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Glowing plants spark debate

Critics irked over planned release of engineered organism.

Ewen Callaway

04 June 2013



A glow-in-the-dark tobacco plant was first engineered by scientists in the 1980s.

SCIENCE/AAAS

Among the many projects attracting crowd-sourced funding on the Kickstarter website this week are a premium Kobe beef jerky, a keyboard instrument called a wheelharp and a small leafy plant that will be made to glow in the dark using synthetic-biology techniques.

The Glowing Plant project, which ends its fund-raising campaign on 7 June, seeks to engineer the thale cress *Arabidopsis thaliana* to emit weak, green-blue light by endowing it with genetic circuitry from fireflies. If the non-commercial project succeeds, thousands of supporters will receive seeds to plant the hardy weed wherever they wish.

The US government has no problem with this prospect, yet some experts and industry watchers are

jittery. They fear that distributing the plants could set a precedent for unsupervised releases of synthetic organisms, and might foster a negative public perception of synthetic biology — an emerging experimental discipline that involves genetically engineering organisms to do useful tasks.

The project, based in the San Francisco Bay Area in California, was conceived as a public demonstration of synthetic biology using gene-writing software and lab-made DNA molecules. The effort also reflects a ‘DIY biology’ movement that seeks to make biotechnology more accessible to the public. “The central goal of the project is to inspire people and educate people about this technology,” says entrepreneur and project co-founder Antony Evans.

He and his colleagues — Omri Amirav-Drory, founder of synthetic-biology software firm Genome Compiler in Berkeley, California, and Kyle Taylor, a former biology graduate student at Stanford University in California — set out to make *Arabidopsis* glow because the feat seemed achievable in a simple garage lab. “There are some people in synthetic-biology circles who would yawn at what we’re doing,” Evans says.

Making plants glow has been possible since the 1980s, when scientists added a gene encoding the firefly enzyme luciferase to a tobacco plant. When sprayed with the chemical substrate luciferin, the plant glowed temporarily (D. W. Ow *et al. Science* **234**, 856–859; 1986). In 2010, another group engineered a tobacco plant to have its own weak glow, using bacterial genes instead (A. Krichevsky *et al. PLoS ONE* **5**, e15461; 2010). Also in 2010, a team at the University of Cambridge, UK, created a genetic circuit in bacteria that makes both firefly luciferase and luciferin, so that the bacteria glow continuously (go.nature.com/4nxcao). The Glowing Plant team plans to tweak the genes in that circuit so that they work in plants.

The more than 7,700 project supporters will also be rewarded with stickers, T-shirts depicting glowing plants or light-bulb vases. The effort hit its initial fund-raising goal of US\$65,000 several weeks early, and passed the \$400,000 mark on 28 May. With the extra cash, Evans and his team will try to create glowing roses too. They are taking no salary, and are borrowing lab and greenhouse space. “It’s a really positive signal for synthetic biology that there’s this big consensus-level interest in genetically engineered objects,” says Mackenzie Cowell, founder of a San Francisco biotech-supply company called Genefoo. He chipped in \$250 to the effort.

But Drew Endy, a synthetic biologist at Stanford University, questions how much light the plants will actually be able to emit, given the limitations on a plant’s ability to harvest energy from the Sun and convert it back into light. “Never mind the genetic engineering involved — just what does the physics say about the feasibility of the project working out?” he says.

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“Is this legal?” asks the project’s Kickstarter site, with the reply “Yes it is!” Evans says that he and his team contacted the Animal and Plant Health Inspection Service (APHIS) at the US Department of Agriculture, which regulates genetically modified (GM) plants if plant pathogens are involved in the work. The agency’s main concern was whether DNA from the pathogen *Agrobacterium* would be used to insert foreign genes, as GM plant efforts often do. “Regarding synthetic biologics, if they do not pose a plant risk, APHIS does not regulate it,” a spokesperson told *Nature*.

To bypass this concern, the Glowing Plant team will use *Agrobacterium* only during preparatory tinkering with the luciferase genetic circuit. When plants are produced for distribution, the team will shuttle the genes into cells using a ballistics-powered device called a gene gun, a process that the agriculture department deems outside its purview (see *Nature* **475**, 274–275; 2011).

