

# **PlantaSyst: Teaming-up for Systems Biology and Biotechnology**

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## **Abstract**

We describe the principles of PlantaSYST, as an example for the novel European Teaming project, funded under the „Spreading Excellence and Widening Participation” Horizon 2020 program. The goal of the Teaming projects is to bridge the gap between research centres with low and high participation in the EU framework program.

## **The PlantaSYST project: establishment of a new Center-of-Excellence in Bulgaria**

One of the new developments of the EU Horizon 2020 framework program, within the Spreading Excellence and Widening Participation funding scheme, is the Teaming action. The goal is to establish new Centers of Excellence (CoE) or substantially upgrade existing centres in the EU member or associated states that currently have low participation in framework programs. Under this Teaming action, these so-called widening countries are partnered with advanced partner research organizations, thereby bridging the gap between the widening and the advanced countries while fostering scientific excellence. In this way, the pockets of excellence in the widening countries are nourished and the advanced partners further distribute their innovation potential.

With these twin challenges in mind, the PlantaSYST project was conceived. The main goal of PlantaSYST is to establish a Center of Plant Systems Biology and Biotechnology (CPSBB) in Plovdiv, Bulgaria (<https://cpsbb.eu/>). The chosen focus of the centre follows the trend that plant systems biology is a rapidly evolving field, evaluating the genome, RNA, proteins, metabolites, besides other molecular constituents of the cell using high-throughput technologies and bioinformatics approaches in order to understand how plants respond as complex systems to developmental cues and environmental challenges. Plant biotechnology largely relies on the advances of plant systems biology to develop sustainable technological solutions for important challenges such as food production, molecules with applications in amongst others medicine, cosmetics and bio-factories.

The first phase of this Teaming project was implemented during 2015-2016, and its main aim was to prepare a robust 10-year business plan for the development of the CPSBB. During that period, CPSBB was registered as a legal research entity in the Court of Plovdiv. The second phase of PlantaSYST was launched in March 2017 and has an expected duration of seven years. This Teaming call faced fierce competition: out of 171 EU-based consortia that had applied initially, only 11 were granted the Phase 2 contract ([http://ec.europa.eu/research/regions/pdf/publications/list\\_teaming\\_project\\_winners.pdf](http://ec.europa.eu/research/regions/pdf/publications/list_teaming_project_winners.pdf)). The PlantaSYST is one of the two Teaming-funded projects related to plant science. The project consortium is composed of five academic research organizations besides the newly established CPSBB as Coordinating institution (Table 1). Of particular importance in Teaming projects is the support from the so-called advanced partners, in this case two German organizations: the

University of Potsdam (UP, based in Potsdam) and the Max Planck Institute of Molecular Plant Physiology (MPIMP, based in Golm).

The grant of 15 m € is envisaged to cover salaries for the personnel during the seven years of the PlantaSYST project as well as soft measures, such as travel and organization of events. At the same time, the Bulgarian Government, through the Operational Program “Science and Education for Smart Growth” (OP “SESG”), has committed additional 15.3 m € to fund the construction of a new CPSBB campus in Plovdiv and to purchase state-of-the-art equipment. The co-funding contract was signed by CPSBB and OP “SESG” in late 2019. Equally important, Plovdiv Municipality supported the project by providing land of ca. 23,500 m<sup>2</sup> in the city of Plovdiv for the new CPSBB campus.

### **Building a research center**

The idea of the PlantaSYST Teaming project was initiated through a connection between the existing participating institutes, recognizing the need to develop the foundations of a new research center that would catalyze the scientific and socio-economical development in Plovdiv. Starting a new research organization from scratch meant a huge founding work to be done, including administrative work (the CPSBB statute, basic administrative rules and procedures that are in compliance with both Bulgarian and EU legislation). The CPSBB was established as fully autonomous research organization (administratively and financially). The autonomy was one of the most important recommendations of the Teaming program, but this was not easy to do as it challenged the research landscape in Bulgaria, where most of the other research organizations are under the umbrellas of either the Bulgarian Academy of Sciences or the Agricultural Academy. At the same time, the human capacity (administration, core research personnel, technical and IT staff) had to be developed. The CPSBB research departments were hence quickly established (Figure 1A).

