In fish, parents' stressful experiences influence offspring behavior via epigenetic changes

March 30 2021, by Jennifer Hellmann

Sticklebacks, with their complex behaviors, make for excellent study subjects. Credit: Brian Stauffer, CC BY-ND

Parents who are exposed to predators pass on information about risky environments to their offspring through changes in gene expression—but how that information affects offspring differs depending on the sex of the parent. My colleagues and I showed this using sticklebacks—a small species of freshwater fish whose brightly colored males care for

developing eggs—in a series of papers recently published in the *Journal of Animal Ecology*.

First, we exposed mothers and fathers to predators. Then we looked at their offspring and measured behavior as well as how genes were expressed in their brains. We found that the sex of the parent exposed to predators matters, but surprisingly, the sex of the offspring also changed how the information influenced behavior.

Predator-exposed fathers produced bolder sons that took more risks, but the father's experiences had no effect on the boldness of daughters. Predator-exposed mothers, on the other hand, produced more anxious daughters and also more anxious sons. These sons and daughters had different patterns of gene expression, matching our behavioral results.

We also studied whether these changes persisted into a second generation. In grandkids, we again found complicated patterns of sex-specific inheritance.

So how does this work? It's not that experiences have changed what genes the parents pass on. Rather, what changes is how those genes are expressed in the offspring. This variability in gene expression is called epigenetics.

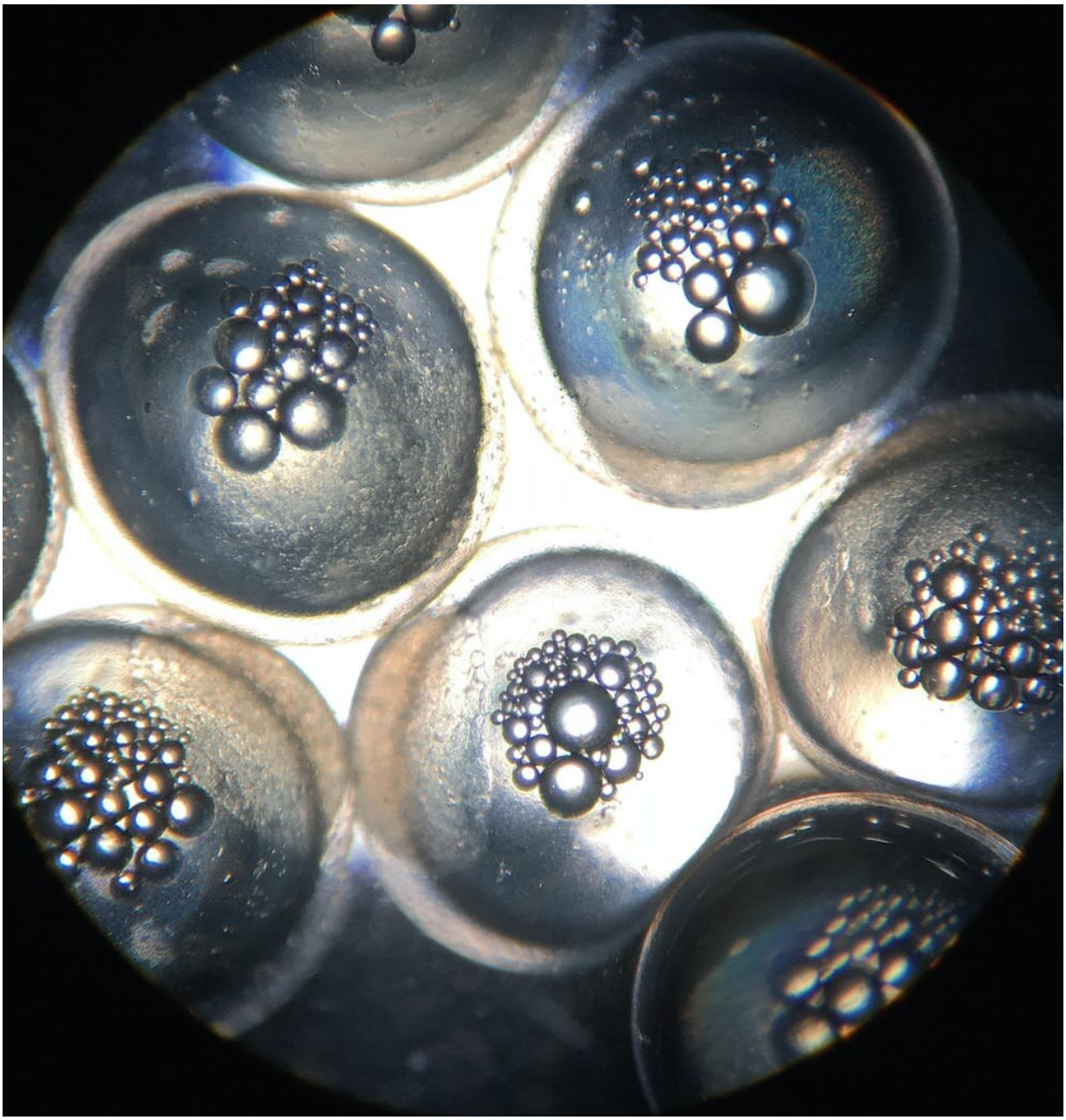
Sticklebacks fear a number of predators in the lakes and rivers they inhabit, including freshwater sculpin, like the one seen here. Credit: Jennifer Hellman, CC BY-ND

Why it matters

My lab is generally interested in how an animal's experiences influence the development and behavior of its descendants. Biologists call this transgenerational plasticity, and it allows parents to give offspring information about the environment before offspring are even born. For example, in mice, when fathers are trained to fear a particular odor, their offspring will fear that odor even if they have not been trained to do so.

Researchers have found transgenerational effects in all sorts of species—including in people. In humans, grandparents' experiences—such as food availabilty or smoking—can have strong, sex–specific effects on weight gain in grandkids.

But studying behavioral changes is much harder than studying weight gain, and our study, albeit in fish, is one of the most careful to date examining sex and behavior in transgenerational plasticity. Studies like ours could help researchers better understand how stressful events today might affect future generations. This could apply to anything, from poverty or PTSD in humans to climate change in reef fish.



Through epigenetics, a parent can pass down information to the next generation of sticklebacks like the ones growing in these eggs. Credit: Jennifer Hellman, CC BY-ND

What still isn't known

Researchers still know very little about the mechanism of these sex-specific effects; how is it possible for paternal experiences to affect sons in one way and daughters in another? Further, do these sex-specific effects have some sort of benefit for future generations? Researchers know this mechanism exists in people as well, but whether these sex differences are harmful or beneficial remains a mystery.

What's next

How parents raise their offspring also plays a huge role in determining behavior. My colleagues and I want to better understand how stress in parents' life might change the way they interact with their kids. For example, if fathers are stressed and pass those effects on through epigenetic changes to sperm, do they change their fatherly behavior as well to magnify or minimize those epigenetic changes?

We are currently running these experiments in sticklebacks and hope that what we learn will be important for humans, too. After all, every human parent knows how stressful life can be.

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