These Solar-Powered Sea Slugs Are the Ocean's Most Prolific Thieves

'If there is magic in the world, surely it is this: the descendants of tiny creatures in leaves, capable of ingesting the sun.'
-Rob Dunn

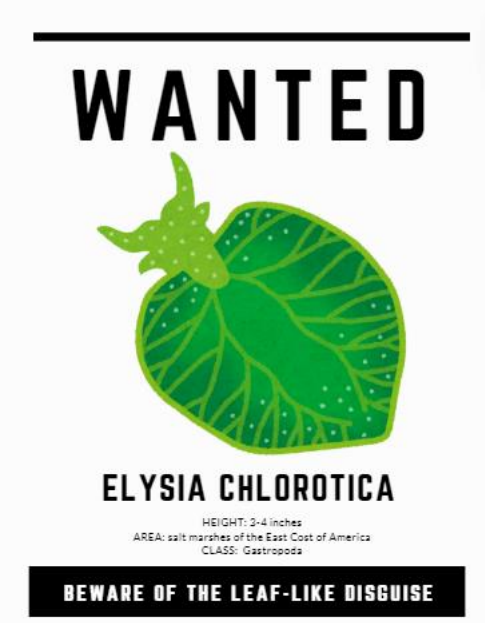


Image created using Canva

The salt marshes off the northeast coast of America at first appear to be a safe and serene place. However, lurking beneath the surface is an unlikely criminal…

At first glance, it may appear to be little more than a single, vivid green leaf, but despite this unassuming appearance, *Elysia chlorotica*, also known as the Eastern Emerald Elysia, is one of the most extraordinary creatures on our planet. Measuring just 2 to 4 inches in length, this sacoglossan (sap-sucking) sea slug takes the phrase "you are what you eat" to a whole new level through its rare ability to live like a plant for the majority of its life.

The young mollusc lurked about the muddy seabed, searching for her algal prey. In the distance, Elysia saw the yellow-green filaments swaying with the tide. Eagerly, she slithered towards them, preparing to carry out the crime she needed to support the solar-powered life of her dreams.

Source: https://www.nsf.gov/news/mmg/mmg_disp.jsp?med_id=68806

Through a process known as kleptoplasty, *E. chlorotica* is able to steal the chloroplasts and other plastids (small bodies involved in photosynthesis and food storage) from the algae it consumes and maintain them within its own cells. This allows these marine criminals to photosynthesise, meaning they can go without another meal for up to a year!

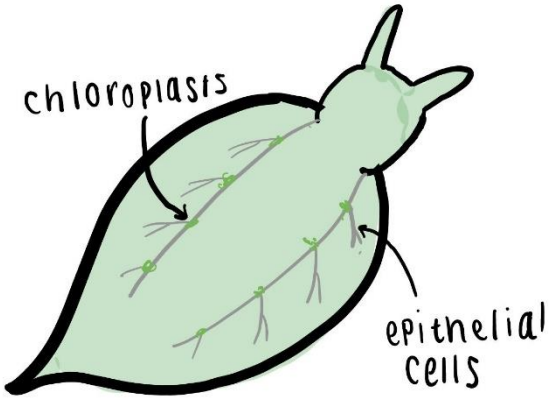
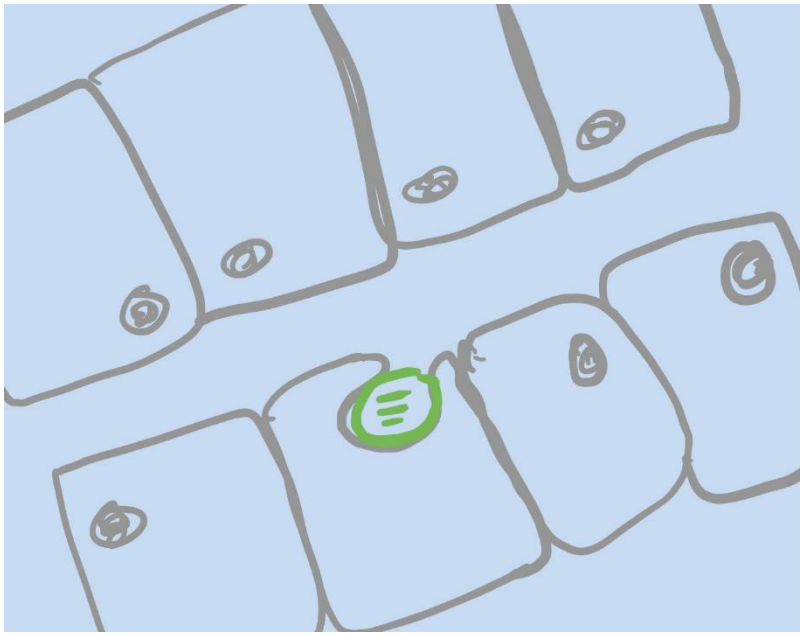


