Case 1 Synthetic Vanillin Case

Synthetic vanillin (Evolva)

The purchasing manager from the Four Seasons Hotel is concerned at the escalating and often fluctuating costs of the Madagascan vanilla pod extract that is used in large quantities for making ice-cream and other desserts by the temperamental-but-brilliant French pastry chef. A recent news has drawn their attention to a synthetic biology company, Evolva who have just started marketing high quality vanilla extract that is produced by yeast at highly competitive prices. The manager wishes to evaluate these two sources of vanilla in order to decide whether the hotel should switch from their existing supplier (The Vanilla Company based in Madagascar) to Evolva's product.

We will be playing the role of the purchasing manager from the hotel while your group will be representing Evolva, a synthetic biology company based in Switzerland. Your group need to convince the manager for purchasing yeast derived vanilla and respond to questions from the manager. Another team will make the case to remain with the existing vanilla extract as representatives of Friends of the Earth.

Synthetic vanillin (Friends of the Earth)

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We will be playing the role of the purchasing manager from the hotel while your group will be representing Friends of the Earth. Your group need to convince the manager for purchasing Madagascar vanilla extract and respond to questions from the manager. Another team will make the case for the yeast-derived vanilla as representatives of Evolva, a synthetic biology company based in Switzerland.

Synthetic vanillin (News)

Creators defend vanilla flavour made using synthetic biology

Evolva say its synbio vanillin is a sustainable alternative to the synthetic variety, but critics say the technology isn't palatable for the environment

On its journey from the fields in Madagascar to your ice cream, sponge cake and chocolate, the vanilla plant is subjected to an intense process: it's cured, dried and

sometimes even oxidised.

Saccharomyces cerevisiae, yeast used by Evolva for brewing vanillin

Given the lengthy nature of vanilla production – it can take several weeks to go from plant to product – the majority of producers turn to synthetic alternatives (vanillin). Synthetic vanillins are generally produced using petrochemicals or wood pulp, and some in the industry consider them to be harmful to the environment. One such organization is Swiss company Evolva, which has developed a way to brew vanillin from yeast - deemed a more sustainable source.

"We're not sure why anybody who cares about sustainability and environmental progress would prefer that the food industry simply continues to source their [artificial vanillin] from chemical companies and paper mills," says Stephan Herrera, the company's vice president.

Using synthetic biology (synbio), scientists at Evolva edit the DNA of yeast, and through a fermentation process, force it to synthesize vanillin. It's a lot more complicated than that, of course, and it's not the first attempt to produce food using synbio. Biohackers are attempting to create a "real vegan" cheese, free of dairy. And biotech company Solazyme is fermenting "a native strain of microalgae" to produce "a lipid powder and a fat source" which could replace oils and eggs in bakery goods, according to a spokesperson.

In the case of vanillin though, synbio has courted media coverage and criticism. The environmental organization Friends of the Earth (FoE) has urged the public to say no to synbio vanillin, referring to it as an "extreme form" of genetic engineering.

"Claims of sustainability for this technology are questionable at best," says Dana Perls, food and technology campaigner at FoE. "We need regulations specific to these new technologies. We need safety assessments that can guarantee the absence of long-term health and ecological impacts."

What about farmers?

Perls says that the potential impact of synbio technology won't just be felt by consumers, but also by rural communities and smallholder farmers whose livelihoods depend on traditional vanilla production. Synbio organisms use sugar as a feedstock; not only is the sugar industry water-intensive, but removes land that would otherwise be used for food production.

“These problems will be exacerbated as this and other synbio applications using yeast, scale up to meet increasing demand,” says Perls. “The [areas] where vanilla beans are grown, may in turn be converted into industrial-scale plantations for sugar.”

Vanilla orchids grow in Madagascar

According to Herrera, because Evolva is targeting the 99% of vanillin that is produced synthetically, its operations shouldn’t affect rural farmers. But given that it means only 1% of the market is vanillin that comes from seed pods, it can be argued that vanilla farmers could still be pushed out of the market. The 1% does currently have the backing of some established brands, though: Häagen-Dazs sources its flavouring from vanilla growers, and this year Hershey announced it will replace its artificial vanillin with natural vanilla.

However, a long-term concern of FoE is that if the price of vanilla increases, food producers will turn their back on vanillin extracted naturally and look elsewhere for cheaper options, such as Evolva’s. The further worry is that these may then be falsely labelled and marketed as “natural”.
“There is this notion that our vanillin will sneak its way into the food chain as ‘natural vanilla’,” says Herrera. “Our product will never be marketed to producers as ‘natural vanilla’ or ‘vanilla’ of any sort, full stop.”

The Guardian, Thursday 28 May 2015
(http://www.theguardian.com/sustainable-business/2015/may/28/creators-defend-vanilla-flavour-made-using-synthetic-biology)

Case 2 Morphine Yeast Case

Morphine-producing yeast (Dueber Lab)

Synthetic biology focused Dueber Lab has been active in reasearch for new morphine-producing bacteria by synthesising a new type of bacteria which is modified to produce morphine. On the way to publishing its results on Nature, an organisation International Center for Technology Assessment (ICTA) interfered the publishing process, stating that the publication could induce misuses such as synthesising heroin-producing drugs. Hence the publication and democratization of this novel technology should be heavily considered.

