CIG FINAL REPORT TEMPLATE

1. FINAL PUBLISHABLE SUMMARY REPORT

A fundamental question in developmental biology relates to the mode through which the final size of a cell, organ, and whole organism is set. Plant growth involves consecutive stages of cell proliferation and post-mitotic cell enlargement. In roots, these stages form a developmental gradient along the apical–basal axis that ultimately determines their length. Small molecule hormone signaling pathways lie at the heart of this growth control. Despite dramatic advances in identifying signalling components, understanding of their spatiotemporal activities and how they integrate to coordinate whole-organ growth is just beginning to take form. Our long term goal is to understand how hormones, with the focus on the plant steroid hormones brassinosteroids (BRs), regulate growth and development. In particular we are interested in analysing the spatio-temporal regulation of the BR pathway, understanding to what extent cell-cell communication is involved during growth of and investigate how mechanical signals integrate with hormonal mediated growth control. In this grant we asked the following main questions: What is the spatio-temporal regulation of BR signal transduction and to what extent cell-cell communication is involved? What is the molecular basis for cell-cell communication? and How mechanical and phytohormone signals integrate to control final size?

Using the Arabidopsis primary root as a model organ, we initially characterized the role of BRs in the root meristem. We showed that BRs are required to maintain normal cell cycle activity and cell expansion. These two processes ensure the coherent gradient of cell progression, from the apical to the basal meristem. We further demonstrated that BR signaling in the root epidermis and not in the inner tissues is sufficient to control root meristem. Next, we investigated the elusive nature of the non-autonomous signal from the epidermis and the role of BR signaling in the inner tissues. Strikingly, we found that BR signal coordinates root growth by evoking distinct and often opposing responses in specific tissues. Whereas epidermal BR signal promotes stem cell daughter proliferation, the stele-derived BR signal induces their differentiation. Using a comprehensive tissue-specific translatome survey, we uncovered a context-specific effect of BR signaling on gene expression. Auxin genes, activated by epidermal BR perception, are necessary for induction of cell division. Conversely, the stele BR perception, accompanied by gene repression, restrains the epidermal effect. Therefore, a site-specific BR signal is essential for balanced organ growth (Fig. 1, left pane;).

In parallel, we found that coordination between two types of epidermal root cells, hair and nonhair cells, establishes root sensitivity to BR. While expression of the BR receptor BRI1 in hair cells promotes cell elongation in all tissues, its high relative expression in nonhair cells is inhibitory. These results show that the relative spatial distribution of BRI1, and not its absolute level, fine-tunes growth We showed that elevated ethylene and local cell wall modification by deposition of crystalline cellulose underlie the inhibitory effect of BRI1. We speculate that mechanisms coordinating BR signaling between hair and nonhair cells, and thereby whole root growth, involve interwoven genetic and mechanical factors.

BR research is of special agriculture interest since BR application and BR genetic modification have been shown to significantly increase crop yield and to play an

important role in plant thermotolerance. Hence, the high-resolution and precise knowledge of BR function and its genomic targets established by my team is also valuable for improving crop traits without unwanted impairment of unrelated pathways.

