Preface

The compartmentation of genetic information is a fundamental feature of the eukaryotic cell. The metabolic capacity of a eukaryotic (plant) cell and the steps leading to it are overwhelmingly an endeavour of a joint genetic cooperation between nucleus/cytosol, plastids, and mitochondria. Alteration of the genetic material in any one of these compartments or exchange of organelles between species can seriously affect harmoniously balanced growth of an organism. Although the biological significance of this genetic design has been vividly evident since the discovery of non-Mendelian inheritance by Baur and Correns at the beginning of this century, and became indisputable in principle after Renner's work on interspecific nuclear/plastid hybrids (summarized in his classical article in 1934), studies on the genetics of organelles have long suffered from the lack of respectability. Non-Mendelian inheritance was considered a research sideline—if not a freak—by most geneticists, which becomes evident when one consults common textbooks. For instance, these have usually impeccable accounts of photosynthetic and respiratory energy conversion in chloroplasts and mitochondria, of metabolism and global circulation of the biological key elements C, N, and S, as well as of the organization, maintenance, and function of nuclear genetic information. In contrast, the heredity and molecular biology of organelles are generally treated as an adjunct, and neither goes as far as to describe the impact of the integrated genetic system. The consequence of this neglect may well be that problems inherently of great importance to understanding of living systems, such as the search for the origins of the eukaryotic world or the functional and phylogenetic efficacy of this design which may have been the basis for the development of the complex societies of multicellular organisms, are overlooked. If some intermediate goal in biology is an understanding of an entire organism, information on individual compartments alone will not suffice.

During the past two decades this sceptical attitude has gradually changed. The principal reason for this is that the application of techniques of molecular biology which contributed substantially to the understanding of biology in general, turned organelle research into a very appealing subject for molecular and cell biologists. When recombinant DNA technology combined with complementing developments in cell biology, biochemistry and ultrastructural research began to be applied to problems of organelle biology, it became apparent that previously unapproachable questions could be addressed. The answers were indeed exciting, interpretable, and suggestive of a multitude of new experiments. For example, it has been firmly established that the genetic material of organelles is unique, ontogenetically stable and a discrete element of the genetic constitution of the

plant that is inherited independently from the nucleus. Moreover, the design of plastomes and chondriomes which differs fundamentally from that of genomes is commensurate with the rules of formal genetics; most characteristics of non-Mendelian inheritance can be explained on the basis of their organisation implying that the *chromosome theory of inheritance* can be extended to the organelle subgenomes. To describe the genetic make-up of the eukaryotic cell in a scientifically unequivocal way the use of the historical, *positive* nomenclature, "genome", "plastome", and "chondriome", to characterize the respective genetic materials in nuclei, plastid, and mitochondria, appears to be most appropriate since these terms underline the interdependence of compartments. We have also learnt that organelle chromosomes possess a substantial, not yet completely unraveled coding potential. However, our knowledge of the structure and function of these genes and of their respective nuclear counterparts, or of the mechanisms of their (co)regulation is still limited. Basic research in this area is very essential. Given the pivotal role of plastids and mitochondria in the energy economy of cell and plant, understanding the molecular basis and phenotypic expression of "intergenomic integration" is a fundamental problem in biology per se and only after the elucidation of these questions can we start to investigate how genetic, environmental and physiological factors regulate the biogenesis and function of organelles during the changing energy requirements of the growing plant. The enormous complexity of the plant genome, including the intricacies of genetic compartmentation, and the division of labour in a multicellular organism present a fascinating intellectual challenge in contemporary biology both from the basic and applied point of view, specifically since modern breeding concepts tend to integrate more and more heterologous gene sources.

The need for an up-to-data account of the state of knowledge in the outlined subject is pressing since there has been no recent treatment of the entire field indicative of its growth, vitality, and momentum. The volume is designed to fill this gap and to convey substantial information on all major areas of organelle molecular biology to those just entering the field and also to the experienced researcher. Written by distinguished scientists who play a leading role in the development of this important area of plant research, the topics examined are divided into 6 sections, formal and molecular organelle genetics of both lower and higher plants, phylogenetic aspects with focus on the comparison between plastid and mitochondrial chromosomes, the gene maps of organelle chromosomes, and various aspects of organelle biogenesis including the expression of organelle genes, their cooperation with those of the nucleus, as well as the import and routing of polypetides into the within organelles. A final section summarizes our present knowledge on peroxisomes and glyoxisomes, since their biogenesis shares features with that of plastids and mitochondria and no recent comprehensive treatise is available on this subject. A few interesting and important aspects of organelle biology have been deliberately omitted. Most conspicuously absent is a detailed

discussion of the architecture and function of promotors of nuclear genes encoding chloroplast proteins since these have been the subject of several recent reviews.

As the editor of this volume, I am indebted to the authors who have summarized their research knowledge in areas that are still emerging and which are in part poorly understood. I would also like to thank them cordially for the prompt submission of their articles and constructive cooperation. Finally, I am grateful to the staff of Springer-Verlag Wien, particularly to Ms. Silvia Schilgerius and Mr. Thomas Redl for their patience with the assembly of this volume.

München, January 1992 Reinhold G. Herrmann