We will be playing the role of NSABB (a governmental organisation that give advice for biosecurity issues on synthetic biology advancements) while your group will be representing Dueber Lab, a lab focused on Synthetic Biology based in UK Berkeley. Your lab projects are mainly on the rewiring or reprograming of molecular pathways. Your group need to convince the NSABB and respond to questions from the NSABB.

Another team will make the case to slow down the publication as representatives of the ICTA.

Morphine-producing yeast (ICTA)

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We will be playing the role of NSABB (a governmental organisation that give advice for biosecurity issues on synthetic biology advancements) while your group will be representing the ICTA, an organisation which aims to provide the public with full assessments and analyses of technological impacts on society. Your group need to convince the NSABB and respond to questions from the NSABB. Another team will make the case to publicise the new morphine-producing bacteria as representatives of the Dueber Lab.

Morphine-producing yeast

Engineered yeast paves way for home-brew heroin

Biotechnology is about to make morphine production as simple as brewing beer. A paper published on 18 May in Nature Chemical Biology reports the creation of a yeast strain containing the first half of a biochemical pathway that turns simple sugars into morphine — mimicking the process by which poppies make opiates. Combined with other advances, researchers predict that it will be only a few years — or even months — before a single engineered yeast strain can complete the entire process.

Besides giving biologists the power to tinker with the morphine-production process, the advance could lead to more-effective, less addictive and cheaper painkillers that could be brewed under tight controls in fermentation vats. At the same time, it could enable widespread, localized production of illegal opiates such as heroin, increasing people's access to such drugs. Recognizing that danger, the synthetic biologists behind the work have already opened a discussion of how to prevent the technology's misuse without hampering further research.

"It's easy to point to heroin; that's a concrete problem," says bioengineer John Dueber of the University of California, Berkeley, who led the latest research. "The benefits are less visible. They are going to greatly outweigh the negative, but it's hard to describe them." Over the past decade, several research teams have tried to coax microbes. The anti-malarial drug artemisinin, originally derived from sweet wormwood (Artemisia annua), is now produced commercially in yeast.

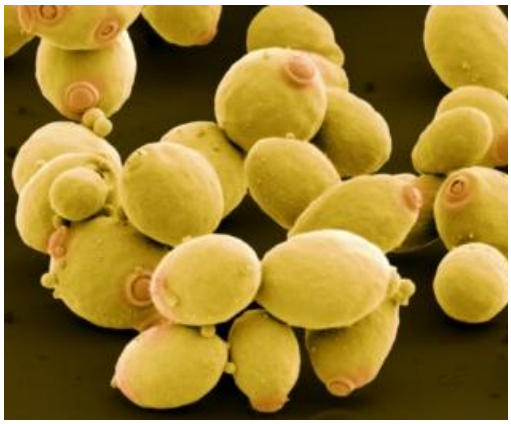
The opium poppy (Papaver somniferum), as the only commercial source of morphine and opioid painkillers such as oxycodone and hydrocodone, is an obvious target for bioengineering. The crop must be grown in highly regulated conditions, in only a few countries. Outside those boundaries, in places such as Afghanistan, it is grown to supply the illegal heroin trade. Producing opiates in industrial facilities from yeast could eliminate the need for the tightly controlled legal plant-production chain.

Afghanistan opium poppy cultivation

But the opiate-synthesis pathway is long — roughly 18 steps — and biochemically complex. Because there is no whole sequenced genome for the opium poppy, identifying the enzymes that catalyse the synthesis reactions has been difficult. So bioengineers have looked for enzymes in other plants, and even in humans and insects, that could carry out the desired reactions when inserted into a microbe's genome. But so far, no one has been able to engineer the whole process into a single organism.

Assembly required

"I don't want to undersell how much work there still is to do, but I don't want to undersell how short that work is," Dueber says. Even when the entire apparatus has been incorporated into a single strain of yeast, efforts will still be needed to make the fermentation processes efficient. In theory, once that work is done, anyone who could obtain the engineered yeast strain would be able to make morphine in a process that is no more complicated than home-brewing beer.



Saccharomyces cerevisiae, yeast used for Morphine synthesis

For that reason, Dueber and his colleagues shared their research before publication with biotechnology-policy specialists Kenneth Oye, of the Massachusetts Institute of Technology (MIT) in Cambridge, and Tania Bubela, of the University of Alberta in Edmonton, Canada. With MIT political scientist Chappell Lawson, Oye and Bubela have written a Comment article in Nature that calls for proactive examination of the risks and benefits of engineering organisms to make compounds that are both useful and dangerous. They urge drug and bio-security regulators, law-enforcement agencies, scientists and public-health officials to come together to develop safeguards that minimize risk without quashing research.

"From the perspective of law enforcement, this is a new technology that could be abused with negative consequences," says Lawson, who spent 18 months as an

adviser to the commissioner of US Customs and Border Protection. “I don’t think anyone wants millions more opiate addicts.”

“This work has very interesting and important implications, but there are regulatory gaps,” says Oye. “The question is, can regulators be nimble and figure this out before people finish the work?”

Extracted and edited from Nature. 18 May 2015
(http://www.nature.com/news/engineered-yeast-paves-way-for-home-brew-heroin-1.17566)