

Pattern Selection on the Growing Tips of Plants

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This would be a project in mathematical biology, concerned with the interplay of chemical pattern formation (Turing-type reaction-diffusion dynamics) and the shapes of plants. Reaction-diffusion models have an extensive tradition in mathematical biology, and have been applied to many phenomena in developmental biology (embryology). Plant development is uniquely challenging, in that pattern formation is happening simultaneously with, and coupled to, changes in tissue shape and size. The great majority of work in reaction-diffusion theory has been on fixed domains, and there is much scope for new work on growing domains and geometry changes. Previous work in this area has explored the generation of three-dimensional plant shapes by reaction-diffusion patterning^{1,2}, and analysis of pattern selection on hemispherical tips³.

The present project would be to investigate patterning during a common sequence in plant development, in which a hemispherical growing tip flattens prior to forming a new type of shape. We have experimental data on this phenomenon in conifer embryos, in which flattening occurs just before the first leaves are formed. Bessel function solutions of reaction-diffusion equations on a disc fit very well to the observed leaf pattern⁴. If chemical pattern is driving surface shape change, we would like to understand how spherical harmonic solutions of the initial hemisphere change into the Bessel functions of a flattened disc. This project would likely involve computation to study a full model involving patterning-growth feedback, especially how patterning boundaries are altered to form a disc from a hemisphere, as well as analysis to characterize the pattern selection occurring during a smooth transformation of the geometry, from hemisphere to disc (without feedback).

¹ Harrison LG, Wehner S, Holloway DM (2001). Complex morphogenesis of surfaces: theory and experiment on coupling of reaction-diffusion to growth. *Faraday Discussions* **120**: 277-294.

² Holloway DM, Harrison LG (2008). Pattern selection in plants: coupling chemical dynamics to surface growth in three dimensions. *Annals of Botany* **101**: 361-374.

³ Nagata W, Harrison LG, Wehner S (2003). Reaction-diffusion models of growing plant tips: bifurcations on hemispheres. *Bulletin of Mathematical Biology* **65**: 571-607.

⁴ Harrison LG, von Aderkas P (2004). Spatially quantitative control of the number of cotyledons in a clonal population of somatic embryos of hybrid larch *Larix x leptoeuropaea*. *Annals of Botany* **93**: 423-434.