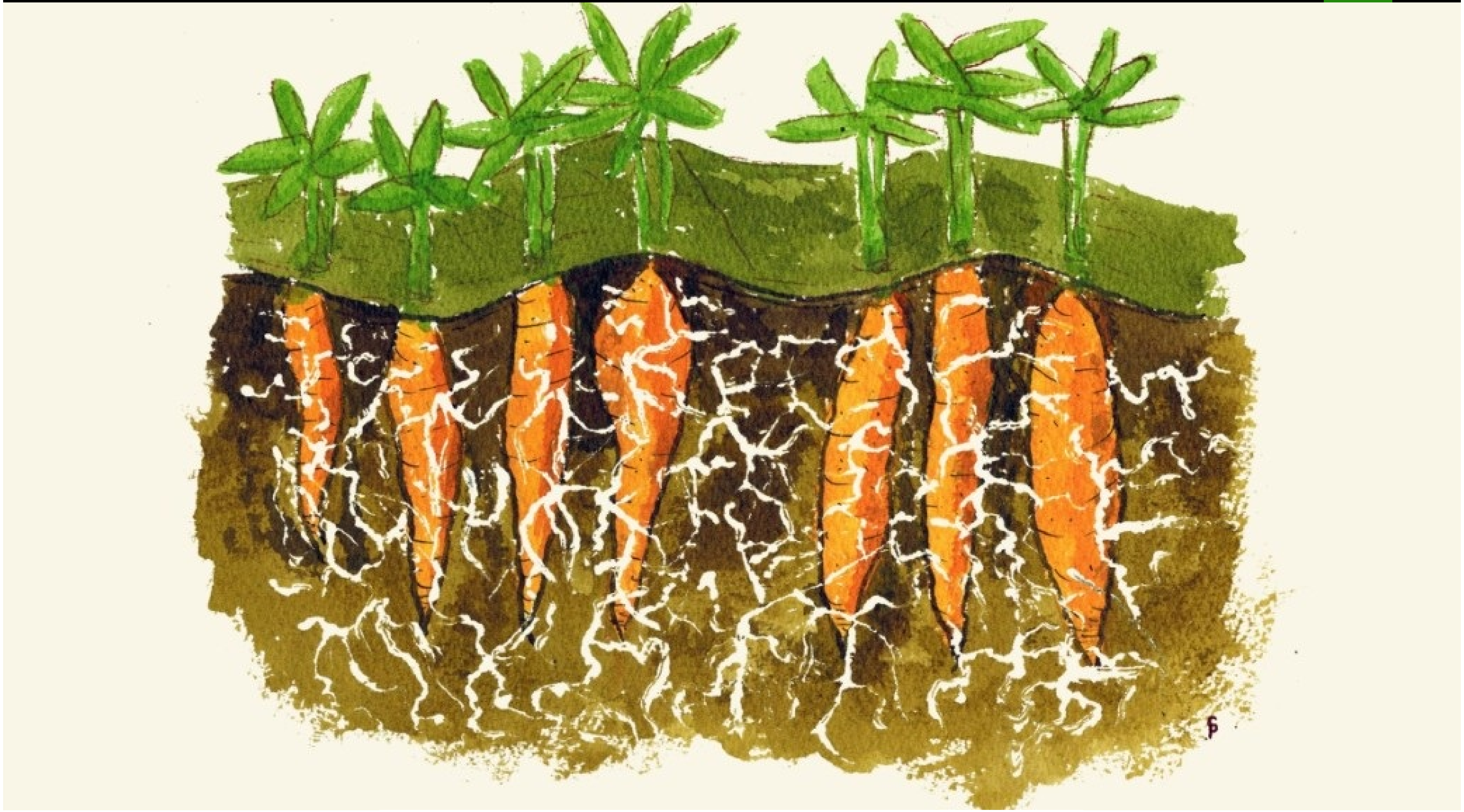


ECOLOGYBLOG, FUNGUS, MICROSCOPIC LIFE

HETEROKARYOSIS HYPOTHESIS: COULD IT HELP FEED THE WORLD?

JANUARY 22, 2014 | JOHN UPTON | LEAVE A COMMENT

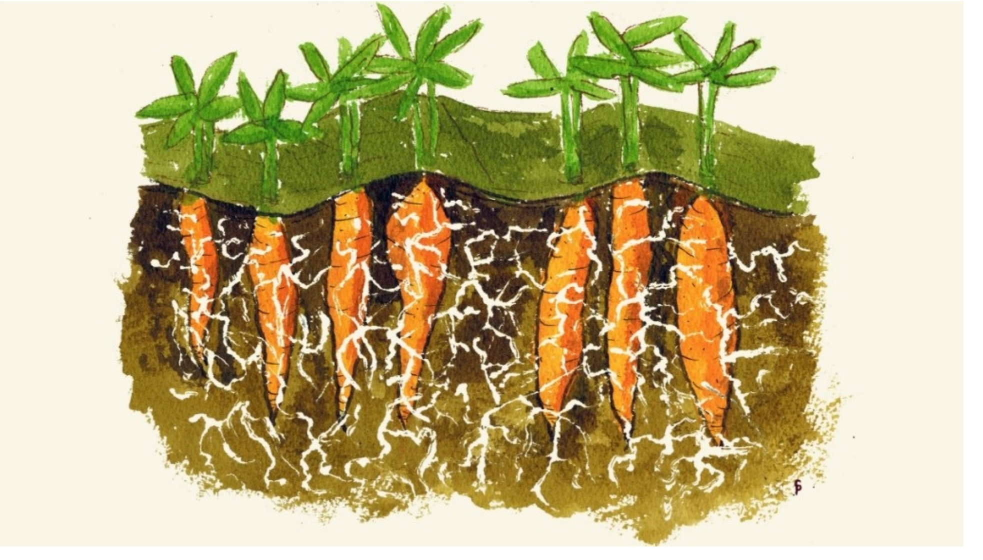
As scientists have started to figure out what a mycorrhizal fungus really is, they've discovered that it might be a really fun guy.