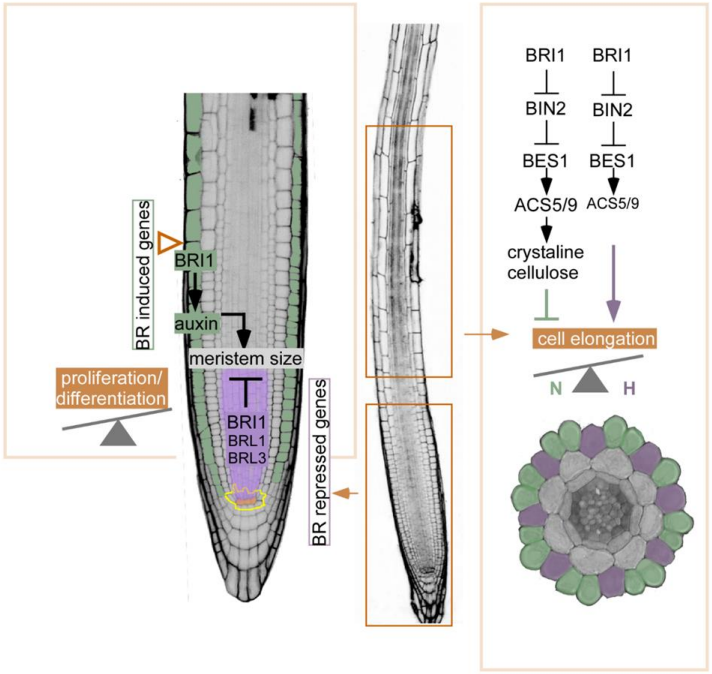

Fig. 1 *Left:* Contrasting tissue-dependent impact of BRs co-ordinate root growth. (A) BRI1, active in the epidermis, promotes auxin biosynthesis and its transport to the inner cells, thereby promoting daughter stem cell proliferation. In contrast, BRI1 and its two homologues, active in the stele, promote cell differentiation, buffering the epidermal effect. These tissue-dependent effects of BR activity are accompanied by context-specific modulation of gene expression (Hacham et al, 2011; Vragovic et al., 2015). The orange arrow indicates the meristem transition zone. Epidermal tissue is marked in green. The apical meristem zone of the stele tissue is marked in purple. The QC is highlighted in orange and the stem cell niche is enclosed in a yellow line. *Right:* The relative expression level of BRI1 in hair (purple color) and non-hair cells (green color) determines the intensity of its downstream signaling and subsequent whole-root growth, via positive and negative effects on unidirectional cell expansion, respectively (Fridman et al., 2014).

The aforementioned achievements were a direct result of the CIG grant. The CIG grant contributed tremendously to my ability to assemble an excellent and highly motivated research team, to win competitive grants and publish high profile scientific papers. In addition, it enabled my team to integrate into the Israeli/European scientific community, implicated in invitation to international meetings in Europe and joint collaborations with different labs. Our research has gained attention by highlights in Faculty1000 and by two prestigious prizes from the Technion, one to myself and another to my graduate student. Taken together, this grant made a significant impact on my prospects to receive full tenure and subsequently a position as Full Professor.

2. USE AND DISSEMINATION OF FOREGROUND
DISSEMINATION MEASURES

Publications (peer reviewed)

1. Vragović, K., Sela, A., Friedlander-Shani, L., Fridman, Y., Hacham, Y., Holland, N., Bartom, E., Mockler, T.C. and **Savaldi-Goldstein, S**. Translatome analyses capture of opposing tissue-specific brassinosteroid signals orchestrating root meristem differentiation. *Proc Natl Acad Sci U S A* 112, 923-928 (2015)
2. Fridman, Y., Elkouby, L., Holland, N., Vragovic, K., Elbaum, R., and **Savaldi-Goldstein**. S.Root growth is modulated by differential hormonal sensitivity in neighboring cells. *Genes & Dev* 28, 912-920 (2014).
3. Fridman, Y & **Savaldi-Goldstein, S**. Brassinosteroids in growth control: how, when and where. *Plant Sciences*. 209, 24-31 (2013).
4. Hacham, Y., Holland, N., Butterfield, C., Ubeda-Tomas, S., Bennett, M.J., Chory, J. & **Savaldi-Goldstein, S**. Brassinosteroid perception in the epidermis controls root meristem size. *Development* 138, 839-48 (2011).

3. RESEARCH TRAINING ASSESSMENT

3. SCIENTIST IN CHARGE QUESTIONNAIRE

1. **What is the size of the hosting research group? 0**

2. **How many researchers have you supervised within this project?**

   - **Corresponding to how many person months? 8 person, total of 264 months**

Number of publications resulting directly from the research project:

- **Recruited researcher(s) alone 0 ____**
- **Recruited researcher(s) with authors other than yourself ____4**

3. **Participation of the recruited researcher(s) at conferences (number):**

   - **Passive _0___**
   - **Active __8__**
   - **How do you rate the overall success of the research training? Very Good**

4. **Rate the overall level of the recruited researcher(s) integration in the research team and the host organisation with regards to:**

   - **participation in meetings/seminars: Very Good**
   - **discussions of results and project-related topics: Very Good**
   - **co-operation with other team members: Very Good**
   - **co-operation with other researchers of the host institution: Very Good**

5. **Rate the overall performance of the recruited researcher(s) with regard to:**

   - **originality of fellow(s) approach towards research (initiative/independent thinking): Very Good**
   - **capacity to develop new skills and to benefit from training: Very Good**
   - **productivity (research results/publications/international conference attendance): Very Good**
   - **communication skills: Very Good**
   - **group leader skills (collaboration with other groups/project management): Very Good**
   - **training and/or teaching skills: Very Good**
   - **Comment:**

6. **Has this project provided additional links with other research groups or institutions? YES**

7. **If yes, indicate the number of contacts in each case**
   a. **Universities ___3_**
   b. **Research Centres ____**
   c. **Industry/private companies ____**
   d. **Others____**
   e. **If Other, please specify: ____**

8. **Rate the importance of the following outcomes of the research training:**

   - **results of the research: Very Good**
   - **number of publications: Very Good**
   - **development of research: Very Good**
   - **establishment of international collaborations: Very Good**

- **transfer of knowledge/technology: Very Good**
- **training of students/researchers: Very Good**
- **further academic qualifications (PhD, habilitation etc.) for fellows Very Good**
- **Comments:**

YOUR OPINION ABOUT THE MARIE CURIE ACTIONS:

9. **Comments:**
10. **Did you have previous knowledge of the Marie Curie actions? NO**
11. **If yes, what sort of image do you think that the Marie Curie actions have among the scientific community in your research area?**