Green fluorescent protein expression was used to test a genetic ON/OFF mechanism in herbaceous plant *Nicotiana benthamiana.*

THE PRODUCTIVE PLANT SWITCH

Synthetic biology is being used to genetically engineer flora to produce industrially useful products, all with ON/OFF control.

To more reliably produce industrially useful plant-based products, Hiroshi Masumoto and Daisuke Shibata, from the Kazusa DNA Research Institute in Japan, are inserting strings of genetic instructions controlled via protein packages.

Though scientists have now become adept at introducing genes into plants, adding more than a handful is still very difficult, as is precisely controlling the expression of these introduced genes. Both challenges limit the ability to engineer healthy plants to produce specific chemicals for industry, say the researchers.

Masumoto and Shibata are harnessing technology usually used to manipulate artificial chromosomes for clinical research to generate and insert long stretches of synthetic, controllable DNA into plant genomes.

"We are focusing on creating isopentenyl diphosphate (IPP), which is an important precursor to other metabolites, including natural rubber, and the starting compounds for the biosynthesis of anti-cancer drugs or novel biopolymers, such as polyterpenoid resins," explains Masumoto.

NOW THEY ARE INSERTING LONG STRETCHES OF SYNTHETIC, CONTROLLABLE DNA INTO PLANT GENOMES.

In collaboration with Seiji Takahashi from Tohoku University, an expert on IPP metabolism, the team from Kazusa DNA Research Institute is building a stretch of DNA to carry all seven genes in the IPP synthesis pathway.

Once complete, these seven genes will be inserted into plants, and will be able to be manipulated by bacteria-and-plant-protein fusion packages. These packages can control gene expression by changing how the inserted genes are placed into a DNA packaging structure known as chromatin.

The shape of DNA's chromatin wrapping affects how strongly a gene is expressed. So when a modified plant is treated with a fusion package through its leaves or root system, the bacterial portion binds to engineered sites on the inserted genes and the plant portion can cause the chromatin around the inserted genes to close, limiting gene expression.

Treating plants with different fusion-protein packages can also reverse this process. "This way we can shut down all the introduced genes when they are not needed and then switch them all on at once," explains Shibata.

The ability to deactivate inserted genetic instructions is an advantage over existing genetic engineering approaches, which can sometimes result in imprecise results. For example, if some of the introduced genes switch on at the wrong time, it can cause unintended consequences – such as inhibited growth, silencing relevant gene expression, and unhealthy plant specimens.

According to Shibata: "Further development of this research should help plants, or microbes, reliably produce many industrial substances. We hope the technology will be used widely in Japan's future bioeconomy."

This research is part of Japan's Smart Cell Project, which is run by the New Energy and Industrial Technology Development Organization (NEDO). ■

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