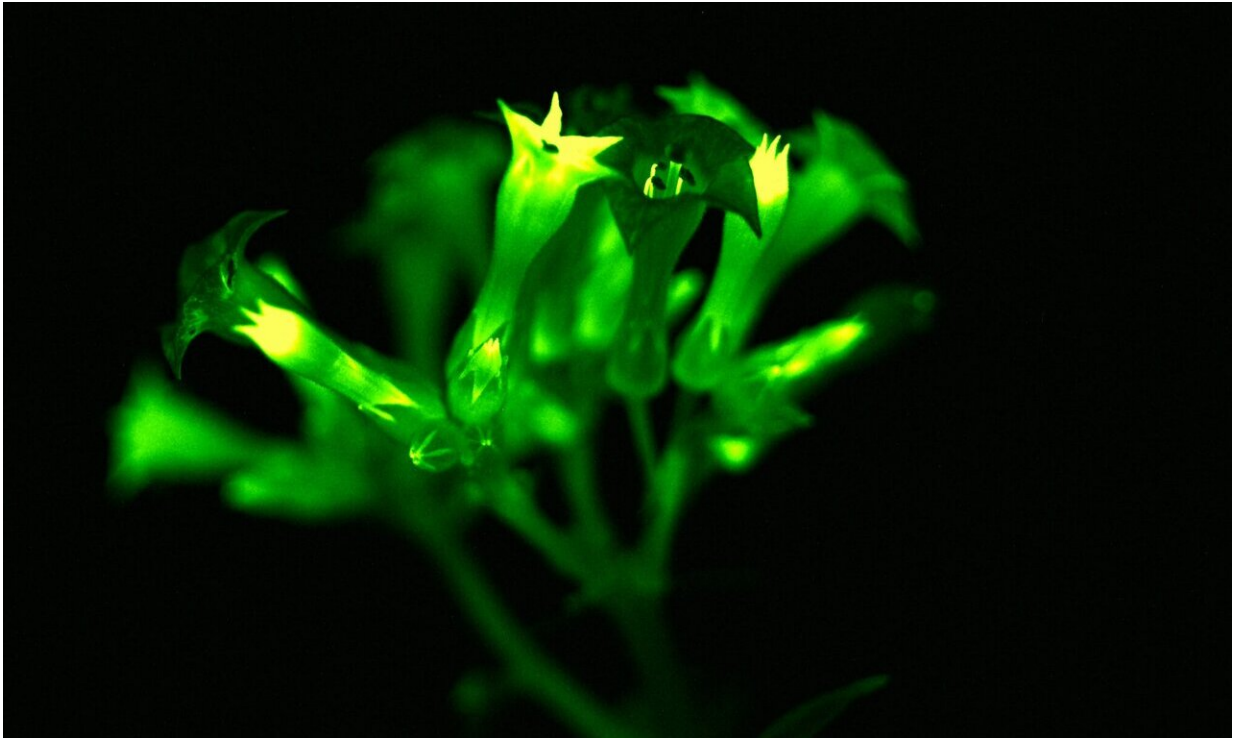


Sustainable light achieved in living plants

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Glowing flowers. Credit: Planta

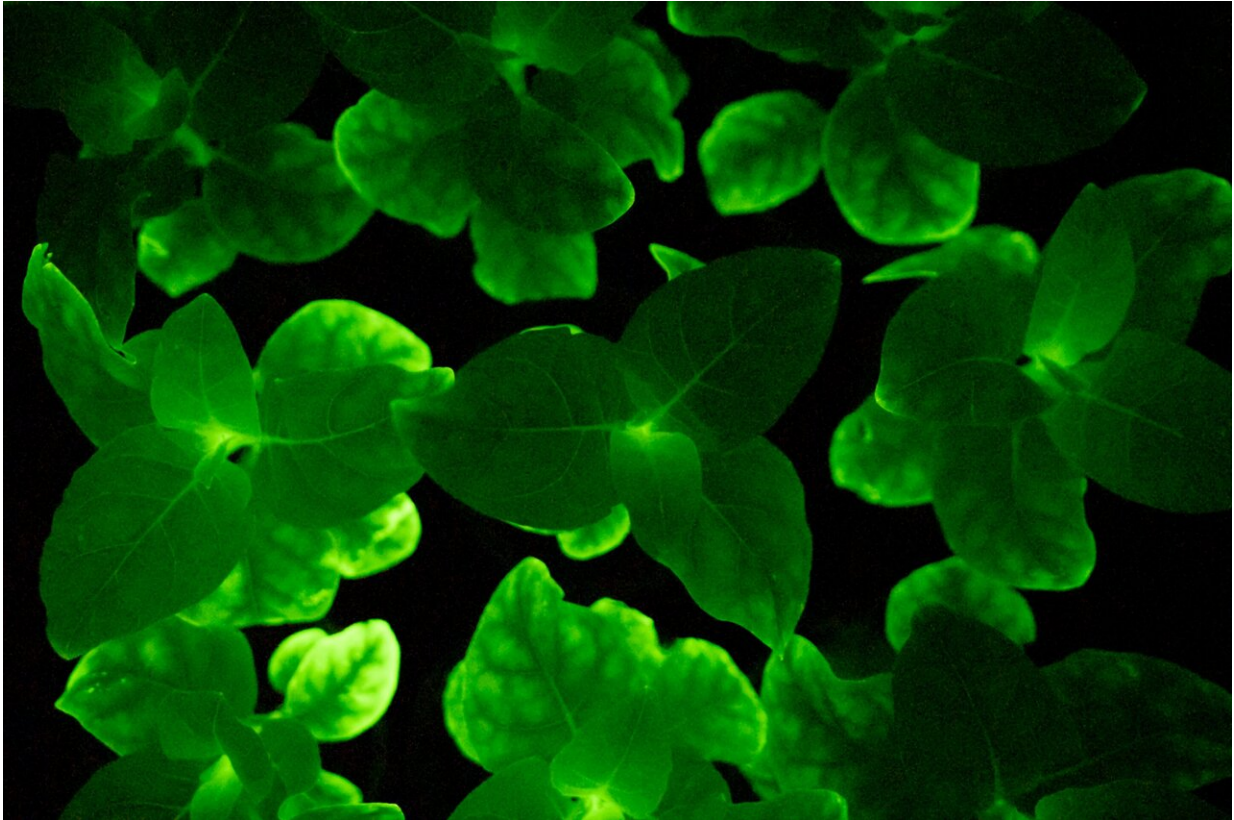
The movie *Avatar* evoked an imaginary world of lush bioluminescent jungles. Now the popular fascination for sustainably glowing foliage is being realized through advances in designer genetics. This week in *Nature Biotechnology*, scientists have announced the feasibility of creating plants that produce their own visible luminescence.

