BIO-PROCESSING

An exploration using plant cells as design tools.

Xylem cells from artichoke plants, Autodesk IDEA Studio, Eureqa software.

David Benjamin (American) / Fernan Federici (Argentinean)—Columbia University Graduate School of Architecture, Planning and Preservation, New York, USA / University of Cambridge, UK / Creative Machines Lab, Cornell University, New York, USA

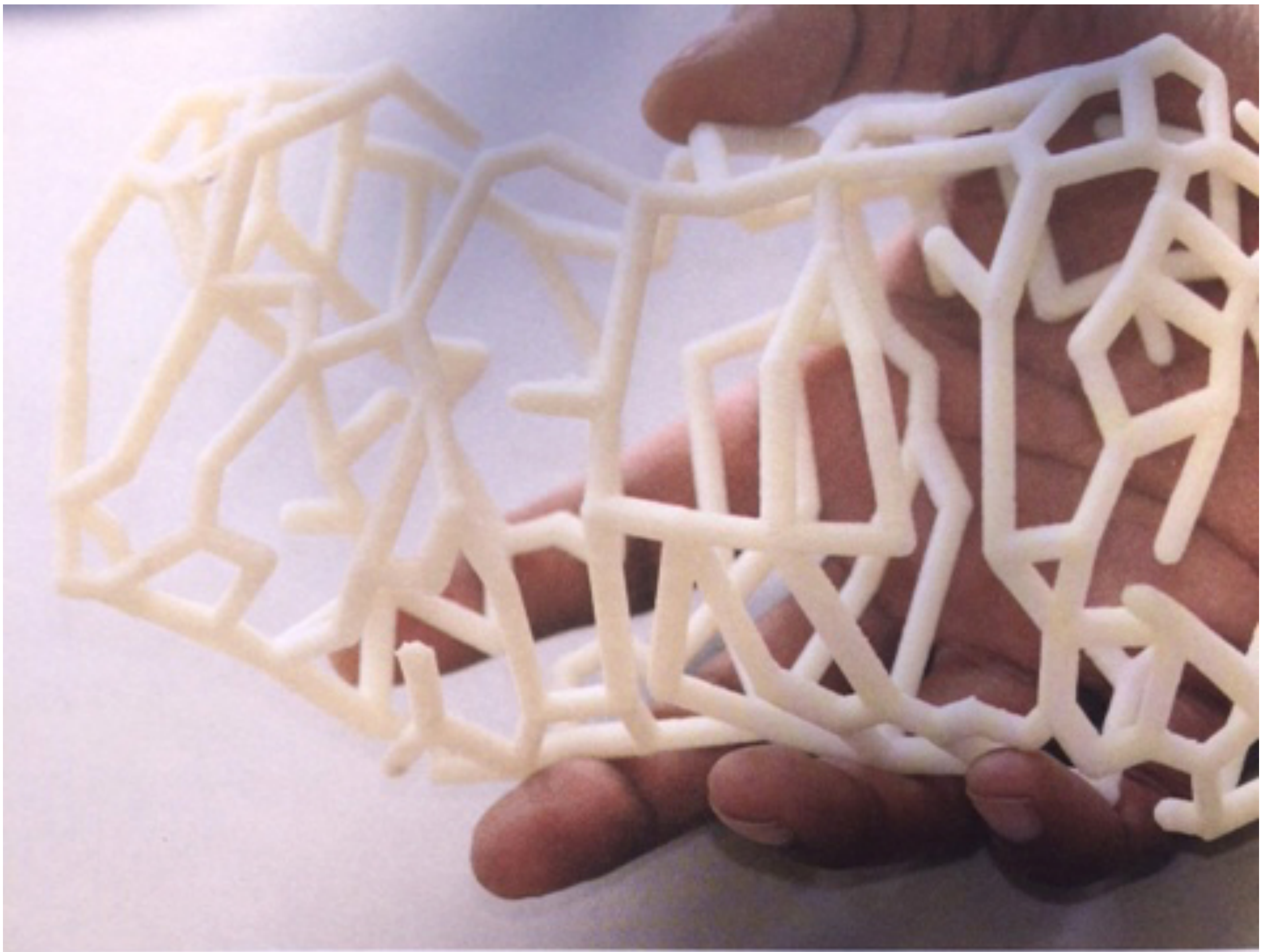
PROTOTYPE

This joint project brings together a synthetic biologist and an architect as part of the Synthetic Aesthetics program, supported by the National Science Foundation. It explores new ways of applying biological systems as design tools, with a focus on using cells as bioprocessors.

While there may be numerous examples of identifying and using the form of nature in design and architecture, the team seeks to identify and utilize the logic of nature. Echoing investigations first made by D'Arcy Wentworth Thompson and outlined in his seminal *On Growth and Form* (1917), this exploration digs beneath outward appearance to harness the underlying processes of optimization found in plants.

