Final note on the project *How do lichens withstand desiccation?*

The project you helped fund reached satisfactory results and conclusions that were published on August 27 2021 in the open access journal G3: Genes|Genomes|Genetics (https://academic.oup.com/g3journal/advance-article/doi/10.1093/g3journal/jkab279/6347584). We ended up partly substituting the experiments we had proposed originally (mostly RNA sequencing) with other experiments which also provided the basic information we were seeking. *Before you read (or not) the details below, we would like to thank again each one of our backers for their moral and financial support, essential to the success of this project, and Experiment.com for catalyzing the reaction!* Your support is also acknowledged at the end of the published paper.

Our basic question

Do the introns that are uniquely abundant in the ribosome RNA genes of lichens affect the desiccation resistance for which lichens are famous for? For the non-specialists, let us briefly recall what are "introns", what are "ribosome genes", and what is special about the introns in the ribosome genes of lichens.

- *Introns:* if you think metaphorically of a gene as a molecular videotape telling a story (gene "stories" are instructions to build molecules), you can visualize introns as the parts of that videotape that contain commercials. For the cell, like for you, commercials (introns) must be removed if you want to understand the uninterrupted story. Cells in fact cut out the introns that interrupt the molecular messages of genes and reattach the various parts of the messages into continuous and flawless molecular stories. (You may wonder why genes have introns since they don't seem to help. Well, the answer is long and complicated but again, if you think more broadly of commercials, you may find reasons why they exist, even if they are annoying).
- *Ribosome genes:* are a group of genes whose messages (stories) are used to make ribosomes, the cellular machines that make proteins.
- *Removal of introns from lichen ribosome genes:* in lichens, the introns in ribosome genes have unique flaws that make them more difficult to remove than introns in other genes. We think that these "flaws" are ultimately responsible for the introns' effects on lichen biology.

Our results

- The introns embedded in the ribosome genes of lichen fungi increase desiccation resistance and slow down growth.
- Slow growth and desiccation resistance are both caused by interference of the introns with the assembly of ribosomes.
- The slowing down of ribosomal assembly by the introns is due to the slow removal of these "flawed" introns from the gene message. Imagine trying to actuate a cake recipe (building a ribosome) where random lines of meaningless text were inserted here and there within the meaningful text, and you had trouble cutting them out. Your cake preparation would be slowed down too!
- The delayed assembly of ribosomes results in slower growth because fewer proteins are produced, and proteins are necessary to all cellular functions, from metabolism to structures, to growth; slow growth allows lichens to survive in resource-poor environments.
- The reduction in protein content also makes the cells more resistant to the loss of water during desiccation. The reasons why fewer ribosomes and proteins in the cells of lichens would make them more resistant to desiccation require complex explanations which are beyond the scope of this note. We ask you to "believe" us on this point. Not as a religious but as a scientific belief, which is always subject to further experimental tests that can confirm, modify, or falsify it.

Conclusions

Our results ascribe to lichen ribosomal gene introns the hitherto unsuspected function of increasing lichen desiccation resistance and their ability to survive in environments generally “inhospitable” to most organisms. Can this knowledge be used to increase desiccation resistance in food crops for instance, especially in the face of global warming? As you can imagine, many scientists are already working on a variety of ways to increase desiccation resistance in crop plants. Engineering special introns into the ribosome genes of test plants may be worth trying but, like all interventions into the multibillion-year evolutionary “wisdom” of nature, must be performed with caution and concerns for safety and effectiveness. For instance, one simple question of many would be: how much would potential increases in desiccation tolerance through ribosome gene introns be offset by decreases in plant growth?

Finally, a philosophical note on the pursuit of usefulness in science. Science of course is immensely useful to humans in practice, from health to cars, airplanes, and phones, and should continue to be valued and pursued for that (with the unfortunate caveat that we also recklessly misuse much of it…). However, also the pursuit of happiness that scientists experience just for the sake of understanding how the universe works, from the smallest atoms or molecules in a lichen or in us to the largest black holes in galaxies, is part of what makes us human, like pursuing arts or philosophy. When we asked what those introns might do in lichens, our immediate goal was not to be useful and improve desiccation resilience in crops. We were just trying to understand a piece of the lichen puzzle. But hey, when in the course of human events something pops up that may be of practical use, feel free to run with it, but do it with care, intelligence, foresight, and humility!