Biostatics of *Arabidopsis thaliana*: 1-Dimensional Mathematical Models of the Growing Root

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Abstract

To understand how an organism or ecosystem develops as a whole is a primary goal of systems biology. A mathematical model of an organ serves this goal by being simple and, at the same time, descriptive of the various developmental aspects, such as cell division, growth, tissue mechanics, genomics, etc., and the interplay between them. The organism of choice in this study is *Arabidopsis thaliana*, a plant that has been the object of extensive and successful research. We model mathematically two regions of the plant's root, the stele and the outermost cell layer. Using the rotational symmetry of the root, we view the longitudinal cross section of the root as a 2-dimensional region. The stele and the outer cell layer are two subregions that, in the context of our models, can be viewed as functionally independent of the rest of the root. Each subregion is then approximated, neglecting the transverse dimension, as a 1-dimensional continuum, on which our mathematical models are constructed. For the stele, our model predicts that mitotic activity decreases exponentially with the distance from the quiescent center. For the outer cell layer, we offer two continuum-mechanical models, aimed at describing the motion of the tissue and its elastic properties. In the first of these models, we assume constant stiffness and obtain that a point in the tissue originally occupying position s is displaced after a time t to a new position, $s + t\,u(s)$, where u is a function well approximated by the linear form $a_0 + a_1 s$. In the second model, we assume linear displacement and find that the stiffness then varies in space, increasing toward the root tip at the rate $1/\sqrt{s}$ as $s \to 0$. This correlates with the expansin concentration found to decrease towards the root tip in certain plants.

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