I mean, ahem. They've discovered that it might really be fungi.

Genetic sequencing is revealing surprising secrets of arbuscular mycorrhizae. The discoveries are casting doubt on notions of fungal individuality and offering new ways of boosting the amount of food that's grown the world over.

Mycorrhizal fungi, aka myco, are soil dwellers that forage for water and nutrients, which they exchange for sugars produced by photsynthesizing plants. As I explained recently in *Grist*, they cool the globe and boost crop yields.

Research during the past decade suggests that what many of us would assume was a single myco fungus might actually be lots of mini fungi bits — genetically diverse nuclei that live and work together inside what we would logically perceive to be a fungus. There, the nuclei collaborate to create long mycelia and hyphae that stretch from root to root, delivering water and nutrients up to the plants, and passing carbon from the plants down into the soil.



Illustrated by Perry Shirley.

This proposed blend of different nuclei is called the heterokaryosis hypothesis (a heterokaryon is a cell containing genetically diverse nuclei) — and it’s highly controversial. A recently flurry of papers has concluded that it is flat-out wrong, but those findings have been criticized by scientists who subscribe to the hypothesis.

If correct, the hypothesis could help scientists solve a couple of longtime fungal mysteries.

For one thing, it could help explain how and why mycelia from seemingly different fungi fuse together as they snake through the soil.

It could also explain how these types of fungi reproduce. Molecular evidence tells us that the fungi exchange genes, which suggests that they are mating. But scientists have never been able to figure out quite how they're doing it. The heterokaryosis hypothesis suggests it's the nuclei within each fungus that are breeding. It appears that they are migrating through fusions between the hollow mycelia.

“Why this heterokaryosis thing is so important,” said Ian Sanders, a professor of evolutionary biology at the University of Lausanne, “is because — I believe — we can use these genetic differences among the nuclei to create fungi that make plants grow better.”

Sanders has been involved with research in Colombia, where fungi have been developed that boosted cassava yields by one fifth while requiring less fertilizer. The research program is being expanded to Africa, where cassava, a root vegetable similar to a potato, is a dietary staple.

The breakthroughs relied on breeding techniques that took advantage of fungal heterokaryosis. More such breakthroughs would mean bigger yields of crops, more food, and less world hunger.

(Speaking of food, it’s worth noting that the heterokaryosis theory has nothing to do with mushrooms. There are two main types of mycorrhizae. Endomycorrhizae, which are the subject of this article, are arbuscular. They pierce the roots of plants with tiny vesicles and arbuscules, which are microscopic organs that helped both kingdoms of life adapt to life on land some 460 million years ago. It is the other type of mycorrhizae, ectomycorrhizae, the less common and less ancient union that engulfs roots without penetrating them, that produces mushrooms.)

Endomycorrhizae fungi infuse the roots of nine out of ten crop varieties, yet we know precious little about them. That’s largely because of complications inherent in trying to study an organism that’s intricately woven into the body of another; the result of nearly a half billion years of interdependent evolution.

The heterokaryosis hypothesis has its detractors. They point to research, such as this paper published this month in *PLOS Genetics*, in which nuclei sampled from a single fungus were nearly genetically identical. Supporters of the hypothesis point to findings from other research where vast genetic diversity appears to have been discovered. Sample sizes in some of the experiments have been very low, and just a few strains have been analyzed, making all of the results highly contentious.

One believer in the hypothesis is Toby Kiers, a mycological researcher at Vrije Universiteit Amsterdam. ”It’s a neat concept, because even within an individual you’ve got individuals,” she said.

Kiers will begin lab experiments next month designed to help breed mycorrhizal strains that further boost crop yields. I highlighted the planned research in a recent magazine article about myco fungus in *The Ascender*:

> *[Kiers] has secured funding to watch mycelia squeeze through tiny mazes, peering at them through microscopes as they trade nutrients with plants for sugars under different conditions. The goal, she says, is to “study their decision-making skills.”*

Kiers’s research will combine cutting-edge microscopy and mycology with old-fashioned breeding techniques in a bid to select the most useful fungal strains. ”They’re quite easy to select on,” she said, “because there’s so much genetic variability — even within a single hyphae, within a single spore.”