



# **Plant Genetics and Genomics in Practice**

*First Edition*





# **PLANT GENETICS AND GENOMICS IN PRACTICE**

**Kornelia Polok**

*Department of Genetics  
University of Warmia and Mazury in Olsztyn*

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## Cover

The cover was designed by Kornelia Polok, Photos by Kornelia Polok

**Front cover:** The cover represents major steps of molecular analysis of plant material. First, Roman Zielinski (from left), Tadeusz Zwijacz (Tatra National Park) and Michal Zielinski collect pine needles in order to assess the origin and evolutionary relationships of *P. rhaetica* inhabiting the Podczerwone peat-bog (Podhale, Poland). Then, in the laboratory, DNA markers are identified. A child, Michal Zielinski presents nicely steps of a PCR reaction – this is to demonstrate the simplicity of analyses.

**Back cover:** The picture of European Union fellows visiting the peat-bog in Olsztyn demonstrates the necessity of wide international co-operation in modern science. The fellows spent four months in Poland within the GenCrop. They are: from left – Luis Cabrita, Portugal; Amrou Farouk, Egypt; Roman Zielinski, Poland; Alberto Marin Sanguino, Spain; Jana Haluskova, Slovakia; Michal Zielinski, Poland.

## Plant Genetics and Genomics in Practise

Book Website: <http://www.uwm.edu.pl/katgenbiol>, e-mail: kpolok@onet.eu

## Photos and Figures

All photos are taken by Kornelia Polok, all figures are designed by Kornelia Polok

*Review:*

*Prof. dr hab. Roman Zielinski*

*Proof-reading:*

*Prof. dr hab. Roman Zielinski*

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**Studio Poligrafii Komputerowej „SQL”**

10-964 Olsztyn, ul. Wańkowicza 24, tel./fax +48 89 542 03 39, 89 542 87 66  
e-mail: [studio@sql.com.pl](mailto:studio@sql.com.pl)

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*Genetics is not a merely a set of tools.  
Genetics is a coherent and fruitful way of thinking*



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# Preface

All biological processes are programmed and need to be regulated in every living organism. A gene is the basic unit by which the traits are determined. Genes affect the reproductive success of organisms and each mutation in a gene, no matter whether spontaneous or induced, irrespective of a causing agent (transposons, polymerase slippage and others) influences on the behaviour of organisms and their fitness. Alleles with advantageous effects can be widespread in a population while these with negative influences are eliminated or their frequencies are held at the very low level. Thus, the presence of many alleles at a locus, differences in their frequencies resulting from selection, in the other words – genetic variation, is the essence of life. It is responsible for the population divergence that can, but not must, be accompanied by the acquisition of reproductive barriers. A mutation record history can be disclosed with advent of molecular biology methods and can be used to establish relationships between organisms. Genes are, therefore an invaluable document of the history of life. Taking an evolutionary point of view it is often easier to answer why a gene causing a disease has become common in a population. This point of view allows to identify and to treat causes rather than symptoms. Hence, a complete genetic analysis of the biological phenomena should take into account this evolutionary perspective. This way of thinking, recognizing each studying problem as a part of unified whole resulting from evolutionary changes, should be adapted to all teaching courses and scientific considerations.

Owing to advances in genetics and evolutionary biology, vigorous research and new ideas, we are witnessing one of the major scientific revolutions delving into the distant past and providing an unprecedented understanding of the natural world. Not only this is dramatically changing our knowledge but also it is leading to significant practical applications in agriculture, public health, computer science and many others. It is vital that educated people understand the contributions that genetics and evolutionary biology have made and will continue to make for the future welfare of human beings. Any educated person should know something about genetics and evolutionary biology, and should understand why it matters that these subjects are taught in schools. In addition, for any researcher who envisions a career in a broad range of life sciences, an understanding of genetic processes and evolution is fundamental.

I have structured this book to begin with basic concepts in genetics, then I continue with genomics emphasizing that the organism is not the sum of its genomic parts. In addition, the Biodiversity and Biotechnology parts provide the basis for understanding the genetics as the foundation for conservation biology and plant breeding. Finally, I included Bioinformatics to give some ideas about using modern software in biological analyses. However, my goal was not to evaluate plant research across the entire field. I would rather like to have focused on areas in which I have an experience and where I can illustrate processes with my own investigations. In addition, the variety of novel techniques together with limitation of university courses makes it difficult to present all methodological approaches. There are undoubtedly topics I have missed, but there is no reason why these cannot be explored independently reading the primary literature. My idea was to gear the book towards master and doctoral students to help them to understand the complexity of life, to describe the core experimental approaches and to interpret results. This is an introduction to plant genetics and genomics intended to encourage students to develop a familiarity with the field wherever their interests may lead. The print edition will be accompanied with the on line version and additional resources useful in conjunction with the classrooms. Finally, without doubts new methods and concepts will arise as soon as this book appears in print, therefore, improvements will be done both in the electronic version and supplementary materials according to technological progress.

*Kornelia Polok*  
*May 2010*



# Pedagogy of the book



## Theory

Each chapter opens with the concise description of the important ideas and concepts. It balances fundamental principles with new information.



## Practical examples

The part presents examples emphasizing fundamental concepts based on own results and solved problems. Experimental designs and methodological approaches are shortly described.



## Technological links

Links to the supplementary materials including animation, quizzes and detailed experimental protocols on the Book Website as well as the World Wide Web.



## Challenging questions

A set of questions to provide students with the opportunity to enhance their understanding of the concepts covered in the chapter.



## Problems to solve

Work-out problems to develop analytical skills and creativity. The problems are of varying difficulty, they often demand literature review and unconventional thinking.



## Further reading

Examples of useful literature resources with short description for those who would like to continue adventure with genetics.