### **Infrastructure development**

The CPSBB obtained a building from the PlantaSYST partner MVCRI at the beginning of the project (Figure 1B). This was an important development, which allowed rapid employment of core research and technical personnel, and hence intensification of the scientific activities at CPSBB. At the same time, the Bulgarian Government recognized CPSBB as an infrastructure of strategic importance and hence included it in the National Roadmap of Research Infrastructure ([www.mon.bg/upload/4013/Roadmap\\_2017\\_ENG.pdf](http://www.mon.bg/upload/4013/Roadmap_2017_ENG.pdf)), which allowed CPSBB

to obtain essential equipment for its building in the MVCRI campus. Further infrastructure development is expected in the coming years, when the new CPSBB campus will be constructed in Plovdiv (Figure 1C). The campus will have a contemporary administrative building with offices, large auditorium and seminar rooms, laboratory complex, rooms for specialized equipment, and greenhouses.

### **Developing the human potential**

One of the very first steps was to rapidly find and employ core administrative, technical, and scientific personnel. The administrative personnel was of paramount importance for the running of the center, as it was involved in establishing the basic rules and procedures of CPSBB as well as the employment and administrative service of the scientific personnel. The core scientific and the technical personnel, in turn, contributed to the development of the infrastructure and the scientific outputs (high profile research papers and new collaborative projects).

At present, the CPSBB has six research departments - Bioinformatics, Molecular stress physiology, Plant cell biotechnology, Plant development, Plant metabolomics, Vegetable breeding and two service departments - Funding and Technology transfer & IP management. The CPSBB is international, striving to employ the best scientists from all over the world, and is set to further expand its human resources once the new CPSBB campus is constructed.

### **Scientific activities of CPSBB**

The CPSBB scientific departments (Figure 1A) conduct collaborative research with the PlantaSYST partner institutions in several important fields of plant systems biology and plant biotechnology. The Department of Bioinformatics provides support to the experimental departments at CPSBB in all major aspects related to the analysis of “omics” data sets (including e.g. next generation sequencing data from e.g. RNA-seq, ChIP-seq or whole-genome sequencing; primary and secondary metabolite profile data, and others). Furthermore, it conducts its own research, e. comparative genomics of extremophile plants. The Department of Molecular Stress Physiology investigates how plants employ their genetic potential to cope with abiotic and oxidative stress. One research area is deciphering the molecular mechanisms of tolerance against desiccation and long-term darkness in the resurrection species *Haberlea rhodopensis*, using biochemical, physiological, and “-omics” (transcriptomics, metabolomics, lipidomics, to name a few) approaches [1]. Another research direction, the project partners

have identified a new flowering plant-specific gene that plays an important role in regulating abiotic and oxidative stress tolerance [2].

In cooperation with an Irish company, BioAtlantis, scientists from CPSBB and Potsdam are developing an effective, environmentally friendly molecular priming technology in which a seaweed biostimulant induces plant defense genes and metabolites resulting in subsequent stress tolerance [3,4]. This technology was tested successfully with model and crop plants [*Arabidopsis thaliana*, tomato (*Solanum lycopersicum*), pepper (*Capsicum annuum*)] The cooperation with companies is of particular importance to CPSBB, as it links the center to the industry, allows fast transfer of the applied research to the end users (e.g., farmers), and provides long-term sustainability to the center. Currently, CPSBB has cooperation agreements with five companies. The cooperation with BioAtlantis has been particularly fruitful, yielding several co-authored research articles and one new Horizon 2020 project, coordinated by CPSBB.

The Department of Plant Development focuses on the effect of adverse environmental conditions (in particular drought) on the development of vegetable crops (e.g., tomato) with a strong emphasis on the role of transcription factors and their gene regulatory networks to unravel the crosstalk between developmental, hormonal and stress-related signalling pathways.

