Computational Morphodynamics of Plants

Project Personnel:
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Project Summary:
A grand challenge facing the plant biology community is to understand how plants develop and grow - that is, how genomic and environmental information combine to produce a three-dimensional and highly dynamic plant consisting of intercommunicating cells and tissues. The proposed workshop will develop plans to create a novel computational approach that will bridge existing gaps between biochemical, cellular, and organismal levels of understanding. Central to the approach is the notion that much of the necessary bridging information can be computationally extracted from images and used to inform computational models that reveal the causal relationships between biochemical and genetic activities of cells and cellular activities in development on one hand, and between cellular activities in development and the structure and function of tissues at the organismal level, on the other.

There are three specific areas of need: acquisition and analysis of images of cells, tissues, and organ systems actively undergoing morphogenesis; computational modeling, to represent and test specific hypotheses for the mechanisms by which cellular activities and cell-cell communication and coordinated growth result in defined and dynamic cellular patterns; and mechanical modeling, to provide computer representations of plant tissues in which each cell, its mechanical influence on its tissue, and the results of mechanical force on its enlargement and division combine to provide a realistic and testable substrate for developmental models. The grand challenge will be greatly served by a cyberinfrastructure that facilitates the flow of information about growth and development from image acquisition devices to interoperable databases to modeling functions.

The 1-day workshop is expected to involve approximately 30 participants. (A followup day of strictly optional technical discussions may also be scheduled.) The opportunities and present barriers to progress in the three different areas of need will be assessed. Participants will create a strategic plan for developing cyberinfrastructure required for image acquisition and analysis at the subcellular, cellular and organ levels; computational modeling of pattern formation in developing plant tissues; and mechanical models of plant tissues using finite element models at the cellular and tissue level. An expected outcome is that close and well-defined links between the iPlant central organization and the individual laboratories that have already developed tools and/or data sets will emerge as a key element of a feasible Grand Challenge project. Workshop time will also be dedicated to exploring educational opportunities, with emphasis on plant and computation lessons for middle and high school biology classes, and on the possibilities for the products of the project to influence undergraduate research and pedagogy.

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