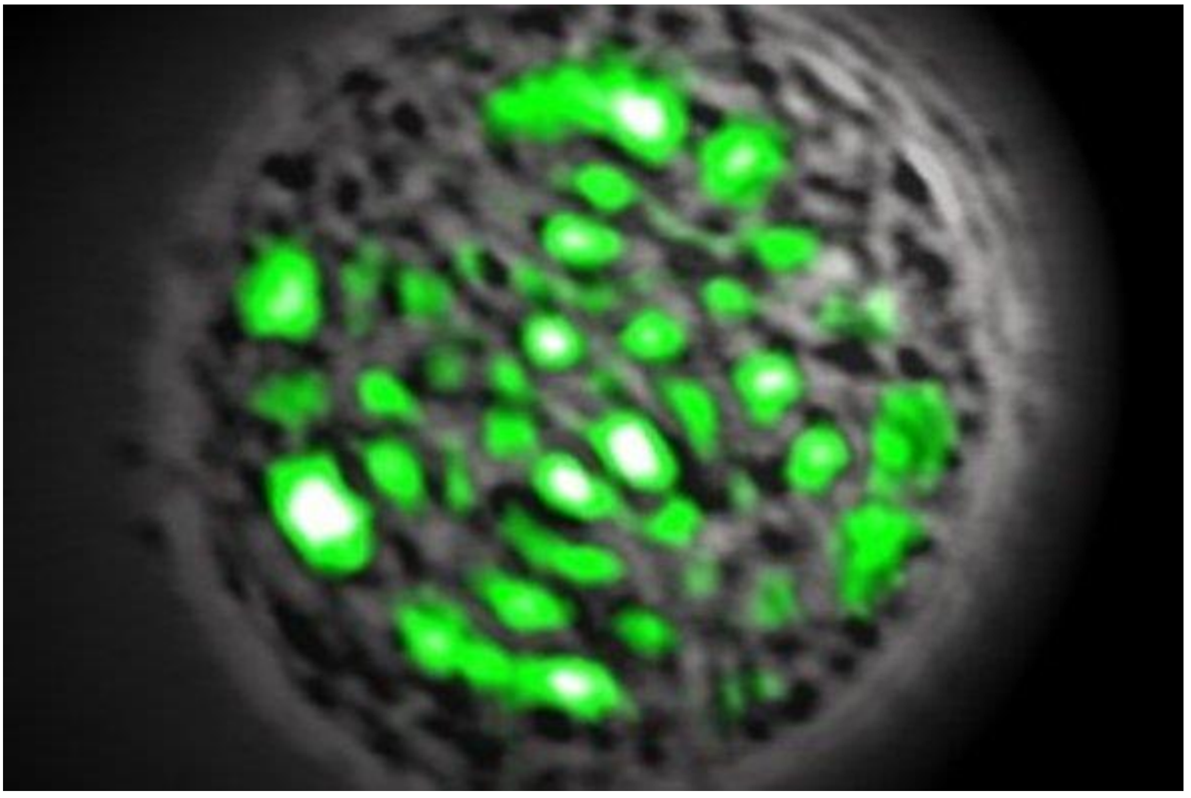
Green Fluorescent Protein Makes for Living Lasers

A single mammalian cell expressing a mutant green fluorescent protein is the first living object to be used as a laser

- By John Matson on June 13, 2011



Credit: Malte Gather

In a unique fusion of biology and physics, researchers have created the world's first living laser. Single cells containing a special protein that acts as an optical amplifier have been coaxed to emit green laser light, according to a new study. And, perhaps surprisingly, the cell survives its stint as part of the laser.

The researchers achieved the feat with the help of a well-known protein that has a distinct green glow. The green fluorescent protein (GFP), first isolated from a jellyfish in the 1960s, has found numerous uses in biomedical imaging, including as a visual marker to trace gene expression in living organisms, and won three GFP pioneers a Nobel Prize in Chemistry in 2008. The new research opens the door to more advanced biophotonic applications harnessing the intensity and information-carrying capacity of laser light, but it is not yet clear what uses might be feasible.

Malte C. Gather and Seok-Hyun Yun, both at Harvard Medical School and Massachusetts General Hospital, inserted the genetic material needed to express a form of the GFP protein, known as enhanced GFP, or eGFP, into a living cell derived from a human embryonic kidney cell line. EGFP is a commonly used mutant version of the protein that fluoresces more brightly than the GFP in jellyfish.

In a study published online June 12 in *Nature Photonics,* Gather and Yun report engineering the first living laser by placing an eGFP-bearing cell inside a reflective optical cavity and hitting it with pulses of blue light. (*Scientific American* is part of Nature Publishing Group.) With low-energy pulses, the cell glows only by ordinary fluorescence. But at a certain threshold its optical output changes suddenly. The light becomes almost completely uniform in color (a pure green of about 516 nanometers in wavelength), increases in brightness and becomes directed rather than diffuse.

"You can see it with the naked eye," Yun says. "As soon as it reaches the threshold you can see it. It's a nice green."

In the five decades since the invention of the laser, researchers have managed to entice all kinds of inanimate matter into emitting coherent laser light, including the so-called edible laser of 1971. "Somebody used dye and put it into a gelatin and then shined a pump light and saw laser light coming out of it," Yun says. "They called it an edible laser, but you don't want to eat that dye because it's toxic."

In 1975 researchers from the National Bureau of Standards (now the National Institute of Standards and Technology) tapped the optical properties of ethyl alcohol to make lasers from gin, rum and vodka. But ethyl alcohol was a poor laser medium compared to poisonous methyl alcohol, the group reported in IEEE Journal of Quantum Electronics, concluding that "it is quite obvious that there are better uses of ethyl alcohol."

But using proteins in a living cell as a gain medium to amplify light within a laser system is novel. "I believe it is quite new to have a laser which is actually produced from a living material and that in fact survives several minutes as the laser gain medium," says chemist Steve Meech of the University of East Anglia in England, who wrote a commentary accompanying the research in *Nature Photonics*.

The research is likely to generate excitement in the photonics field and beyond, but Meech notes that finding applications could be tricky. "I think that's the difficult question to answer for this," he says. "Of course, the old scientist's defense is, 'What use is a baby?' Which is an old quote from [Michael] Faraday. Having said that, I have spent some time trying to come up with applications for this and haven't."

Yun and his colleagues are now working on investigating possible uses; for instance, using the laser system as a sensitive monitor of intracellular processes. Light bounces back and forth within the resonator cavity and passes through the cell numerous times before being emitted as laser light, so the researchers suspect that any cellular changes could be writ large in the light output. "We are now trying to understand whether we can get any information about this cell through its optical properties," Yun says.

At the moment, the new discovery has satisfied the researchers' intended purpose—to simply demonstrate that such a device could work. "It actually came from pure intellectual curiosity," Yun says. "From the very beginning we had a vision to make it work inside a cell."