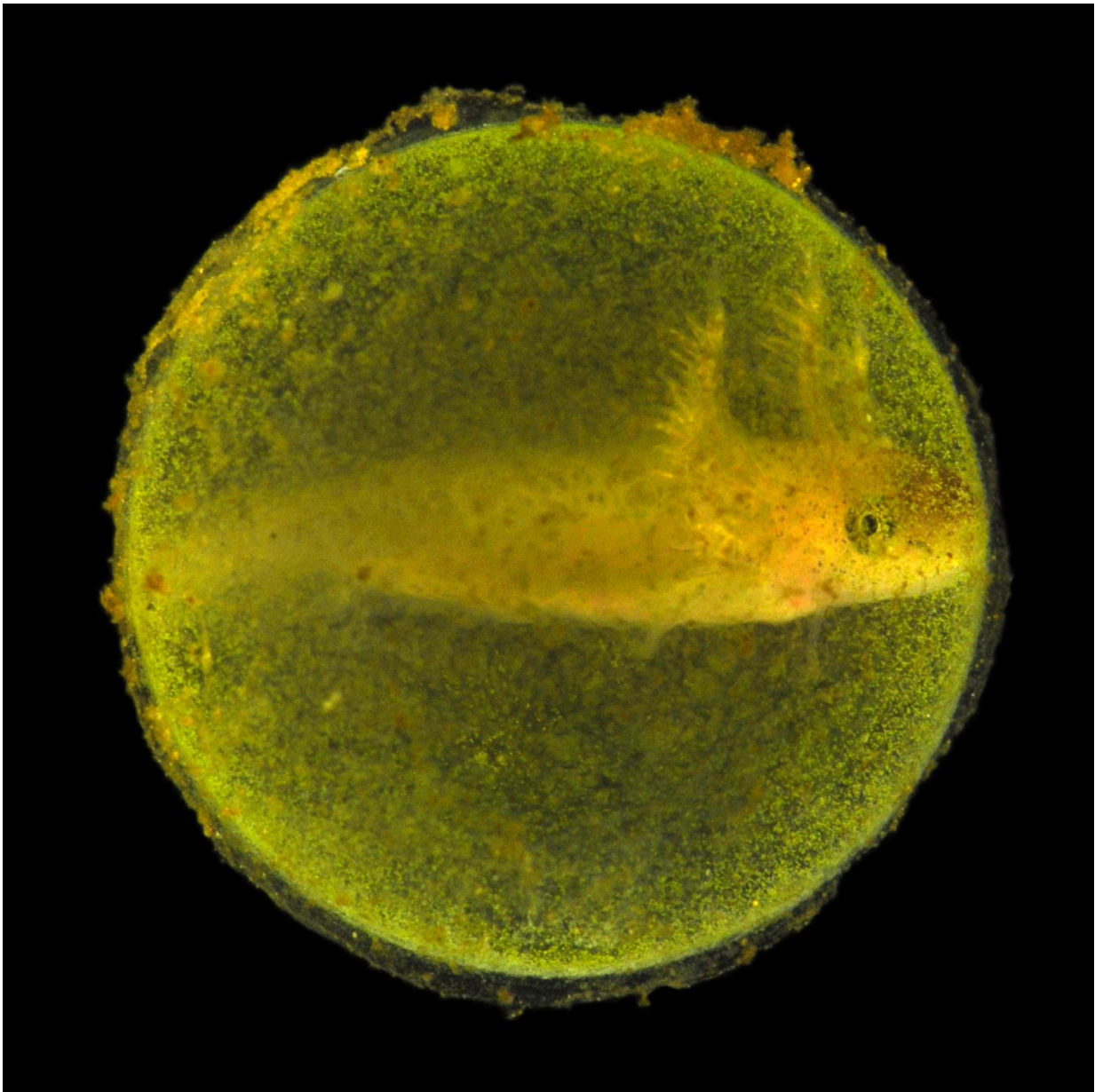


For a green alga, spotted salamanders are stressful hosts

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A single spotted salamander embryo encased in an egg, which is green due to the presence of symbiotic algae. Credit: © Roger Hangarter

New research shows how two drastically different organisms—a green alga and the spotted salamander—get along as cellular roommates. Scientists at the American Museum of Natural History and Gettysburg College found that this symbiosis, the only known example that includes a vertebrate species, puts stress on algal cells, changing the way they make energy, but does not seem to negatively impact salamander cells. The work is published today in the journal *eLife*.

"Science shows us the many ways that life is interconnected, especially on the microscopic level, where we see how many organisms depend on close contact with or internalization of other species for food, defense, or reproduction," said lead author John Burns, a postdoctoral researcher in the Museum's Division of Invertebrate Zoology. "But the relationship between this particular alga and salamander is very unusual."

