



# Jeffrey A. Long

Associate Professor  
Plant Molecular and Cellular Biology Laboratory

**“A plant’s shoot system is responsible for all of the above-ground portions of the plant, such as leaves, branches, and flowers, and is the site of photosynthesis. The root system lies below the ground and provides water and nutrients to the plant. My lab’s research is focused on how a plant embryo sets up this apical/basal polarity.”**

Controlled by a tightly regulated choreography that determines what goes up and what goes down, plant embryogenesis establishes a very simple structure that contains two stem cell populations: the shoot meristem, which will give rise to all the “above-ground” organs such as the stem, the leaves, and the flowers, and the root meristem, which gives rise to roots. While investigating why a defective *TOPLESS* gene messes with a plant’s basic architecture—mutant embryos develop into a seedling topped with a second root instead of a stem with leaves—Long and his team discovered that functional *TOPLESS* codes for a repressor protein that inactivates the genes that otherwise would cause root development in the shoot area of the plant. Their latest study revealed that these fate-transforming genes are two familiar characters: *PLETHORA 1* and *2*, which had been known to act as master regulators that determine the identity of the root meristem. Without *TOPLESS* to keep them turned off, the two *PLETHORA*s are free to impose their will on the top half of the plant embryo, causing the development of a second root instead of a shoot.

With the “below-ground” hierarchy worked out, the question of how the identity of the shoot meristem is determined was still unanswered. Trying to unearth the missing master regulators of shoot development, the researchers searched through tens of thousands of mutant plants till they hit on a member of the *CLASS III HD-ZIP* transcription factors, known as *PHABULOSA*, that fit the bill. When forcefully expressed in the traditional territory of the *PLETHORA* duo, *PHABULOSA* transformed the root into a shoot, resulting in a seedling with leaves on both ends. Further studies revealed an antagonistic relationship between the *PLETHORA* and *HD-ZIP III* genes, ensuring that they stay where they belong and don’t get in each other’s way.

Understanding these mechanisms at a molecular level is one of the key areas of fundamental plant biology, which could be used for developing agricultural plants with more desirable traits.

For more information, please visit  
[salk.edu/faculty/long.html](http://salk.edu/faculty/long.html)



**Left to right:**

Naden Krogan, Peter T. Smith, Rhiannon Biddick, Rebeca Gonzalez Bayon, Jared Sewell, Dior Kelley, Bas van Schooten, Jeff Long