

PREFACE

During the last decade, a remarkable proliferation of interest in root development has taken place. The reason for plant roots to be and remain an exciting and intriguing field of science is not explicitly clear. When compared to flowers, roots distinctly lack the ornamental attractiveness of flowering structures. Pondering over this seeming contradiction, I think the answer might be found in the secret and hidden nature of roots. Scientists are, by default, attracted by mysteries: the bigger the puzzle, the larger the provocation to dig into the enigma. Among all growth processes occurring in plants, the development of roots is without discussion, at the summit of secrecy. Roots reside their entire life in the soil sheltered from daylight, proliferate and colonize the rhizosphere through the continuous development of new meristems that arise deep inside tissues invisible from the surface, interact sneakily with various microorganisms that provoke dramatic growth changes and are capable of reacting upon the ever-changing soil conditions in an unfathomable way. Indeed, plant roots grow and develop while continuously monitoring information from the environment. They are often subjected to periods of soil water deficit and, unfortunately, the frequency of such phenomena is likely to increase in the future even outside today's arid and semiarid regions. Therefore, it will become essential to understand root development in detail in the next decades, to learn how plants cope with a changing environment, and to translate the fundamental knowledge into applications. No doubt, there is still a long way to go and the question is whether a deeper understanding of fundamental root biology could be implemented on time into applications to ease the essential needs of the future world population. Nevertheless, it is at least hopeful to notice that insight into the subterranean part of plants has seriously made progress in the recent years, especially at the level of its developmental biology. Data have been accumulating exponentially and the entire root development area cannot easily be summarized in the format of one single review paper. Hence, I am glad and proud that representatives of all top laboratories on root development have accepted to contribute to the timely publication of this book and have helped me with this challenge. As, you will see, they all did a great job.

In the first four basic chapters, the main root developmental processes are covered. In contrast to previous root development reviews, these chapters are characterized by the enumeration of an increasing number of molecular components that are essential for root development and have been identified recently. This tendency reflects that our discipline has come to maturity. A major player in this evolution has certainly been the selection of and the

restriction to one single model system, namely *Arabidopsis thaliana*. The root of this species has all it needs to guarantee easy laboratory handling and experimentation. On top of this, its genome is sequenced and a myriad of molecular tools have become available. In the first chapter, the origin of the primary root during embryogenesis and the establishment of a typical cellular pattern are discussed as well as the preservation of this pattern after germination, implying the introduction of the concept of a stem cell niche in the root tip. The second chapter deals with the development of the vascular tissue with references to the involvement of plant hormones and summarizes some large-scale approaches, which collectively have been designated as 'vascular genomics', a new discipline in root developmental biology. In the third chapter, the focus lies on particular tissue layer of the root, namely the epidermis. It is a border tissue through which roots make contact with the soil. Following a discussion on its development and the specification of the different cell types, an outlook on its nutrient uptake function is provided. Chapter 4 discusses the branching of roots, a process that contributes considerably to their plasticity toward changes in the rhizosphere. It is therefore no surprise that this chapter concludes with a section on the agricultural importance of lateral root formation. In contrast to lateral roots, adventitious roots are part of the root system that are not derived from the primary root; their formation is discussed in Chapter 5. This aspect of root development also incorporates a high economic potential because it represents the essential step in the vegetative propagation of plants. The lion's share of this chapter deals with the many environmental and endogenous factors that influence adventitious root formation, illustrating the extreme complexity of this process. An intensively studied developmental process occurring in roots is root gravitropism that is by far the most obvious adaptive trait of roots. Several recent breakthroughs of gravitropism are summarized in Chapter 6. In the following four chapters, we step out of the *Arabidopsis*-dominated world and learn more about root development of cereals and ferns and changes in root architecture induced by symbiotic interactions with soil microorganisms. In these chapters, our view on root development is largely expanded by the treatment of issues that are completely lacking in the *Arabidopsis* model. Nevertheless, on many occasions, the authors can make interesting comparisons with some fundamental insights provided by the *Arabidopsis* root community, highlighting the value of a multidisciplinary thinking while studying roots. I hope that this book will contribute to bring the different root scientists together and will help researchers and students to compare their findings with observations made in other plants. Next, the importance of nutrient availability on root development is treated in Chapter 11 from an evolutionary perspective: the availability of mineral nutrients has played a major role in evolution and development of the diverse root system architectures. Finally, in Chapter 12, we return to the *Arabidopsis* model, but this time to discuss novel molecular tools that have led to the creation of expression maps of over 22 000 genes at a cellular resolution. The importance of such genome-scale

data sets is commented and should convince any reader that systems biology approaches can be implemented in and are beneficial for root developmental research. In the coming years, this approach will be extremely valuable to decipher this complex biological process.

Before allowing you to descend to the below-ground level and to enter the fascinating world of roots, I want to thank all contributors for their impeccable texts and for their endless patience with the 'not that speedy' editing process for which I am personally the one to blame. Furthermore, I am indebted for the daily support and motivation of my scientific work to all present and previous members of the Root Development group at the Department of Plant Systems Biology in Gent and, last but not least, to Martine De Cock, the secret weapon of our department, who has been editing uncountable manuscripts over the years and who, this time again, helped me during the preparation of this book.

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