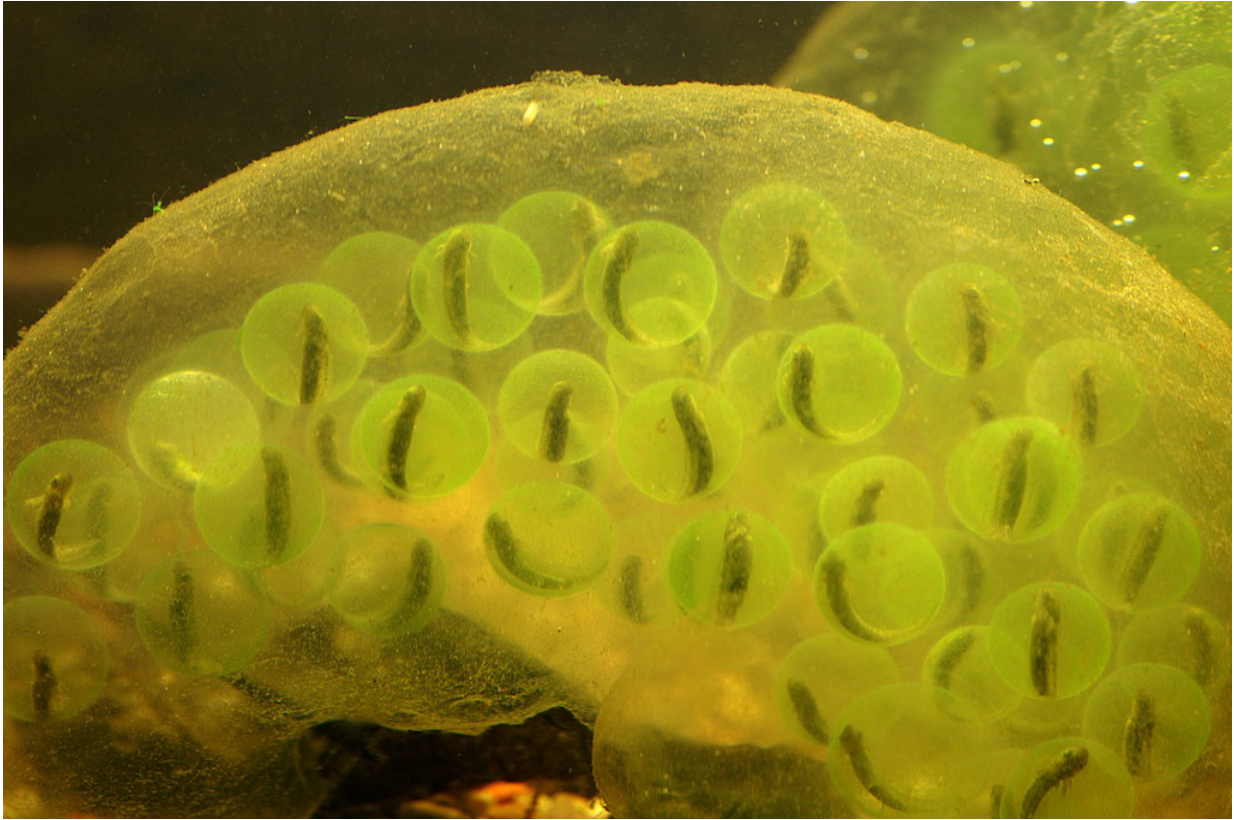
Scientists have known for more than a century that a green alga (*Oophila amblystomatis*) grows in the egg cases of the [spotted salamander](#) (*Ambystoma maculatum*)—the strange pairing is visible to the naked eye in the green hue of salamanders' eggs. The symbiosis was originally thought to occur only between the salamander embryo and the algae living outside it. The embryos produce nitrogen-rich waste that is useful to algae, and the algae increases the oxygen content of the fluid around the respiring embryos. But recent research has revealed that the algae are actually located inside cells all over the spotted salamander's body. This cell-within-a-cell relationship can also be found in corals and in the guts of cicadas, but the green alga-spotted salamander interaction is the only known example of a symbiont entering the cells of a [vertebrate species](#).

"This is really such a strange arrangement to think about, that the salamanders allow the algae to live in their egg cases. It would be like having a bunch of [green algae](#) in a womb," said study co-author Ryan Kerney, an assistant professor at Gettysburg College. "What we set out to look at now is the kind of molecular change that happens when the salamander cells and green algae cells are together."

In the new *eLife* study, the researchers compared RNA from the cells of five different groups: salamander cells with algae, salamander cells without algae, the [algal cells](#) living in salamander cells, the algae living in the egg capsules, and algae cultured in the laboratory.

They found that algae inside salamander cells are stressed and change the way they make energy. Instead of using light energy to produce food to support the salamander host, as happens in coral-algae interactions, the algae in salamander cells struggle to adapt to their new environment. Whether the [algae](#) benefits from this cell-within-a-cell interaction remains unclear. In stark contrast, affected salamander cells appear to recognize the alga as foreign but show no signs of stress during the interaction. The researchers found that the [salamanders](#) overexpress several genes that might suppress an immune response, suggesting that the host cell experience is neutral or beneficial.

"We are learning that these two fundamentally different [cells](#) are changing each other dramatically, and this might be relevant for other symbiotic systems, including human and parasitic microbe relationships," said study co-author Eunsoo Kim, an assistant curator in the Museum's Division of Invertebrate Zoology.



A spotted salamander egg mass. Developing embryos are encased in eggs that are green due to the presence of symbiotic algae. The green alga enters cells of the spotted salamander embryos during development. Credit: © Roger Hangarter

More information: John A Burns et al, Transcriptome analysis illuminates the nature of the intracellular interaction in a vertebrate-algal symbiosis, *eLife* (2017). [DOI: 10.7554/eLife.22054](https://doi.org/10.7554/eLife.22054)

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