer strains. These results suggest the farming strains have a greater advantage for future survival during food shortages.

Burkholderia is a genus of bacteria that is considered to be inedible to *D. discoideum*. However, it is also found to be carried by the slug during the farming process. This curious finding brings forth questions relating to why the slugs carry this type of bacteria if Burkholderia does not directly serve as a nutritious resource for the new colony. Interestingly enough, studies have shown that Burkholderia bacteria can actively influence the farming behavior, and overall survival, of certain strains of *D. discoideum*. Specifically, the species Burkholderia xenovorans has the ability to harm non-farmer *D. discoideum* but not the farmer clones.

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When farmers carrying the *B. xenovorans* bacteria are mixed with non-farming *D. discoideum*, the farmers tend to outcompete the non-farmers in spore production. Thus, the farming amoeba and bacteria appear to engage in a mutualistic symbiotic relationship in which the farming *D. discoideum* is ensured a bountiful harvest free from competition with other *D. discoideum*, and Burkholderia is given the opportunity to hitchhike to a new environment. This facilitates both the survival of the amoeba and the bacteria.

Recent literature has further elucidated this relationship. Due to the prevalence of inedible bacterial species in farming colonies of *D. discoideum*, the role of Burkholderia bacteria was inspected under a finer lens. Studies have shown that Burkholderia can induce non-farming *D. discoideum* strains to farm bacteria, their genus included. This finding led to a surge of research exploring the capacity of Burkholderia to influence the farming behavior of non-farmers. Studies questioned if the bacteria could promote carriage in the second generation of induced *D. discoideum*, and indeed it was found to induce secondary bacterial carriage. Since there exists this transgenerational persistence of farming in non-farming strains of *D. discoideum*, the scientific community believes that Burkholderia may induce epigenetic changes in the amoeba. However, there is not yet evidence as to the extent of Burkholderia's inducible effects across a third generation. The epigenetic effects of bacteria are a sure route for future studies.

The aforementioned relationship appears to be one that is unique to a specific strain of Burkholderia bacteria. However, research has also observed the farming behavior to be associated with another genus of bacteria, Flavobacterium. This genus has similarly been suggested to induce farming in non-farming *D. discoideum*. The extent to which Flavobacterium are farmed and induce farming is not yet understood. Further, it is not yet known how or why certain bacteria are carried instead of consumed by the amoeba.

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Understanding which bacteria are able to induce farming will help uncover the mystery behind the primitive farming behavior of *D. discoideum*. As of now, all that is known is that the bacteria evade consumption, assemble and encourage sporulation, and are carried off to a new environment along with the spores and amoeba. If a common denominator among farming-associated bacteria is identified, it will open future opportunities to discover why specific strains of bacteria are farmed. Then the similarities in bacteria can be examined all the way down to the structural level, and they can provide information relating to both evolutionary biology and epigenetics. This would allow for a clearer history of multicellular development and possibly provide insight on how we could manipulate the biological future. By using *D. discoideum* as a potential model organism for transgenerational epigenetic modifications, it is possible we may learn about our own DNA and heritage. Slug or no slug, these amoeba have a lot to tell us. ●

To learn more about this topic see: "Primitive agriculture in a social amoeba" by Debra Brock, Tracy Douglas, David Queller, and Jan Strassmann, published in *Nature* in 2011.