Ph.D. projects in progress

1.

Mentors: Attila Fehér, Katalin Gémes

Doctoral School: University of Szeged, Faculty of Science and Informatics, Doctoral School of Biology

Ph.D. student: Dóra Bernula

Title of the research topic: In vitro root-based regeneration system in Arabidopsis

Description of the research topic: In recent decades, uncountable number of research articles reported successful *in vitro* regeneration of various plant species. Two main systems are widely used for in vitro plant regeneration: de novo organogenesis or somatic embryogenesis (SE). Both regeneration processes can occur either directly or indirectly without or with intermediate callus formation. Our goal is to develop an efficient *in vitro* root-based experimental regeneration system that allows the induction of organogenesis and SE in Arabidopsis plants and the comparison of the two processes. Our further aim is to monitor the cellular and molecular changes during the induction phase of these regeneration processeses. In addition, we examine what may cause the differential regeneration capabilities of roots of whole seedlings and disected root explants.

2.

Mentor: Zoltán Magyar

Doctoral School: University of Szeged, Faculty of Science and Informatics, Doctoral School of Biology

Ph.D. Student: Tünde Vaskó-Leviczky

Title of the research topic: The regulatory role of activator E2FA and E2FB during Arabidopsis seed and embryo development

Description of the research topic: Cell proliferation in plants is strictly regulated during embryo development, where oriented divisions take place during morphogenesis in a highly predictable manner. Morphogenesis is followed by maturation, and these events are coordinated during embryo and seed development but it is not exactly known how.

During this thesis we aimed to functionally characterize the activator E2F transcription factors during seed and embryo development. We find that, surprisingly, mutation of both E2FA and E2FB (e2fab) has very little effect on the expression of cell cycle genes in the proliferative phase and, accordingly, the number of embryonic cells in mature seeds is similar in wild-type and e2fab plants. Conversely, proliferation genes are upregulated during the maturation phase in e2fab mutant embryos compared with wild-type embryos. Moreover, we show that E2FA and E2FB together repress AFL genes, which are key regulators of seed maturation, at various stages in seed development. We also find that the seed storage proteins 12S globulin and 2S albumin accumulate prematurely during the morphogenic phase in mutants of E2FA and E2FB. Thus, our results reveal

that E2FA and E2FB coordinate the switch between the morphogenic and the maturation phase of seed development by preventing the untimely expression of genes specific to each phase.

3.

Mentor: Zoltán Magyar

Doctoral School: University of Szeged, Faculty of Science and Informatics, Doctoral School of Biology

Ph.D. student: Erika Őszi

Title of the research topic: Functional characterization of Arabidopsis E2FB transcription factor

Description of the research topic: Model plant Arabidopsis has a single RETINOBLASTOMA-RELATED gene (RBR) controls cell proliferation through the regulation of E2F transcription factors. Previously E2FB was characterized as a transcriptional activator of cell cycle genes, but its function in developmental context was less established yet. During this thesis the regulatory role of E2FB was studied in the emerging first leaf pair of model plant Arabidopsis. Surprisingly, cell number in the leaf epidermis decreased in the ectopic E2FB expressing lines, while it was found to be elevated in the e2fb mutants. By forming complex with RBR, E2FB was found to inhibit cell cycle genes for establishing quiescence in cells committed to differentiate. In addition, E2FB-RBR repression operates in leaf meristemoid cells to determine their final numbers. Non-transcriptional regulatory function of E2FB was also discovered as E2FB was shown to make complex with auxin efflux PIN proteins to regulate their activities.

4.