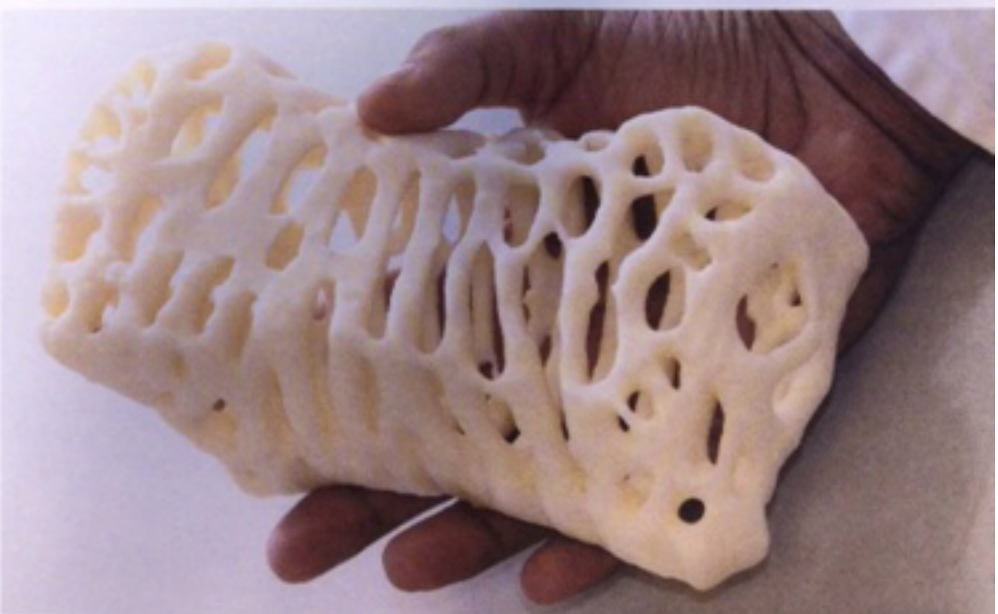
Bio-processing uses patterns in xylem cell growth to solve architectural structural design problems. One goal is to extract the complex behaviors of these cells at the micrometer scale and to apply them to architecture at the scale of meters.

In the course of this collaboration, the team studied the physical constraints of a cell in order to see how its exoskeleton might offer material-distribution solutions for architectural forms. To do this, it generated data sets corresponding to the growth of the xylem cell exoskeletons, then fed this data into an application developed by Hod Lipson (a robotics engineer at Cornell University, Ithaca, New York), called Eureqa. This software then derived a mathematical equation approximating the data. This in turn becomes a tool to create new cell-like forms for potential applications.



127

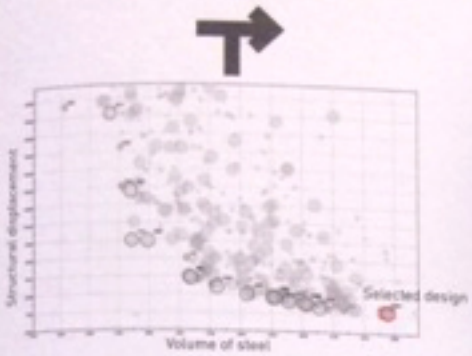
al model of an exoskeleton that has been
d using evolutionary computation. [See
flow example at the top of pages 84–85.]



128

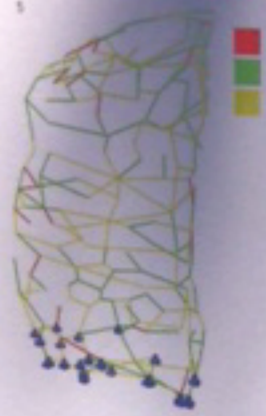
al model of an exoskeleton designed
equation derived from observations
cell growth.