Such regulatory runarounds need to be scrutinized, says Todd Kuiken, who studies synthetic-biology issues at the Woodrow Wilson International Center for Scholars, a think tank in Washington DC. Although he has few concerns about streets lined with glowing *Arabidopsis*, he thinks that the lack of oversight of future, riskier projects could prove problematic.

And Allison Snow, an ecologist at Ohio State University in Columbus who studies the risks posed by GM plants, says that it won’t do synthetic biologists any public-relations favours if plants make it into the wild. People will be more likely to support synthetic biology, she says, if it is associated with disease treatments or clean biofuels. “This is such a frivolous application,” she says (see ‘Bioluminescent boom’).

Bioluminescent boom

The Glowing Plant project is not the only foray into publicly available genetically modified organisms. Transgenic zebrafish (*Danio rerio*) that produce a fluorescent protein have been on the market since 2003, although their sale is not permitted in the European Union, Canada, Australia or California. And BioGlow, a commercial venture in St Louis, Missouri, informed the US agriculture department last year of plans to produce light-emitting plants, but the company has made few details public.

Some people are riled already. The ETC Group, a Canadian pressure organization in Ottawa with a history of opposing synthetic-biology applications, launched a “kickstopper” campaign against the project and is looking into legal options to stop it.

Evans says that the team is likely to engineer a type of *Arabidopsis* that survives only if fed a nutritional supplement, reducing the chances of spread. And the team plans to conduct a public dialogue on the project’s ethical, legal and environmental issues before shipping any seeds. “This is a fund-raising campaign,” he says. “It’s not the actual release of the plant.”

Nature **498**, 15–16 (06 June 2013) doi:10.1038/498015a

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Adam Cherson • 2013-06-25 07:41 PM

There is probably no way to stop homo habilis from tinkering with everything around, but we can still wonder (and worry) about the unpredictable and unexpected consequences of our actions. It does seem a little strange for people to be getting so excited by this but I attribute it to our seemingly endless quest for elite social status, measured via publicity, funding, simply gratuitous consumption, and other such foolish metrics. I hope this doesn't sound too fuddy duddy. I'm all for having fun, but can we also be serious sometimes?



Ben Meyers • 2013-06-16 06:12 PM

Mohammad, My fully grown plants do, in fact, glow. Don't be disappointed! Also, we do not prove an hypothesis. However, we may fail to reject the null hypothesis, and conclude that further work towards understanding an alternative hypothesis is justified.



Mohammad KaramiNejadRanjbar • 2013-06-10 08:02 PM

That's more fiction than science. Its never gonna work with their current "idea" of using LRE for regenerating Luciferin. Even if they successfully produce LRE, and LRE does its function as the Japanese group is claiming, they still need a starting supply of Luciferin for it to start to glow. They cant supply a single seed with enough Luciferin to make a fully grown plant glow! It is also worth to mention that LRE function is not proved yet! there are only 2 very weak articles on this topic after about 12 years from the LRE discovery. So, if they really want to do what is claimed in here, its just a scam to collect people's money, and will not result in anything other than disappointment. You don't really need to worry about the environmental impacts of this "Science Fiction".



Patrik D'haeseleer • 2013-06-19 12:41 AM

You're thinking of the firefly luciferin. They're working with the bacterial Lux operon. Very different system, and one which has already been shown to work in plants.



Mohammad KaramiNejadRanjbar • 2013-06-26 05:18 AM

I am not "thinking" of anything. They are always talking about Fire Fly Luciferase!



p j • 2013-06-09 08:58 AM

A Superb Explanation on genetically engineered trees by David Suzuki, well-known Canadian geneticist http://www.youtube.com/watch?feature=player_embedded&v=9hjy-CJlzbM



Mahmoud Reda • 2013-06-09 04:57 AM

These plants glow at night. I am not plant scientist but I think any plant needs to be in the dark for a certain period of time in order to regulate the inhale of CO₂ and exhale of H₂O during photosynthesis



Viktor Jakobsson • 2013-06-06 10:33 PM

Fernando: Regarding your first point, I have a problem understanding the actual problem here. Do you fear that the gene from nature will spread to other organisms and if so, what kind of selection pressure would make the plants keep that gene in the highly unlikely event of horizontal gene transfer?



