Scientist Unlocking the Secrets of Sea Slug that Lives Like a Plant

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(PhysOrg.com) -- Photosynthesis generates the oxygen needed for life on earth as well as the biomass for food and biofuel production. The process is driven by the absorption of the sun's energy by tiny green "bodies" called chloroplasts. The "solar-powered" sea slug Elysia chlorotica has fascinated scientists for years because of its ability to retain "stolen" chloroplasts and carry out photosynthesis as if it was a plant.

Although they are slugs, these small green creatures aren't the yellowish-brown slimy slugs that people typically think of. Rather, they are emerald green marine molluscs that look like a plant leaf, and only need to eat early in their life cycle.

University of Maine biochemistry professor Mary Rumpho-Kennedy has been studying these creatures since 1987, and her recent ground-breaking research offers some insight into the potential for evolution of photosynthesis in an animal through symbiosis and gene transfer.

As their first meal, the sea slugs suck out the cellular contents of their algal prey and retain the green chloroplasts in cells lining their digestive gut. With this special type of symbiosis, the sea slugs never need to eat again; instead, they survive for months on sunlight and air – just like a plant – by carrying out photosynthesis.

Rumpho-Kennedy's work, recently published in the "Proceedings of the National Academy of Sciences USA," explains the possibility that when the sea slug feeds on its algal prey it not only acquires chloroplasts, but also algal nuclear DNA.

The algal nuclei go through the sea slug's gut and are broken open releasing the algal DNA. This DNA is either taken up freely floating by cells lining the gut or it is transferred by some type of vector, possibly a virus. The foreign DNA then becomes part of the animal nuclear DNA transferring genetic information from the algal nucleus to the sea slug. This DNA contains the genetic information to make chloroplast proteins essential for photosynthesis to continue. Animal DNA does not contain these genes and thus, cannot support photosynthesis.

"When you eat lettuce, the chloroplasts and nuclei go through your gut but the enzymes chew them up and digest them," Rumpho-Kennedy said. "With the sea slug, the chloroplasts aren't digested and the animal turns green. The sea slug has to acquire these chloroplasts once each generation or development stops."

Scientists have long studied a phenomenon called vertical gene transfer, in which genetic material (a copy of one's DNA) is passed on from an organism's ancestor to the next generation.

They've also studied horizontal gene transfer between prokaryotes (typically a single cell organism that lacks a nucleus which contains its genetic material), or from a prokaryote to a eukaryote (that has a nucleus that contains its DNA), or more rarely, between two closely related eukaryotes. But the idea of horizontal gene transfer between two unrelated multicellular eukaryotes, from an alga to a mollusc in the case of the sea slug, is something new.

Rumpho-Kennedy ultimately hopes to discover how the sea slug is able to get the algal DNA into its system and make it work, determine the minimal requirements for photosynthesis, and understand how the foreign material avoids destruction in the sea slug.

It will take additional research to determine why the sea slug's immune system doesn't attack the foreign chloroplasts or DNA, but the discovery could lead to breakthroughs in understanding immunity and disease.

"A lot of parasites can fool the immune system," Rumpho said. If scientists can determine how the chloroplasts are able to avoid detection in the sea slug, they may be able to determine how parasites are able to attack humans.

She noted that humans have more sophisticated immune systems than sea slugs, but the mollusc still should try to attack the foreign green bodies and DNA within their cells. Instead, the sea slug retains the chloroplasts intact and incorporates the foreign genes from the algal nucleus into its own nuclear genome. Rumpho-Kennedy and students in her lab are continuing to look at various possibilities to explain this.

"Understanding this unusual organism gives a whole new meaning to ‘going green!’," she said.

Provided by University of Maine

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