The secret language of microbes

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Social microbes often interact with each other preferentially, favoring those that share certain genes in common. However, the basis for this behavior, known as "kind discrimination," is often unclear. A new study reveals a so-called "green beard" system used by a fungus to decide whether or not it should approach a new individual in the neighborhood and fuse with it.

The new study, performed at the University of California (Berkeley) and publishing in the Open Access journal *PLOS Biology* on 14th April, shows that the filamentous fungus *Neurospora crassa* uses a set of highly divergent genes to discriminate "self" from "non-self" cells over a distance and to actively seek out those favored cells (those of the same "kind").

This mechanism of discrimination fits a hypothesis called the "green beard effect," a name coined by Richard Dawkins to describe a model for the evolution of kind discrimination. According to this system, organisms must acquire three things - an arbitrary peculiarity (the "green beard"), the ability to detect the green beard on others, and the tendency to treat such green-bearded individuals preferentially.

When genetically identical asexual spores of *Neurospora crassa* germinate (termed germlings), they undergo chemotropic interactions and eventual cell fusion. "These genetically identical cells undergo a dialog, alternately 'listening' and 'speaking', which is essential for chemotropic interactions," says lead author Professor N. Louise Glass. In this study, the researchers examined how genetically different germlings

communicated, discovering to their surprise that *N. crassa* populations fall into discrete communication groups.

"It seems like all strains speak the same basic fungal language, but due to different dialects, some strains cannot understand each other, and therefore are unable to establish communication necessary for cell fusion," says Dr Jens Heller, first author of the study.

Germlings from the same communication group are chemically attracted to each other, but germlings from different communication groups grew past each other to find a germling of their own communication type. The authors subsequently identified a specific set of highly variable genes (called "determinant of communication" or doc genes) within *N. crassa* populations that mediate the communication group affiliation.

By analyzing communication frequency of strains lacking the doc genes or where versions of the doc genes associated with a different communication group were "swapped", the authors show that genetic differences at the doc genes are necessary and sufficient to determine "self" identity. While genetically different strains with identical doc genes show up to 95% communication frequency, strains that are otherwise genetically identical but differ only in their version of the doc genes communicate with less than 10% frequency. "It was fascinating and surprising for us to see how well this kind discrimination system actually works," says Dr. Jens Heller. These data indicate that the doc genes function as "green beard" genes, involved in mediating long distance kind recognition by actively searching for one's own type, which results in cooperation between non-genealogical relatives.

Fusion between germlings brings fitness advantages to *N. crassa*, such as more rapid colony establishment. Dr Heller says, "Since we know that programmed cell death can result from fusion of incompatible partners in *N. crassa*, choosing the right partner at a distance can be important".

Prof. Glass, principal investigator of the study, summarizes, "Our findings reveal a heretofore under-appreciated complexity in fungal communication. We have only scratched the surface on communication and interactions of these enigmatic organisms."

More information: Heller J, Zhao J, Rosenfield G, Kowbel DJ, Gladieux P, Glass NL (2016) Characterization of Greenbeard Genes Involved in Long-Distance Kind Discrimination in a Microbial Eukaryote. *PLoS Biol* 14(4): e1002431. DOI: 10.1371/journal.pbio.1002431