Fernando Santiago • 2013-06-23 05:44 PM

Viktor: Firstly, apologies for the delay in reply. Being a molecular biologist I can assure you that I am aware of many possibilities of "what could go wrong," though I am also first to admit the unlikelihood of them occurring. I'd like to pose a question: is horizontal gene transfer the only possible concern? My knowledge ends at molecular biology. I do not claim to be an ecologist, environmentalist, or botanist. What I find fault with is the "what could go wrong" attitude that precludes the possibility of anything possibly going awry. As a molecular biologist myself, I often find it challenging to consider the higher-order effects of the interactions I study in the lab. Consider that, for example, the light produced by the plant may interfere with the mating cycle of nocturnal insects or birds native to areas other than your own. Consider the possibility that insects with a predilection for feeding upon the plant become more visible to predators, and thereby suffer a decline in population. Again, I am not an ecologist or entomologist. Rather, I have respect for the fact that biological systems very rarely exist in isolation. In many jurisdictions people require an 'environmental impact statement' before doing something as mundane as redesigning a sidewalk. Before sending these plants out across the nation and into homes and habitats across several interconnected ecosystems, ask yourself if you have addressed these concerns extensively and exhaustively enough for all of us in the public. Are you prepared to bear the responsibility for having decided what is safe for release to the public, and into nature, for the rest of us?



Viktor Jakobsson • 2013-06-26 07:30 PM

I'm doing my masters in molecular biology so if you wish to go esoteric do :). I wouldn't however say that my knowledge ends at molecular biology, I guess what you mean is that your expertise ends there, which is all well and good. I presume you are aware of the state of the GMO debate? It stopped being science a long time ago, nowadays it's mostly if not only politics. I think the concerns you raise are valid however. I am very concerned about the state of this debate, today it is virtually a debate where someone can say that "GMO causes cancer" and get away with it due to the fact that pseudo-scientific groups/individuals have repeated it so many times that people just starts to accept it. Although as a biologist you know that no such claim makes any sense whatsoever, if a particular gene insertion in a particular plant caused cancer then THAT is the problem, NOT the technique (and no GMO on the market have been showed to do that). If you understand what a gene is, then the fear should go away. I am sure that you know that there is possibilities using gene transfer that could greatly benefit virtually everyone in the world (not least in combating climate change), it is just very sad that the debate is about pesticide resistance and big corporations. This debate demands the ability to keep at least two things in your head at the same time, thus

disqualifying everyone who is not really looking for answers but rather just enjoy having opinions instead of reading up on the subject. Considering the insane impact we have had on nature, and the absurd consequences our mindless burning of fossil fuel has, I find it absurd to worry about the effects of genes that ALREADY, mind you, is in nature, and what they might do if they exist in another organism. As a molecular biologist I am surprised that you view genes the way you do.



p j • 2013-06-09 10:05 AM

The issue is very complex as it ultimately impacts the greater planetary biosphere when you take into account all the genetic engineering going on with our food, plants, trees, fish, animals...you name it...with little or no regulation, oversight or long-term independent peer reviewed studies. The risk of changing our ecosystems forever into unknown properties is high and, further, the impact on environmental and human health even greater. So I sought out this explanation in terms I, too, can understand from renowned Canadian geneticist, David Suzuki: "Genetically Engineered Trees - What You Need To Know <http://sco.lt/7804v3>



Viktor Jakobsson • 2013-06-09 11:42 PM

This is a good example of the pseudo-scientific non-sense so prevalent in the anti-GMO camp. Virtually nothing you said makes sense. Please, have some respect for this website, provide us with a proper scientific source that supports your claims or go back into hiding. Now, in regards to your link, I now know that you know nothing of this subject. Anyone that links to a video of some dude saying that the genes from a fish will be confused and angry if they find themselves in a potato is not worth taking serious. The real issue is really that GM crops could provide fantastic opportunities to for example battle climate change, but since crazy people like pj here are hell bent on stopping it no matter the consequences that is probably not going to happen.



This comment was deleted.



