Farming amoebae carry around detoxifying food

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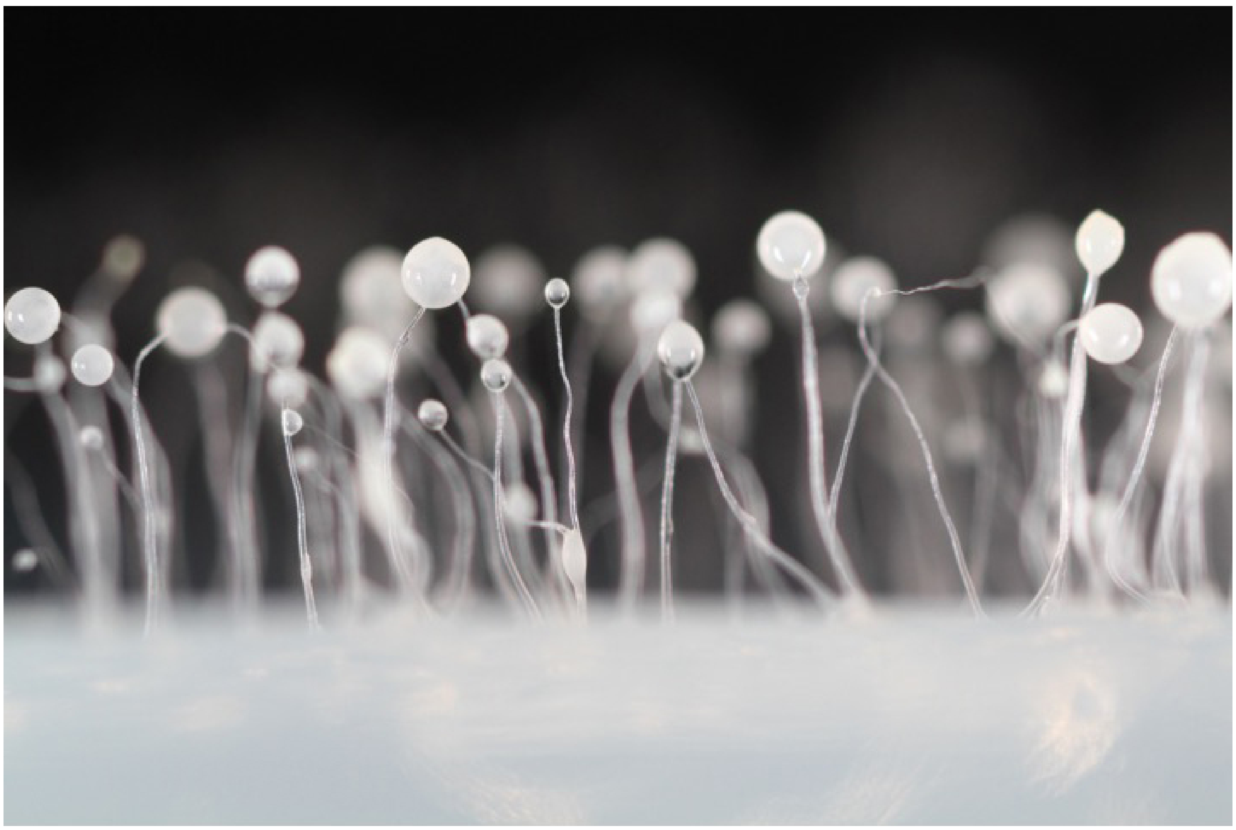

The social amoeba *Dictyostelium discoideum* has both solitary and communal life stages. As long as food is abundant, it lives on its own, but when food is scarce the amoebae seek one another out. Together they form a slug that migrates toward the light and then a fruiting body that disperses spores from atop a stalk. The fruiting bodies are pictured here. Credit: Strassmann/Queller lab

Humans aren't the only farmers out there. Five years ago, the Queller-Strassmann lab at Rice University, now at Washington University in St. Louis, demonstrated that the social amoeba *Dictyostelium discoideum*—affectionately nicknamed "Dicty"—can maintain a crop of food bacteria from generation to generation, giving these farmers an advantage when food is scarce.