The scientists revealed that bioluminescence found in some mushrooms is metabolically similar to the natural processes common among plants. By inserting DNA obtained from the mushroom, the scientists were able to create plants that glow much brighter than previously possible.

This biological [light](#) can be used by scientists for observing the inner workings of plants. In contrast to other commonly used forms of bioluminescence, such as from fireflies, unique chemical reagents are not necessary for sustaining mushroom bioluminescence. Plants containing the mushroom DNA glow continuously throughout their lifecycle, from seedling to maturity.

The new discovery can also be used for practical and aesthetic purposes, most notably for creating glowing flowers and other [ornamental plants](#). And while replacing [street lights](#) with glowing trees may prove fantastical, the plants produce a pleasant green aura that emanates from their living energy.

The report in *Nature Biotechnology* was authored by 27 scientists, led by Drs. Karen Sarkisyan and Ilia Yampolsky. The research was carried out principally through a collaboration between Planta, a biotech startup in Moscow, the Institute of Bioorganic Chemistry of the Russian Academy of Sciences, MRC London Institute of Medical Sciences, and the Institute of Science and Technology Austria. Financial support was provided by Planta, the Skolkovo Foundation, and the Russian Science Foundation.



Glowing young plants. Credit: Planta

According to the authors, the plants can produce over a billion photons per minute. Dr. Keith Wood, CEO of Light Bio, states that "thirty years ago, I helped to create the first luminescent plant using a gene from fireflies. These new plants can produce a much brighter and more steady glow, which is fully embodied within their genetic code." Light Bio is a new company that plans to commercialize this novel technology in ornamental house plants in partnership with Planta.

Designing new biological features is more complex than merely moving genetic parts from one organism to another, however. Like gears in a watch, the newly added parts must metabolically integrate within the

host. For most organisms, the parts needed for bioluminescence are not all known. Until recently, a complete part list was available only for bacterial bioluminescence. But past attempts to create glowing plants from these parts have not gone well, largely because bacterial parts typically do not work properly in more complex organisms.

Little more than a year ago, scientists uncovered the parts that sustain bioluminescence in mushrooms. For the first time, the living light of an advanced multicellular organism was fully defined. In the present report, the authors disclose that mushroom bioluminescence works particularly well in plants. This allowed them to make glowing plants that are at least ten-fold brighter. Using ordinary cameras and smartphones, green illumination was recorded coming from leaves, stems, roots, and flowers. Moreover, the sustained light production was achieved without harming the health of the plants.

Although mushrooms are not closely related to plants, their light emission centers on an [organic molecule](#) that is also needed in plants for making cell walls. This molecule, called caffeic acid, produces light through a metabolic cycle involving four enzymes. Two enzymes convert the caffeic acid into a luminescent precursor, which is then oxidized by a third enzyme to produce a photon. The last enzyme converts the oxidized molecule back to caffeic acid to start the cycle again.

In plants, caffeic acid is a building block of lignin, which helps provide mechanical strength to the cell walls. It is thus part of the lignocellulose biomass of plants, which is the most abundant renewable resource on Earth. As a key component of plant metabolism, caffeic acid is also integral to many other essential compounds involved in colors, fragrances, antioxidants, and so forth. Despite their similar sounding names, caffeic acid is not related to caffeine.

By connecting light production to this pivotal molecule, the glow emitted

by the plants provides an internal metabolic indicator. It can reveal the physiological status of the plants and their responses to the environment. For instance, the glow increases dramatically when a ripe banana skin is placed nearby (which emits ethylene). Younger parts of the plants tend to glow most brightly and the flowers are particularly luminous. Flickering patterns or waves of light are often visible, revealing active behaviors within the plants that normally would be hidden.

In this published research, the authors relied on tobacco plants because of their simple genetics and rapid growth. But the benefits of mushroom bioluminescence are broadly fitting to plants. Research at Planta, and by Arjun Khakhar and colleagues, have demonstrated feasibility for other glowing plants, including periwinkle, petunia, and rose. Even brighter plants can be expected with further development. New features may be possible, such as changing brightness or color in response to people and surroundings. Through this living aura, we may even gain a new awareness of our [plants](#) that emulate the inspiring allure of Avatar.

More information: Plants with genetically encoded autoluminescence, [DOI: 10.1038/s41587-020-0500-9](https://doi.org/10.1038/s41587-020-0500-9) , www.nature.com/articles/s41587-020-0500-9

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