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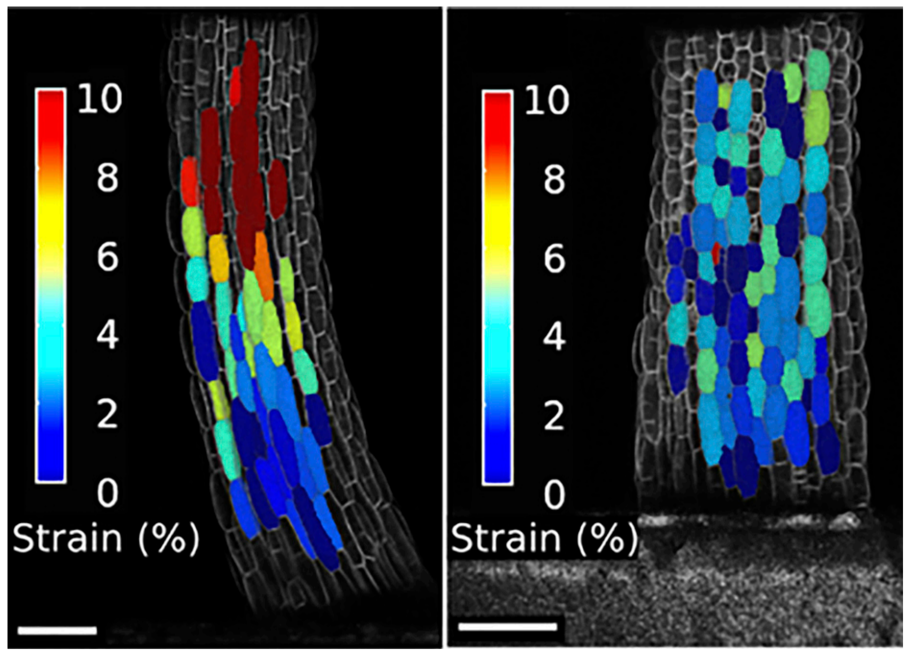
IN BRIEF

Open-Source Device Tracks Mechanical Properties of Living Plant Cells in 3D [OPEN]

The mechanical properties of plant cell walls—determined largely by the orientation of cellulose fibers embedded in the wall (Probine and Preston, 1961)—have a profound effect on plant growth and morphology. Being able to measure spatial variation in these properties would open many exciting research avenues; it would allow us to decipher the mechanisms by which various inputs and conditions alter plant growth at the cellular level and examine how the activities of specific genes are translated into organs of a particular shape.

To date, measurements of the mechanical properties of plant materials have relied on extensometry (in which samples are pulled with a known force and deformation is measured) and indentation-based methods (in which samples are indented and the force required to do so is measured). Both methods have limitations; the former measures only tissue-level mechanics in large samples, and the latter quantifies cell wall properties only perpendicular to the axis of growth. Now, in a Breakthrough Report, **Robinson et al. (2017)** introduce a robotic system, named ACME (automated confocal micro-extensometer), that functions like a traditional extensometer, but is miniaturized, mounted on the stage of a confocal microscope, and fully automated. ACME computes the mechanical properties of samples at the cellular level based on changes in features of the tissue itself (tracked in time-lapse z-stack images) during application of a known force or deformation.

As proof of concept, the authors used their system to track the mechanical properties of *Arabidopsis thaliana* hypocotyls treated with the growth hormone gibberellic acid. They found that cells along the growth axis of treated samples displayed a gradient in mechanical properties, whereas those of untreated samples did not (see figure). Furthermore, they demonstrated that mechanical stretching triggers an irreversible increase in cell length in living plant cells but that the increase is partially reversed in dead plant tissues once stretching stops. The system can be used to investigate the mechanical properties of any plant tissue that is smaller in one direction than in the other two. For instance, the authors were able to use their system to compute the strain in the pavement cells of live cotyledons.



ACME reveals a gradient in the mechanical properties of Arabidopsis hypocotyl cells treated with gibberellic acid. Cells along the growth axis of living Arabidopsis seedlings displayed a gradient in strain (i.e., relative increase in length) in response to an applied force when treated with gibberellic acid (left), but not in the absence of treatment (right). Bars = 100 μm. (*Adapted from Robinson et al. [2017], Figures 5G and 5H.*)

ACME can be assembled using a combination of commercially available and custom parts. To make this powerful tool readily available to the research community, the authors have provided the 3D printing plans needed to create the hardware, the custom software that controls the hardware and interprets the measurements, and a detailed user guide. While the authors used ACME to study the mechanical properties of Arabidopsis seedlings, the system can be adapted for larger samples and other imaging systems. Thus, ACME promises to provide exciting insights into the mechanisms underlying cell expansion and morphology in a range of plants and tissue types.

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