The Department of Vegetable Breeding at the CPSBB, in cooperation with MVCRI, is exploiting the vast diversity of Bulgarian pepper and tomato varieties [5]. The Department of Vegetable Breeding is collaborating closely with the Department of Metabolomics who are also evaluating the diversity of tomato [6] and the Department of Plant Cell Biotechnology who are also evaluating pepper [7] and medicinal plants [8], using hyphenated mass-spectrometry technologies [9].

The main research focus of the Plant Cell Biotechnology department includes the biosynthesis of value-added molecules and the development of biotechnological tools for their sustainable mass production along with the application of emerging platforms for comprehensive metabolite profiling [*i.e.*, Nuclear Magnetic Resonance (NMR)-based metabolomics] and biochemometrics (chemometrics in tandem with anti-obesity, anti-inflammatory and immunoregulatory assays) [10-13].

## **Challenges and opportunities**

Developing a new independent Center of Excellence itself is highly complex; securing its long-term sustainability is equally difficult. Hence, the PlantaSYST project by nature has been very

challenging. Keys to the ultimate success are, among others, the long-term support of the Bulgarian Government and Plovdiv Municipality, as well as establishing strategic cooperation with leading universities, research organizations, and biotechnological companies.

### **Links with Academia and interactions with other Horizon 2020 funded consortia**

CPSBB has established and maintained fruitful cooperation with numerous partners globally. In particular, the leading scientists involved in the International Scientific Advisory Board of CPSBB, have provided independent objective evaluation of CPSBB activities which has guided CPSBB throughout the years and streamlined research. Furthermore, scientists from CPSBB maintain connections with more than fifty research organizations globally, which is reflected in joined scientific articles and research projects.

The PlantaSYST project links with the other Teaming phase 2 projects through the “Teaming club”. The coordinators of the Teaming phase 2 consortia maintain regular contacts in order to discuss project challenges, solutions, and future opportunities for the developments of their research centers.

Two ongoing Horizon 2020 projects involve PlantaSYST partners. TomGem, with participation of MVCRI and MPG, designs heat tolerant tomato varieties and management practices. RESIST, with participation of CPSBB, MPG, and UP, deciphers the genomes of desiccation-tolerant plants, and the genetic basis and molecular mechanisms of drought tolerance in model and crop plants such as tomato and pepper.

### **Closer to the real world: Partnership with Industry and end-users**

CPSBB and other PlantaSYST project partners maintain viable cooperation with several European companies. The partnership with industry is part of the strategy for securing long-term sustainability of CPCBB and provides direct translation of the fundamental knowledge into practical applications. The CPSBB has partnership agreements and/or contracts with BioAtlantis Ltd. (Ireland), the Huvepharma (Bulgaria), SUBA Seeds (Italy), the Bulgarian Pepper Association, among others. The contact with end users such as vegetable breeding associations and farmers is equally important, making sure that the applied research conducted by the PlantaSYST partners meets the demand of the society.

The CPSBB already has a joint H2020 project with BioAtlantis (RESIST project) and is currently preparing three other collaborative projects with companies. Further opportunities for collaborative research with academic and industrial partners exist in the next framework program **Horizon Europe** which offers support for research and innovation and fosters

European and international partnerships and we hope that sharing our experience here will be helpful for others to follow in our footsteps.