Viktor Jakobsson • 2013-06-10 07:03 PM

Yes or perhaps it is the Illuminati? Why do people like you read science news?
Flabbergasted.



ramsey affifi • 2013-06-05 07:26 PM

This is a great article because it describes the very real risks inherent in this precedent-setting crowdfunding case. Well done! For those of you concerned, visit ETC GROUP's action page and petition site to put pressure on Kickstarter so that they re-think releasing funds for such a careless project: http://www.avaaz.org/en/petition/Tell_Kickstarter_not_to_allow_bioengineered_organisms
<http://www.etcgroup.org/kickstopper>



Dany Ehrenbrink • 2013-06-05 09:01 AM

It is interesting to see how many extras come out of the wood work as soon as there might be a literally visible trail of cross breeding in nature when these plants get out in the open. Let's just face it over the last decade more GMOs have been put out there as ever before, just look at the regular crops used in the agricultural industry. Did cross breeding happen ? Yes, of course, around 20% of regular crops do carry the GMO genes already. I think the major concerns are less about GMOs and more about the way they are funded for this very reason. One thing is for sure, in the future we will see more things happening in this way and the structures in place will need to adapt quickly if they want to keep a lid on it. Crowd funding will turn most of traditional ways to obtain funding for research on its head and while that is not always a good thing like one might argue in this case, it also offers chances for otherwise unfunded or under funded projects. Due to the very nature of the process being "popular" science is actually part of the attraction to obtain funding. Personally I do not see a reason why science research can not be serious in the questions ask and still be popular to attract the funding it deserves. Especially fundamental research would have a chance to make its case and get it out to the public in times when especially the basic research is under funded or cut completely.



p j • 2013-06-09 09:22 AM

The USA biotech regulations are so lax, if any, that any loophole they see they will jump on, to get gmo's into the marketplace -- until we wake up and it is too late to turn back. Looking at the small number of donors here, compared to the huge amount raised I suspect that much of the money came from the biotech cartel themselves. It is a very powerful, billion dollar industry with deep, global government connectiona and is running out of control. Lord help our environment and ecosystems. This is a very serious situation and requires deep thought and certainly a more responsible approach toward the chain reaction of the whole eco biosphere we all have to live and survive in. Here is a superb explanation by Renowned Canadian Geneticist, David Suzuki on Genetically Engineered Trees and What You Need to Know <http://sco.lt/7804v3> The Next GM Biotech Wave: Extreme Genetic Engineering. The Implications and Ethics <http://sco.lt/6TyUmv>



Viktor Jakobsson • 2013-06-09 11:47 PM

Conspiracy theories, religious, anti-GMOist. It fits perfectly.



Fernando Santiago • 2013-06-04 06:27 PM

Firstly, I believe we approach this type of scenario with the same "wisdom and foresight" that we did centuries past when we introduced non-native species in an attempt to control, for example, crop pests. While I'm not exactly beside myself with fear, these ARE plants. They are not [non-reproducing] lamp-posts. The considerations here go way beyond simple transgenics/molecular biology into population biology and ecology and a host of others. To take these techniques out of the lab and apply them in a manner that may potentially affect the ecosystem and the environment - all for the sake of novelty - is somewhat irresponsible, I'd say. Secondly ... we have fluorescent plants, and mice, and rats, and cats, and rabbits - commercially available. Don't get me wrong: I'm all in favor of creative applications and "thinking outside the box" ... but this project, in my opinion, really does cross the line into kitschy pop science, and garners little more than a "yawn," if not a bit of concern for where this type of thinking might lead in the hands of somewhat more reckless entrepreneurs.



Viktor Jakobsson • 2013-06-04 05:17 PM

Okay, so, Nature, please explain to me what the dangers are here? That the conspiracy-prone Anti-GMO activists claim that this will result in 30 feet killer crabs comes as a surprise to no one. But this article insinuates that the worries might be rational so could you please explain to me what these rational scientific worries actually are? Do you fear that gene from the firefly might escape into NATURE? Come on, your stance on GMOs is way too timid, with your feature edition on GMOs fresh in mind. I am however perhaps a bit frustrated with the GMO debate overall, but isn't this by scientist for scientist? Oh well.



p j • 2013-06-09 09:23 AM

Here is a superb explanation by Renowned Canadian Geneticist, David Suzuki on Genetically Engineered Trees and What You Need To Know <http://sco.lt/7804v3> The Next GM Biotech Wave: Extreme Genetic Engineering. The Implications and Ethics <http://sco.lt/6TyUmv>

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