Reproductive Biology of Angiosperms

The science of understanding plant reproduction is more than four hundred years old. Today, with integration of molecular biological tools, plant reproductive biology has catapulted into an exciting field of research. It has become an integral part of evolutionary biology, conservation biology, climate change studies, population biology, genetics, horticulture and many more fields. Considering the widening scope of plant reproductive biology, this book focusses on teaching the core concepts of plant reproduction supplemented with latest findings in the field. Uniquely, this book addresses both theoretical and practical perspectives by providing easy protocols of experiments related to the content of each chapter, thus, making the book useful for an entire spectrum of students, teachers and researchers.

The content of the book is designed for the undergraduate syllabi of embryology, reproductive biology of flowering plants, reproductive ecology of flowering plants, and plant breeding, taught in universities across the country. The content is well-supplemented with photographs and illustrations to enhance the understanding of the structures and processes involved in plant reproduction. Interesting information, which may incite the curiosity of learners, appears at appropriate places in the narrative in a box format. Detailed comparisons of similar/related concepts which commonly are difficult to comprehend for first-time learners are especially brought out in the text. The key concepts are revisited at the end of each chapter in the form of glossary. Practice questions at the end of each chapter have been added as part of pedagogical approach of conceptual learning. To help readers develop a complete understanding of the subject, step-by-step description of experiments related to the content are also provided.

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Reproductive Biology of Angiosperms

Concepts and Laboratory Methods

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To Our Gurus ...

Our Constant Source of Inspiration

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Foreword

Plants in general and flowering plants (angiosperms) in particular are the essential components for sustenance of life of all non-photosynthetic organisms on our planet. Plants reproduce by asexual as well as sexual means. Asexual reproduction is not congenial for long-term sustenance and evolutionary processes of the species because of genetic uniformity of the progeny. Sexual reproduction which permits genetic recombination is the dominant mode. Although Angiosperms were the last to evolve as land plants, they soon became the most successful and dominant group amongst land plants. Their success is largely due to the mode of their reproduction through the evolution of the flower and the consequent advantages it brought in. For human beings, flowering plants provide most of their essential needs – food, fibres, shelter, medicines, clean air and water. Reproduction is the basis for sustenance of any species. Thus, understanding reproductive biology of flowering plants is important not only from the fundamental point of view but also for their manipulation for human welfare. Reproductive biology of angiosperms is more complex when compared to other groups of plants because of the involvement of the flower. The progress in understanding the structural and functional aspects of reproduction has been very slow.

Initial studies on reproductive biology of angiosperms were largely confined to examining embryological details using fixed and sectioned materials. Enormous data accumulated over the years on the developmental details of the pollen grains, ovules and female gametophyte, double fertilization, embryo and endosperm, seed and fruit development. These advances were taught to the undergraduate and postgraduate students under the title embryology of angiosperms as a part of their curriculum. Following the development of electron microscopy and histochemistry, embryological details were further elaborated by using these techniques. Development of aseptic culture techniques broadened scope for experimental studies on embryological processes leading to a slow but steady understanding of the functional details of embryological structures. These developments were incorporated in some of the books of embryology under a chapter on experimental embryology. However, there was hardly any integrated account of embryological processes in relation to the structure with their function. Pre-fertilization aspects of reproductive biology covering the details of pollen, pistil, and pollen–pistil interactions, which are unique to angiosperms and play a critical role in their successful evolution, were the last to enter the field of embryology of angiosperm. Surprisingly, pollination on which plenty of literature has long been available and which is a critical requirement for angiosperm reproduction was not a part of embryology.

Now enormous data has accumulated on all aspects of reproductive biology of angiosperms through interdisciplinary studies and it is high time to teach this subject as "Reproductive Biology" (rather than embryology) integrating all these advances starting with flower development until fruit and seed maturation and their dispersal.

Continued research and teaching of reproductive biology of angiosperms has become highly relevant in the light of human-induced environmental changes (intensification of agriculture, habitat loss and degradation, overexploitation of bio-resources, introduction of alien species and climate change) in recent decades and their impact on the sustenance of biodiversity and crop productivity. Human activities have not only accelerated extinction of species but also have pushed a large number of species to endangered status leading to the sixth mass extinction crisis. In the absence of effective remedial measures, a large proportion of biodiversity is likely to become extinct by the end of this century. Therefore, conservation of biodiversity is likely to become one of the most important agendas of the world in the coming decades. Reproduction is the basis for the sustenance of any species. In flowering plants, recruitment of new individuals which is the final step in a series of sequential reproductive events is the basis of species sustenance. Environmental changes have induced severe constraints on many reproductive events, particularly pollination and seed dispersal, leading to recruitment constraint. For any effective conservation of angiosperm species, it is important to understand reproductive biology of endangered species to identify reproductive and/or recruitment constraints and to apply effective measures to overcome such constraints. Plant conservation attempts so far, particularly in developing countries, have not been very successful; one of the reasons being our ignorance of the reproductive biology of the species to be conserved. Knowledge about reproductive biology is important not only for effective conservation but also to monitor the success of conservation measures.

