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Amoebas trap bacteria using nets of DNA: the same mechanism as human immune cells

by Lukáš Novák[1] | PhD student

[1]:Department of Parasitology, Faculty of Science, Charles University in Prague, Czech Republic

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Our multicellular bodies containing trillions of cells seem to have little in common with protists, the tiny single-celled creatures inhabiting every drop of water, which spend their days eating bacteria or each other, parasitizing larger organisms or living from light. And yet, this is how our ancestors looked like. It took almost one billion years to fine-tune the coordination between cells so they can altruistically cooperate within our tissues and organs. However, there are still several features in our cells which don't let us forget our humble unicellular predecessors. For example, the motile “tails” of sperm cells are nothing else than flagella which protists use to propel themselves through water. The immune cells circulating through our bodies and defending us from invaders have another hint. The mechanism by which they engulf and swallow the harmful bacteria reflects the eating habits of our ancestors. Now researchers from Geneva, Switzerland and Houston, Texas discovered another fascinating heritage, also within the immune system.

It has been known for over ten years that several types of immune cells of humans and other animals can trap and kill pathogenic bacteria by casting nets made of DNA. Yes, the same DNA which stores the information about our bodies and rules over cellular processes can also be used as a lethal weapon against pathogens. The bacteria get immobilized in the sticky DNA like in a fishing net and then are killed by antimicrobial chemicals covering the DNA strings. Discovery of this addition to the immune cells' arsenal, besides their already known abilities to swallow bacteria and to secrete antimicrobial substances, was astonishing. However, it is now becoming even more interesting as we learned that this mechanism is not a recent innovation by advanced multicellular animals but an ancient feature shared with at least one lineage of protists, the social amoebas.

Most amoebas live lonely unicellular life but the so called social amoebas developed a remarkable instance of multicellularity. The individual cells of social amoebas spend most of the time crawling around in soil just like their solitary relatives. When stressed, for example by food scarcity, the amoebas start to communicate using chemical signals and join to form a millimeter-sized multicellular stage called slug. The slug then travels for many hours like a single body to find an ideal spot to form a final life stage, the fruiting body, which resembles a mushroom, and will then release spores. Cells within the two multicellular stages are differentiated into groups with diverse functions and even form tissues. Like any other multicellular body, the slug attracts the unwelcome attention of hungry bacteria, and so it needs an immune system. This role is played by a special population of cells which swallow and kill the invading bacteria just like in the human body. It was a great surprise for the researchers when they saw these cells showing also a behavior clearly resembling the casting of DNA nets by human immune cells.

They observed the amoeba cells releasing a cloud of unknown material when the slug was crawling across a patch of pathogenic bacteria, and the stricken bugs were dying. The researchers performed series of biochemical experiments that showed that the released material is indeed DNA. They also added bacteria-sized beads to the slug's environment and saw that these are rapidly trapped by the DNA. So, they knew they were witness to a familiar phenomenon. But is it related to the animal DNA nets mechanism? Or did it evolve separately in the social amoebas? After all, they are not closely related to us (more than plants but less than fungi) and our last common ancestor lived more than a billion years ago. To answer this final question, researchers genetically manipulated the social amoebas in order to understand the regulatory mechanisms which rule over the DNA nets formation and found that the mechanism is largely identical between amoebas and humans, i.e. the genes in charge of coordinating the process are the same in both lineages. It is very unlikely that such a complex mechanism would evolve twice separately, with the same regulatory genes. Thus, the researchers conclude that trapping and killing bacteria by casting poisoned nets of DNA is an ancient feature that must have been present already in our single-celled ancestors. The social amoeba may now become a model organism for studying human immunity.