Mentors: Attila Fehér, Katalin Gémes

Doctoral School: University of Szeged, Faculty of Science and Informatics, Doctoral School of Biology

Ph.D. student: Péter Benkő

Title of the research topic: The role of polyamine oxidases in adventious root formation

Description of the research topic: *De novo* root organogenesis is one process during which adventitious roots regenerate from wounded plant tissues or organs and during which auxin has important role. In plants, wound induces ethylene production. Ethylene may interact with auxin in several developmental processes. Indeed, ethylene and auxin act synergistically to control specific growth and developmental processes such as root elongation and root hair formation, but antagonistically others such as lateral root formation. Polyamines are known to interfer with auxin sensitivity as well as ethylene synthesis. Polyamines and ethylene share a common precursor, S-adenosyl-L-methionine (SAM), which explain their antagonistic role. Polyamine (spermidine and spermine) catabolism is mediated by polyamine oxidases (PAOs). Arabidopsis has 5 AtPAO genes among which AtPAO5 has a primary role in polyamine homeostasis rather than in hydrogen peroxide/nitric oxide production as it has

a dehydrogenase activity. Thus, AtPAO5 might indirectly control polyamine-dependent developmental processes. Our aim is to investigate the involvement of AtPAO5 in root organogenesis and to examine its effect on ethylene and auxin biosynthesis/sensitivity, as well as on ROS and NO levels during this process.

5.

Mentors: Attila Fehér, Katalin Gémes

Doctoral School: University of Szeged, Faculty of Science and Informatics, Doctoral School of Biology

Ph.D. student: Nikolett Kaszler

Title of the research topic: The role of polyamines and polyamine metabolism in the in vitro shoot regeneration capability of Arabidopsis roots.

Description of the research topic: For a long time, in the model plant, *Arabidopsis thaliana*, shoot regeneration was achieved through callus formation (indirect organogenesis). However, during recent years, it has been recognized that callus formation is not required for de novo shoot formation from Arabidopsis root tissues and the direct conversion of lateral root primordia (LRP) to shoot meristem can take place in response to cytokinin application. Endogenous polyamine level has been shown to control cytokinin levels in Arabidopsis. Our aim is to investigate the role of polyamine metabolism during the direct way of shoot organogenesis from Arabidopsis LRPs. Our further goal is to examine the effect of polyamine metabolism on auxin, cytokinin, nitric oxid and ethylene levels during the process.

6.

Mentor: Attila Fehér

Doctoral School: University of Szeged, Faculty of Science and Informatics, Doctoral School of Biology

Ph.D. student: Orsolya Beöthy-Fehér

Title of the research topic: The role of ROP-GTPase-centered signalling in plant meristem functions

Description of the research topic: The main aim of the project is to highlight role of putative plant-specific receptor kinase (RLK) – ROP nucleotide exchanger (RopGEF) – ROP GTPase – ROP effector kinase (RLCK VI_A) signalling modules in apical meristem (shoot, root, flower) maintenance and function. One of our aims is to identify the elements of these meristem-specific RLK-RopGEF-ROP-effector complexes. We plan to determine their contribution to the maintenance of the stem cell niche and to the regulation of organ formation (phyllotaxis, flower morphogenesis, root development). The RLK-RopGEF-ROP module can serve as a signalling node to integrate various developmental and environmental signals. We suppose that this integration is partly exerted via post-translational modifications (phosphorylation) of ROP-activating RopGEFs. We aim to

provide example(s) for this level of regulation including the functional consequences of these modifications in vitro as well as in planta.

7.

Mentor: Fehér Attila

Doctoral School: University of Szeged, Faculty of Science and Informatics, Doctoral School of Biology

Ph.D. student: Bolor-Oyut Batbayar

Title of the research topic: Temperature regulation of Arabidopsis morphogenesis – the role of the RLCK VI_A2 kinase

Description of the research topic: Based on the literature data and our preliminary results we propose to elaborate the role of the ROP-GTPase-activated Arabidopsis RLCK VI_A2 kinase in plant temperature responses, especially in thermomorphogenesis. To reach this goal, the upstream regulators and the downstream substrates of the kinase will be identified with emphasis on their link to cell elongation and plant growth under high ambient temperatures. In addition, temperature-dependent regulation of cell division and differentiation will be investigated in the apical meristems in association with thermomorphogenesis.