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## **Resources**

<https://cpsbb.eu/>

<http://plantasyst.eu/>

[http://ec.europa.eu/research/regions/pdf/publications/list\\_teaming\\_project\\_winners.pdf](http://ec.europa.eu/research/regions/pdf/publications/list_teaming_project_winners.pdf)

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Table 1. The PlantaSyst Consortium

<b>Affiliation</b>	<b>Leading researcher</b>	<b>Country</b>
Center of Plant Systems Biology and Biotechnology (CPSBB)	Tsanko Gechev	Bulgaria
Maritsa Vegetable Crops Research Institute (MVCRI)	Dimitrina Kostova	Bulgaria
The Stephan Angeloff Institute of Microbiology (IMicB)	Milen I. Georgiev	Bulgaria
Max Planck Institute of Molecular Plant Physiology (MPG)	Alisdair R. Fernie	Germany
University of Potsdam (UP)	Bernd Mueller-Roeber	Germany
Institute of Molecular Biology and Biotechnology (IMBB)	Ivan Minkov	Bulgaria

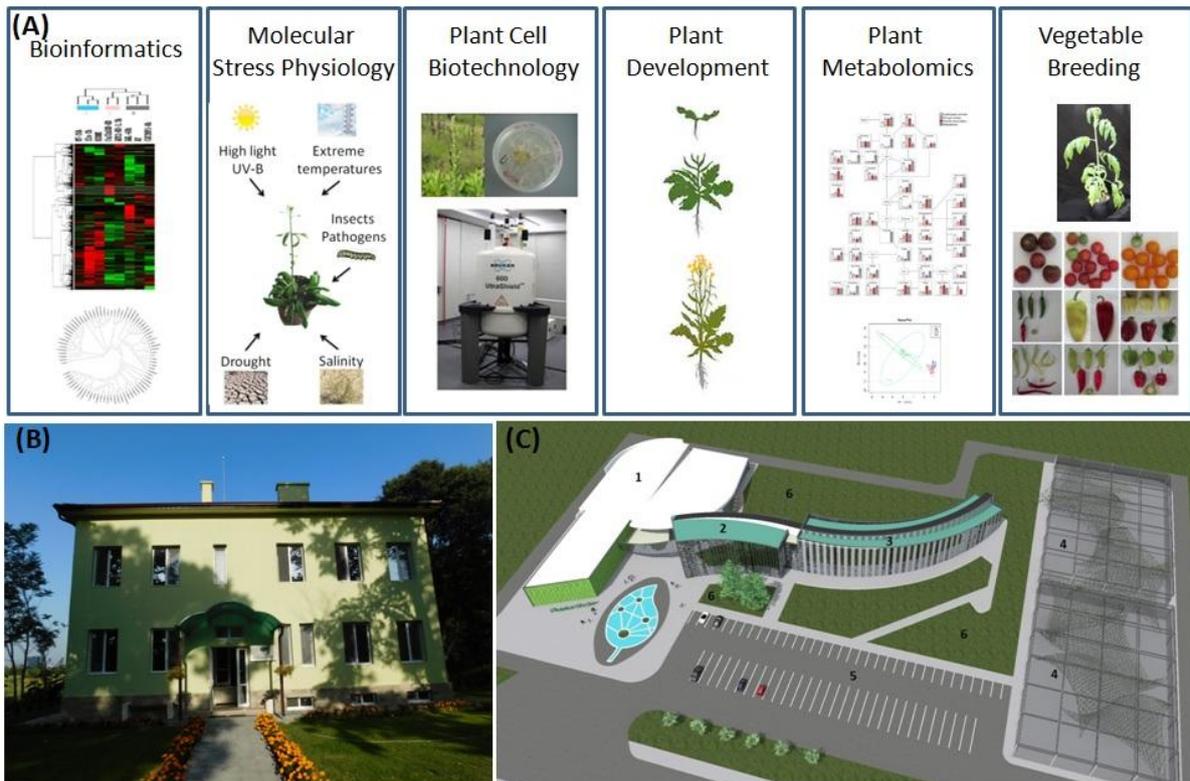


Figure 1. Research and infrastructure of CPSBB. (A) Research departments; (B) The current CPSBB building in the MVCRI campus; (C) Plan of the new CPSBB campus (23,500 m<sup>2</sup> area), to be constructed during phase 2 of PlantaSYST. The numbers indicate: 1, administrative corpus; 2, laboratories; 3, specialized rooms; 4, greenhouses; 5, parking; 6, recreation area.