4



Applying scale, materials, and loading conditions of architecture

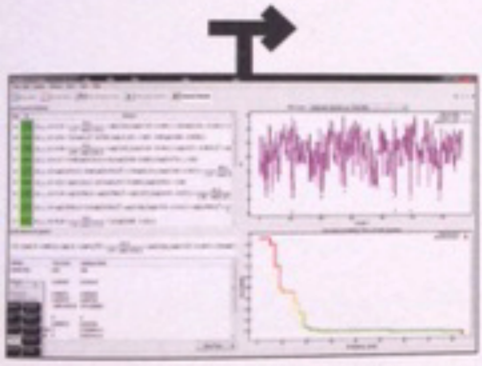
5



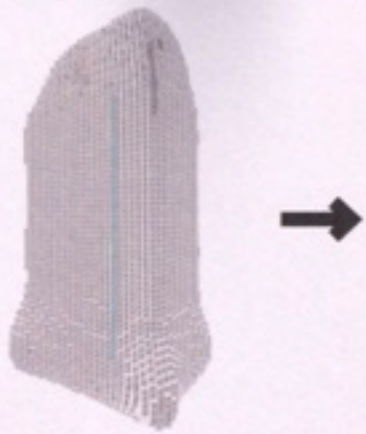
Structural performance of fit design

6

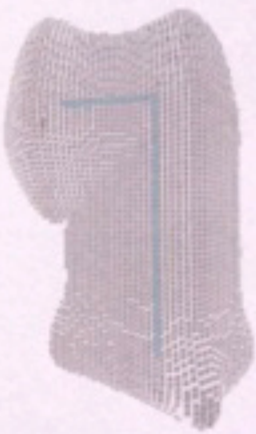
Computationally evolved design



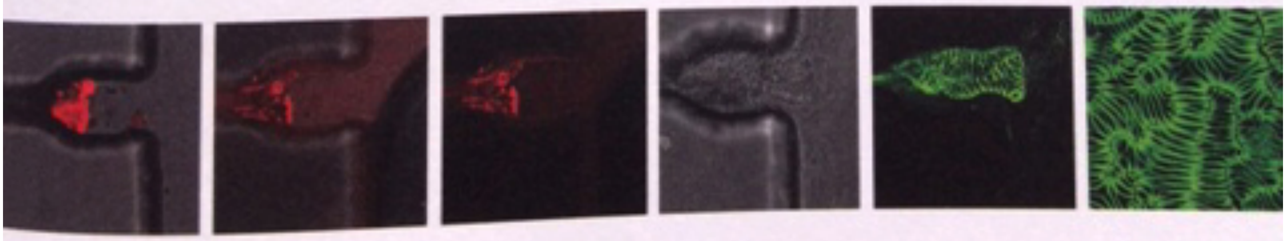
Mathematical equation that approximates the data

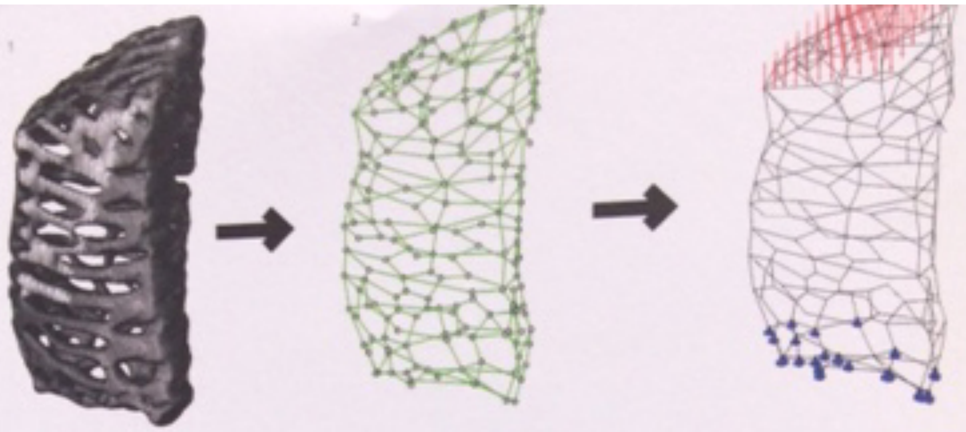


Form produced with equation and blue control line



Alternative form produced with equation and revised blue control line

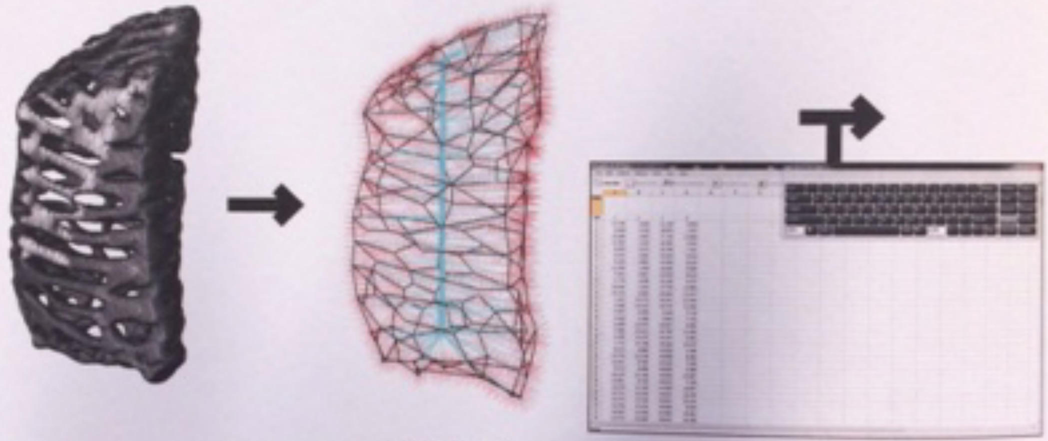




Original cell

Centerline model

Applying scale, materials, and loading conditions of architecture



Field of vectors and blue control line

Dataset generated from vector and control line

ABOVE 129

These workflows exhibit the logic of a xylem cell's growth using computational tools. The first workflow starts with a xylem cell scan, converts it to a digital model, applies structural forces in a computer simulation, then uses a genetic algorithm to generate and evaluate various possible configurations to find the form with maximum strength and minimum material. In the second workflow, an equation for xylem cell formation is derived by analyzing data relating to the distances, thicknesses, and angles of the natural cell. This equation is then used to calculate how the natural system might create exoskeletons in more complex shapes.

OPPOSITE 130

In this last workflow, xylem cells are induced to fill a custom void (such as the U-shaped space shown here), allowing for the observation of how xylem cells 'solve' a variety of spatial problems.