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Need sex? It's probably something about stress

Heat turns colonial algae into hotties.

When algae find themselves in hot water, the normally asexual organisms get all stressed out and turn sexual.

Blame it on the free radicals, says a team of researchers.

Colonies of the multicellular green alga Volvox carteri exposed to temperatures of 111 degrees Fahrenheit (42.5 degrees Celsius) had twice the amount of free radicals, oxidants that can damage biological structures, as unheated colonies. High levels of oxidants within their cells activated the algae's sex-inducer gene, the researchers report.

Then the fun starts.

The sex-inducer gene promotes the production of the sex-inducer, a pheromone the colony releases to guarantee willing mating partners.

Volvox carteri, a colonial freshwater alga. The small dots are regular cells and the large ones are asexual reproductive cells. Photograph courtesy of Aurora Nedelcu.

Full size image available through contact

"We're the first to show that oxidants are responsible for sex in this organism," said UA professor Richard E. Michod, head of UA's department of ecology and evolutionary biology and a coauthor on the research. "This is the first demonstration that stress turns on sex-inducer genes."

The research will be published in the June 9 issue of the Proceedings of the Royal Society of London, B. Aurora M. Nedelcu, an adjunct assistant professor at UA and an assistant professor at the University of New Brunswick in Canada, is the lead author of the paper, " Sex as a response to oxidative stress: A two-fold increase in cellular reactive oxygen species activates sex genes." Oana Marcu of the University of California, Irvine, is a coauthor.

It may seem an odd question, but biologists have long puzzled over why have sex.

Besides all the concomitant fuss and muss, sex seems like an inefficient way to pass one's genes to the next generation.

But sex has been around a long time and lots of organisms do it, so there must be a good reason, scientists figured.

One explanation for sex is that valuable genetic variation is created by the mixing of genes that occurs, first when sperm and eggs are formed and again when they merge.

But about 15 years ago, Michod and some of his UA colleagues proposed an alternative explanation called the DNA-repair hypothesis.

They suggest that the process which divvies out parental genetic material to sperm and eggs also repairs the DNA that goes into those cells. The repair mechanism keeps the hard knocks that life dealt the parents' DNA from being passed on to the children.

"Sex is all about maintaining the health of the DNA you give your kids," Michod said.

Although there has been work supporting the DNA-repair hypothesis as the reason for sex in single-celled organisms, Michod said the current work is the first evidence that DNA repair is a reason for multicellular organisms to have sex.

"I'd always believed it, but we never had concrete evidence in multicellular organisms until now," he said. "I'm thrilled."

For many organisms, sex is not the main method of reproduction. Instead, sex is a response to stress.

And stress generally increases the production of free radicals, sometimes called oxidants.

While pondering those two facts, Nedelcu, then a research associate in Michod's lab, wondered whether the signal for sex in such organisms is an increase in oxidants.

To test her idea, she used Volvox, the lab rat of the algal world.

Tiny spheres of gel with individual alga cells spread over the surface of the sphere like polka dots, Volvox colonies can be found in temporary ponds that fill with water in the spring and slowly dry out as summer progresses.

In addition to the outer cells, a colony also has specialized reproductive cells tucked inside the center of the 0.5 millimeter-diameter sphere. Some colonies are male, some are female. The colonies reproduce asexually, by fission of the reproductive cells, about every two days when conditions are good.

As the summer progresses and ponds start heating up and drying out, the colonies become sexual. The sexual colonies have specialized sperm and egg cells that merge to form tough spores that persist until the dried-out pond fills again the following spring. When the spores germinate, the genetic machinery goes through a process called meiosis, which repairs and mixes up the DNA from the parents' sperm and eggs. The new colonies are asexual.

To simulate such late-summer conditions, Nedelcu put culture plates full of Volvox into water baths for two hours. At several points in time, she added a dye that fluoresces when exposed to oxidants. She then measured the fluorescence, which corresponded to the amount of oxidants the Volvox produced.

After only 10 minutes at 111 F (42.5 C), Volvox colonies had twice as many oxidants when compared with unheated colonies.

"This paper shows that sex is a response to oxidants," she said. "Sex evolved as a way to deal with stress and its consequences -- DNA-damaging oxidants."

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