How Does a Single Somatic Cell Become A Whole Plant

It takes a certain amount of flexibility for a plant to survive and reproduce. It can stretch its roots toward water and its leaves toward sunlight, but it has few options for escaping predators or finding mates. To compensate, many plants have evolved repair mechanisms and reproductive strategies that allow them to produce offspring even without the meeting of sperm and egg. Some can reproduce from outgrowths of stems, roots, and bulbs, but others are even more radical, able to create new embryos from single somatic cells. Most citrus trees, for example, can form embryos from the tissues surrounding the unfertilized gametes—a feat no animal can manage. The houseplant Bryophyllum can sprout embryos from the edges of its leaves, a bit like Athena springing from Zeus's head.

Nearly 50 years ago, scientists learned that they could coax carrot cells to undergo such embryogenesis in the lab. Since then, people have used so-called somatic embryogenesis to propagate dozens of species, including coffee, magnolias, mangos, and roses. A Canadian company has planted entire forests of fir trees that started life in tissue culture. But like researchers who clone animals (see p. 85), plant scientists understand little about what actually controls the process. The search for answers might shed light on how cells' fates become fixed during development, and how plants manage to retain such flexibility.

Power of one. Orange tree embryos can sprout from a single somatic cell.

Scientists aren’t even sure which cells are capable of embryogenesis. Although earlier work assumed that all plant cells were equally labile, recent evidence suggests that only a subset of cells can transform into embryos. But what those cells look like before their transformation is a mystery. Researchers have videotaped cultures in which embryos develop but found no visual pattern that hints at which cells are about to sprout, and staining for certain patterns of gene expression has been inconclusive.

Researchers do have a few clues about the molecules that might be involved. In the lab, the herbicide 2,4-dichlorophenoxyacetic acid (sold as weed killer and called 2,4-D) can prompt cells in culture to elongate, build a new cell wall, and start dividing to form embryos. The herbicide is a synthetic analog of the plant hormones called auxins, which control everything from the plant's response to light and gravity to the ripening of fruit. Auxins might also be important in natural somatic embryogenesis: Embryos that sprout on top of veins near the leaf edge are exposed to relatively high levels of auxins. Recent work has also shown that over- or underexpression of certain genes in Arabidopsis plants can prompt embryogenesis in otherwise normal-looking leaf cells.

Sorting out sex-free embryogenesis might help scientists understand the cellular switches that plants use to stay flexible while still keeping growth under control. Developmental biologists are keen to learn how those mechanisms compare in plants and animals. Indeed, some of the processes that control somatic embryogenesis may be similar to those that occur during animal cloning or limb regeneration (see p. 84).

On a practical level, scientists would like to be able to use lab-propagation techniques on crop plants such as maize that still require normal pollination. That would speed up both breeding of new varieties and the production of hybrid seedlings—a flexibility that farmers and consumers could both appreciate.

Can we predict how proteins will fold?
Out of a near infinite of possible ways to fold, a protein picks one in just tens of microseconds. The same task takes 30 years of computer time.

How many proteins are there in humans?
It has been hard enough counting genes. Proteins can be spliced in different ways and decorated with numerous functional groups, all of which makes counting their numbers impossible for now.

How do proteins find their partners?
Protein-protein interactions are at the heart of life. To understand how partners come together in precise orientations in seconds, researchers need to know more about the cell's biochemistry and structural organization.
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Editor's Summary

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