Image showing the position of chloroplasts in the digestive system of *Elysia Chlorotica*

Image created using Notability

Eventually, the great bloom of algae she had been longing for was upon her. Using specially adapted sharp teeth called radula, Elysia pierced the thin exterior and gleefully began to suck the cells out. With careful precision, she kept her prize in tip-top condition: a chloroplast! She quickly hid it in the epithelial cells that line her digestive system, creating the perfect illusion of a leaf to mask her crime.



Algal chloroplast being engulfed into epithelial cell

Image created using Notability

Sneaking the chloroplasts into the cells of *E. chlorotica* is only the first step. As they are organelles that are adapted to functioning in the cells of the *Vaucheria litorea* algae that the slugs eat, they are not able to survive in most host animal cells. This is because other important proteins and enzymes necessary for photosynthesis are expressed by nuclear DNA, as opposed to the DNA carried in the chloroplasts. But *E. chlorotica* is one step ahead. The thieves have planned the perfect crime, and they are already synthesising the algal proteins they need to use the stolen chloroplasts to photosynthesise.

Over time, Elysia's appearance began to change. The bright green pigment inside her brand-new chloroplasts, chlorophyll, began to give her whole body a green tinge, and with the epithelial cells that line her digestive system giving the appearance of xylem in a leaf, she was perfectly disguised from any predators who might hunt her down.

Sunlight, which is transmitted through the water, is captured by the chlorophyll inside *E. chlorotica*'s stolen chloroplasts, where it is used to split water into oxygen and hydrogen. Through a series of enzyme-controlled reactions, the hydrogen is converted into glucose, which can be stored as starch, a storage carbohydrate, or used by the sea slug for respiration.

Elysia knew she must now work hard for her plan to succeed. She wasn't the least bit worried though, for her recipe for success was stored in her DNA.

Curious scientists studied the DNA of *E. chlorotica*, where they identified the presence of one of the algal genes necessary for photosynthesis, the *psbO* gene. The sequence of bases in the sea slug's version of the gene was identical to that of the algal cell's version, which suggests that, on top of stealing chloroplasts, the slugs also stole genes from their food and incorporated them into their own genome! This is likely through the process of horizontal gene transfer. Although horizontal gene transfer is common among bacteria and other unicellular organisms, it is unbelievably rare between two eukaryotic organisms, leaving scientists baffled by *E. chlorotica*'s special case.

Its awesome ability to express the algal genes allows the invertebrates to synthesise the proteins and enzymes needed to support the stolen chloroplasts, meaning they can continue to work for 9 to 12 months, which is about the average lifespan of *E. chlorotica*.

Similar to the incorporation of chloroplasts and mitochondria into eukaryotic cells, scientists have hypothesised that the unique relationship between *E. chlorotica* and the algae is an example of symbiosis, more specifically endosymbiosis, where plastids and genes from the algae live within the cells of the slugs.

Delighted and full of energy, Elysia settled down on the muddy seabed. As the sun's rays shone through the water, she fell into a deep and peaceful slumber, happy in her newfound status as a plant.

Despite how it seems, *E. chlorotica* does not magically transform into a plant but instead can be considered a mixotroph. Generally, animals are classified as heterotrophs, meaning they cannot create their own food and rely on other life to survive. On the other hand, plants are autotrophs, meaning they can synthesise their own food from sunlight, carbon dioxide, and other inorganic compounds. Mixotrophs have the rare ability to consume food like animals and make their own through photosynthesis like plants.

Elysia and her friends were one-of-a-kind; their uniqueness was all thanks to their incredible evolutionary adaptations. However, despite all their fame and glory, it didn't get to their heads, and they spent the rest of their days swimming and sleeping in peaceful harmony in their marine eutopia.

Further reading

- https://www.nature.com/articles/sdata201922
- https://manoa.hawaii.edu/exploringourfluidearth/biological/aquatic-plants-and-algae/structure-and-function/weird-science-kleptoplasty#:~:text=Kleptoplasty%20is%20the%20behavior%20of,%E2%80%9Csteal%E2%80%9D%20the%20undigested%20chloroplasts.
- https://royalsocietypublishing.org/doi/10.1098/rspb.2021.1779
- https://www.pnas.org/doi/full/10.1073/pnas.0804968105