Novel living system recreates predator-prey interaction

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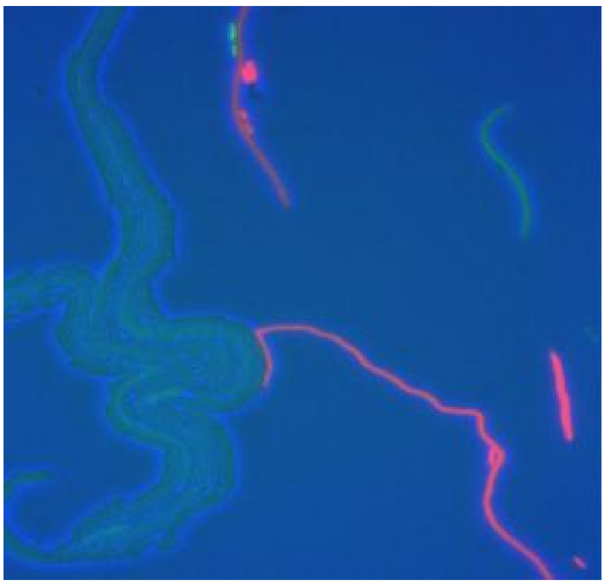

Using fluorescent microscopy, researchers document the predator-prey interaction. The predator cells, shown in green, have caused a prey cell, shown in red, to commit suicide. The elongation and separation of the prey cell is proof of its demise. Credit: Hao Song, Duke

The hunter-versus-hunted phenomenon exemplified by a pack of lionesses chasing down a lonely gazelle has been recreated in a Petri dish with lowly bacteria.

Working with colleagues at Caltech, Stanford and the Howard Hughes Medical Institute, a Duke University bioengineer has developed a living system using genetically altered bacteria that he believes can provide new insights into how the population levels of prey influence the levels of predators, and vice-versa.

The Duke experiment is an example of a synthetic gene circuit, where researchers load new "programming" into bacteria to make them perform new functions. Such re-programmed bacteria could see a wide variety of applications in medicine, environmental cleanup and biocomputing. In this particular Duke study, researchers rewrote the software of the common bacteria Escherichia coli (E. coli.) to form a mutually dependent living circuit of predator and prey.

The bacterial predators don't actually eat the prey, however. The two populations control each others' suicide rates.

“We created a synthetic ecosystem made up of two distinct populations of E. coli, each with its own specific set of programming and each with the ability to affect the existence of the other,” said Lingchong You, assistant professor of biomedical engineering at Duke’s Pratt School of Engineering and member of Duke’s Institute for Genome Sciences and Policy. “This ecosystem is quite similar to the traditional predator-prey relationship seen in nature and may allow us to explore the dynamics of interacting populations in a predictable manner.”

The results of You’s study appear April 15 in the journal *Molecular Systems Biology*. The research was supported by National Institutes of Health, the Defense Advanced Research Projects Agency, the Howard Hughes Medical Institute, and the David and Lucile Packard Foundation.

This field of study, known as synthetic biology, emerged on the scientific scene around 2000, and many of the systems created since have involved the reprogramming of single bacteria. The current circuit is unique in that two different populations of reprogrammed bacteria live in the same ecosystem and are dependent on each other for survival.

“The key to the success of this kind of circuit is the ability of the two populations to communicate with each other,” You said. “We created bacteria representing the predators and the prey, with each having the ability to secrete chemicals into their shared ecosystem that can protect or kill.”

Central to the operation of this circuit are the numbers of predator and prey cells relative to each other in their controlled environment. Variations in the number of cells of each type trigger the activation of the reprogrammed genes, stimulating the creation of different chemicals.

In this system, low levels of prey in the environment cause the activation of a “suicide” gene in the predator, causing them to die. However, as the population of prey increases, it secretes into the environment a chemical that, when it achieves a high enough concentration, stimulates a gene in the predator to produce an “antidote” to the suicide gene. This leads to an increase in predators, which in turn causes the predator to produce another chemical which enters the prey cell and activates a “killer” gene, causing the prey to die.

“This system is much like the natural world, where one species – the prey – suffers from growth of another species – the predator,” You said. “Likewise, the predator benefits from the growth of the prey.”

This circuit is not an exact representation of the predator-prey relationship in nature because the prey stops the programmed suicide of predator instead of becoming food, and both populations compete for the same “food” in their world. Nevertheless, You believes that the circuit will become a useful tool for biologic researchers.

“This system provides clear mapping between genetics and the dynamics of population change, which will help in future studies of how molecular interactions can influence population changes, a central theme of ecology," You said. "There are literally unlimited ways to change variables in this system to examine in detail the interplay between environment, gene regulation and population dynamics.

"With additional control over the mixing or segregating of different populations, we should be able to program bacteria to mimic the development and differentiation of more complex organisms," he said.

Source: Duke University

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