Present book, *Reproductive Biology of Angiosperms: Concepts and Laboratory Methods,* by Yash Mangla, Priyanka Khanduri and Charu Khosla Gupta is going to be an important contribution to the field. It begins with a brief introduction that gives an account of different aspects of reproductive biology and highlights the importance of the subject to other areas of plant biology such as conservation biology, crop production, and evolutionary biology. Historical account, that comes next, elaborates briefly the development of "classical embryology" through various stages into an integrated discipline of "reproductive biology" and highlights the contributions of several well-recognized investigators. Various chapters starting from the flower until seed dispersal give a reasonably comprehensive account of different aspects of reproductive biology. A chapter on genetic transformation is also included at the end. The book is illustrated with photographs and diagrammatic sketches of high quality.

An attempt is made in all the chapters to give an integrated account of reproductive structures (as revealed through light and electron microscopy) and their functions. The deep understanding involved was realized through the application of the techniques from different disciplines such as histochemistry, physiology, biochemistry, molecular biology, and evolutionary biology. Such an integrated account is hardly given in any of the existing books in this field. Boxes and tables have been used profusely to provide clarity on many

aspects. Glossary of a large number of technical terms and key questions are given at the end of each chapter. The details of the practical exercises given for each chapter are going to be very useful for the teachers as well as students. To my knowledge there is no such book available so far in this field. The present book is thus a very welcome addition to the literature on reproductive biology of angiosperms. I congratulate the authors for compiling such a book. I am confident that the volume is going to be very useful not only for teachers and students of Reproductive Biology but also those interested in any aspect of reproduction of angiosperms.

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Preface

The inception of interest in understanding mechanisms of plant reproduction is as old as inception of interest in biology. The seminal work and critical observations by Charles Darwin can be regarded as a foundation for establishing a wide interest in pollinators and reproductive biology of angiosperms as a formal subject. In the last few decades, systematic field investigations, advancement of microscopy tools, and molecular techniques have taken the reproductive biology of angiosperms to a new zenith. The scope of the subject is no longer limited to just studying embryo-endosperm development and taxonomic studies but is extended to study the effect of climate change, evolution, conservation of threatened taxa, raising commercial plantations and orchards, pollinator management, seed development, population biology, phyto-geography, and much more. The reproductive biological studies are also closely linked with the understanding of, physiology, genetics and epigenetics of plants.

For a thorough understanding of the subject, a textbook summarizing the basic concepts of plant reproduction integrated with current research, is the need of the hour for both students and instructors. The aim of the present book is to provide a comprehensive account of basic concepts and recent developments in the field of reproductive biology of flowering plants with essential practical exercises. The book extensively covers all the topics from structure of a flower to seed dispersal and presents the concepts with accompanying color photographs and illustrations wherever necessary, to enhance the level of a student's perception. The new, advanced and interesting information is also provided in a box format in each chapter to reinforce learning. An elaborate glossary and questions are provided with each chapter for quick revision and concept enhancement. Boxes summarizing differences between two terms/concepts which students otherwise usually find difficult to comprehend have also been furnished in the book. This book is a blend of theoretical concepts and details of hands-on exercises in the field and laboratory. Methods for field observations, sample observation tables, and suggestions for plant materials to be used for classroom studies/demonstrations pertaining to each concept have also been provided. In addition, the observation sections under practicals are supplemented with the photographs. This should surely help the instructors to demonstrate and students to grasp the concept effectively

The current book has been specially structured keeping in mind the syllabi of the leading universities in the country. The content is all inclusive of different curricula frameworks implemented by the University Grants Commission across the universities. It can be used

as a text book as well as a reference book by both graduate and undergraduate students along with researchers in the field. The glossary of technical terms at the end of each chapter should help students for quick revision for their competitive and entrance examinations. We hope the present edition of the book will certainly turn into a knowledge resource for the young minds and learners in the field.

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