A single gene leads yeast cells to cooperate against threats

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An ingenious social behavior that mobilizes yeast cells to cooperate in protecting each other from stress, antibiotics, and other dangers is driven by the activity of a single gene, scientists report this week in the journal *Cell*. The cooperating cells use the same gene, dubbed FLO1, as a marker for detecting "cheaters," cells that try to profit from the group's protection without investing in the group's welfare.

The research -- which shows that even the simplest organisms are capable of sophisticated social discriminations in nature -- was conducted primarily by scientists at Harvard University, the Whitehead Institute for Biomedical Research, and the Catholic University of Leuven in Belgium.

FLO1 encodes an adhesive protein at the cell surface that causes individual yeast cells to cohere into clumps, or "flocs," of thousands of cells. In a classic case of strength in numbers, cells on the inside of these flocs are shielded from stress and harmful chemicals by altruistic exterior cells that sacrifice themselves.

"Remarkably, cells expressing FLO1 are not only working together against stress, they are also able to exclude cells that do not express FLO1 from the floc, leaving these hopeful cheaters unprotected," says co-author Kevin J. Verstrepen, a Bauer Fellow and lecturer in molecular and cellular biology in Harvard's Faculty of Arts and Sciences.

The current work helps explain how organisms frequently evolve

behaviors that help others, such as when honeybee workers labor their whole life without reproducing, birds make alarm calls, or humans assist one another. It could also have clinical applications in combating pathogenic yeasts, which represent a serious threat to immunosuppressed patients, as well as in treating biofilms, impermeable mats of microbes that are highly resistant to drugs and other therapies. Pathogens aggregate into biofilms using a mechanism similar to that seen in flocculating yeast.

"Last but not least," says Verstrepen, "the findings are also of interest to brewers, who use the natural clumping of yeast cells to remove the yeast from their beer."

The work by Verstrepen and colleagues helps answer a major question in biology: namely, how cooperation between organisms evolves. Even Darwin realized that altruistic behavior posed a challenge to his theory of natural selection and evolution. Since Darwinian theory predicts that natural selection acts on the level of single individuals, not collaborating groups, a selfish individual who profits by piggybacking off of the social behavior of others would gain an evolutionary advantage -- a dynamic that, over time, would lead these asocial "cheaters" to take over the population, ultimately dooming collaboration.

The paper identifies FLO1 as a rare example of a "green beard gene," a term developed in the 1960s to describe genes that both foster cooperation and also tag altruistic individuals. Only individuals that express these genes are allowed to reap the benefits of group efforts, preventing cheaters from taking over the population. The finding suggests that these once-hypothetical green beard genes may not be so rare after all.

"FLO1 also provides striking support for the 'selfish gene theory,' which puts genes, and not genomes, at the center of evolution," says co-author

Kevin R. Foster, a Bauer Research Fellow at Harvard. "FLO1 is a selfish gene that promotes its own proliferation without much influence from the rest of the genes in the genome -- although remarkably, it exercises this 'selfish' act by promoting an act of social cooperation."

The researchers used common brewer's and baker's yeast (Saccharomyces cerevisiae) as a model for studying social behavior because yeast behavior is driven solely by genetics, without any input from cognitive learning or culture. Also, since S. cerevisiae has been widely studied and characterized, scientists are able to manipulate it with great precision.

Source: Harvard University