Now, new research from the same team shows that these microscopic farmers also rely on their symbiotic bacteria to protect themselves from environmental toxins, a little-studied but increasingly clear role microbes can play for their hosts.

And by studying Dicty's relationship with its bacterial residents, scientists are learning more about the dynamic interactions between hosts and their microbiomes.

Research scientist Debra Brock led the new work, published April 20 in the *Proceedings of the Royal Society B*.

These amoebae are content to be loners when food is abundant, but when it's depleted they come together in the tens of thousands to cooperate. They transform into a mobile slug that migrates in search of fairer conditions and then produces hardy spores to release into the environment and wait out the lean times.

The slug has a tiny pool of specialized cells, called sentinels, that protect it from pests and poisons by ferrying them away.

"The sentinel cells pass through the body, mopping up toxins, bacteria, and essentially serving as a liver, a kidney, and innate immune system and being left behind in the slime trail," said Joan Strassmann, PhD, the Charles Rebstock Professor of Biology in Arts & Sciences.

But it wasn't clear how the farmers prevented their sentinel cells from carrying away and discarding the bacteria they depend on for food.

Debra Brock, a research scientist at Washington University in St. Louis, hunts for wild clones of the social amoeba *Dictyostelium discoideum*. Many of the lab's discoveries have come from the wild clones and not the tame laboratory clone. Credit: Joan Strassmann

"Our question was: If you have to be nice to your bacteria because you want to carry them along as food, how do you have this sentinel cell system at the same time?" Brock said.

So Brock predicted that farmers would have fewer sentinel cells, in order to avoid sloughing off all their symbiotic bacteria. Looking for the tell-tale signs of sentinels in the slug's slime trails, Eamon Callison, a former undergraduate student in the lab working on his senior honors thesis, found that farmers had only half as many sentinel cells as their non-farming relatives.

"Our prediction was true," said Brock. "But that's never the end of the story."

Following the (slime) trail

With fewer protective sentinels, how would these farmers fare against toxins?

"I just figured the farmers have fewer sentinel cells, so it's likely they'll do worse than the non-farmers when exposed to toxins," said Brock. "The farmers actually did better, surprisingly."

While non-farmers were crippled by toxins and produced fewer offspring, the farmers didn't seem to mind at all—with or without the toxin, they produced the same number of viable spores, out competing the non-farmers.

Brock thought the bacteria farmers carried with them might explain this unexpected finding.

So she "cured" the farming Dicty of their symbiotic bacteria and then exposed them to the toxin again. This time, fertility plummeted in the presence of the toxic chemical. Without their bacteria, the amoebae succumbed to the toxin.

Somehow, the bacteria that farmers carry with them not only help them bring along a food source but also protect their hosts from toxins, even making up for fewer detoxifying sentinel cells.

Just how these bacteria provide protection remains a mystery. They could act as a sponge, taking the brunt of the damage and shielding their hosts from the toxin's effects. Or they could actively degrade the toxin, even using it as food.

Similar detoxifying roles for symbiotic bacteria have been discovered across biology, from neutralizing insecticides and fungicides, to allowing mammals like sheep and goats to feed on otherwise toxic plants. But to discover how widespread detoxification is, and how it has evolved or is maintained, will require much more research.

"As far as detoxifying microbial interactions, multicellular animals are really tough organisms to work with, and I think that there's a lot we can figure out with this very simple eukaryote, *Dictyostelium*," said David Queller, PhD, the Spencer T. Olin Professor of Biology in Arts & Sciences.

"We think that this is just the start of a really fabulous system for looking at bacteria-eukaryote interactions," he said.

More information: Debra A. Brock et al, Sentinel cells, symbiotic bacteria and toxin resistance in the social amoeba, *Proceedings of the Royal Society B: Biological Sciences* (2016). DOI: 10.1098/rspb.2015.2727

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