which may have potential as antimicrobial or anticancer drugs.

"It's a nice piece of work with unique approaches and unique applications," says plant geneticist John Finer of the Ohio State Agricultural Research and Development Center in Wooster, who wrote an editorial that accompanied the Raskin team's paper on the protein results in the May issue of *Nature Biotechnology*. Still, Finer cautions, "a lot of work will be needed to show that it can be useful on a commercial scale."

Fade-out. The enzyme xylanase secreted by the roots of the transgenic plant *(right)* digests the blue-colored xylan, forming a clear zone.

In the first phase of the work, Raskin and his colleagues simply demonstrated that plants can secrete a foreign protein from their roots. The researchers tested seeds from tobacco plants into which Uwe Sonnewald's team at the Institute for Plant Genetics in Gatersleben, Germany, had introduced a bacterial gene encoding an enzyme called xylanase, which can digest a blue-colored form of the sugar xylan, turning it clear. When the seeds sprouted on petri dishes coated with nutrient agar containing the blue-colored sugar, the transgenic plants produced "clear zones" around their roots, showing that they were secreting the enzyme.

The researchers then went on to create two transgenic tobacco strains of their own. They introduced the gene for green fluorescent protein (GFP) into one and a human gene encoding an enzyme called secreted alkaline phosphatase (SEAP) into the other, along with regulatory sequences that would allow these genes to be expressed in plants. As with the xylanase gene, the group coupled GFP to a short stretch of DNA encoding "signal sequences," which tell the root cells to secrete the proteins. The *SEAP* gene already had its own secretion signal.

Grown hydroponically, the plants carrying the *GFP* gene exuded the protein from their roots, turning the hydroponic fluids a bright fluorescent green. The SEAP transgenic plants produced even more compelling results, churning out an average of 5.8 micrograms of enzyme per gram of dry root per day—a figure that went up to 20 micrograms when the researchers used a different gene construct with a stronger promoter. For comparison, Raskin points out that maize engineered to produce the protein avidin makes about 230 micrograms of the protein per gram of dry seed weight. He estimates that at the higher production rate, the tobacco roots could surpass the productivity of the transgenic corn over the life of the tobacco plants.

Raskin's team has since branched out in a new direction: coaxing plant roots to churn out higher levels of their own defense chemicals. In unpublished work presented at the meeting, Raskin showed that this can be done, for example, by exposing the roots of plants grown hydroponically to a fragment of a bacterial cell wall or a toxin from a fungus. "Basically, we press different biochemical triggers and see what comes out," he says.

The Raskin team has so far collected about 5000 samples of materials exuded by the roots of 700 different plant species. Some have been screened by the National Cancer Institute's Natural Products Branch, which found that several of these crude extracts killed various cancer cells in lab culture.

Whether the strategy will lead to any new anticancer agents or other drugs remains to be seen. But even if it does, some plant researchers caution that it may not be possible to produce either natural compounds or engineered proteins on an economically feasible scale. Elizabeth Hood, a plant researcher at ProdiGene in College Station, Texas, who has helped pioneer the production of avidin in maize, describes Raskin's technique as "a neat idea." But she adds, production "depends on greenhouse space and hydroponics, and those are very expensive."

Raskin counters that much supermarket produce, including tomatoes and cucumbers, is grown hydroponically, and consumers don't seem to object to the price. And he points out that making therapeutic proteins in mammalian or bacterial cells requires even more costly incubation techniques and sterile conditions. "Rhizosecretion is not going to work for all proteins," he maintains, "but it will work for some." **–TRISHA GURA**

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ASTRONOMY

Subaru Sees an Unruly Pair

A pair of embryonic stars, swaddled in gas and dust, emit parallel jets in this image from Japan's new 8.3-meter Subaru Telescope on Mauna Kea in Hawaii. Material is still collapsing to form these protostars, a system called L1551IRS5, about 450 light-years from Earth. Theorists believe that it spirals inward to form a disk around each newborn star's equator. Some of the material acquires so much momentum, however, that it is thrown out in jets emanating from the poles.

These jets, which stretch 1500 times the distance from Earth to the sun, are pointed toward Earth and are visible partly because a stellar wind from the protostars has swept away material along the line of sight. A second set of parallel jets likely points in the opposite direction but is hidden by intervening dust and gas.

The Hubble Space Telescope discovered the jets, but Subaru is the first Earth-based telescope to see them. Its analysis has revealed the temperature of the jets—several thousand degrees—and their composition, showing that the hot gas is rich in ionized iron. Resolving the jets in such detail from the ground "is a pretty good trick," says Alan Boss, an astrophysicist at the Carnegie Institution of Washington. "It's really a tribute to this great telescope," he says, adding that Subaru's analysis could also sharpen astronomers' understanding of star formation. **–DENNIS NORMILE**

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