Mechanisms for plant shape determination in Marchantia

**Supervisory team:**
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**Project description:**
Plant shapes range from tiny string or mat-like forms to massive multilayered upright forms with complex organ systems such as shoots, roots and leaves. Despite these wide differences in shape, many plant gene families are very ancient, predating diversification. We can therefore study the mechanisms for shape determination in simple plants such as liverworts and use the knowledge gained to understand plant shape determination in general.

To this end, my lab has used a combination of live imaging, statistical model fitting, computational modelling and molecular biology to discover mechanisms regulating shape in the liverwort Marchantia polymorpha (Solly et al. (2017): Current Biology).

We found that Marchantia undergoes a stereotypical sequence of shape transitions during development. Key aspects of global plant shape depend on regional growth rate differences specified by the co-ordinated activities of the growing apical notches. Computational modelling showed that a diffusible, growth-promoting cue produced in the notches is likely to pattern regional growth rate differences, and pharmacological experiments suggested that the plant hormone auxin may equate to the model growth-promoting cue. New models suggest a role for differential oriented growth (anisotropy) in Marchantia shape determination. Anisotropy emerges as an outcome of underlying tissue polarities, and directional auxin transport is one potential mechanism for generating polarity.

Your project will build on the prior work above to determine how auxin contributes to plant shape determination in Marchantia. It will:

1. Predict the effects of different tissue polarities on Marchantia shape by modelling
2. Analyse the auxin distribution in Marchantia in comparison to distributions predicted from modelling
3. Disrupt auxin biosynthesis, directional transport, conjugation and decay and test the effect on growth and shape
4. Use live-imaging, image segmentation and quantitative growth analyses to discover how growth and shape change in plants with different auxin biology.

By combining computational and wet lab approaches, the project will provide training at the cutting edge of the plant evolution and development fields. The techniques that you learn will be broadly applicable in the academic biology and biotech sectors. The skills that you learn will be widely transferable to other areas such as science policy, publishing and computing.
Generating hypotheses of shape determination in Marchantia polymorpha (A) involves measuring the growth rate distribution (B), fitting growth rate data to growth hypotheses (C) and modeling shape determination (D).