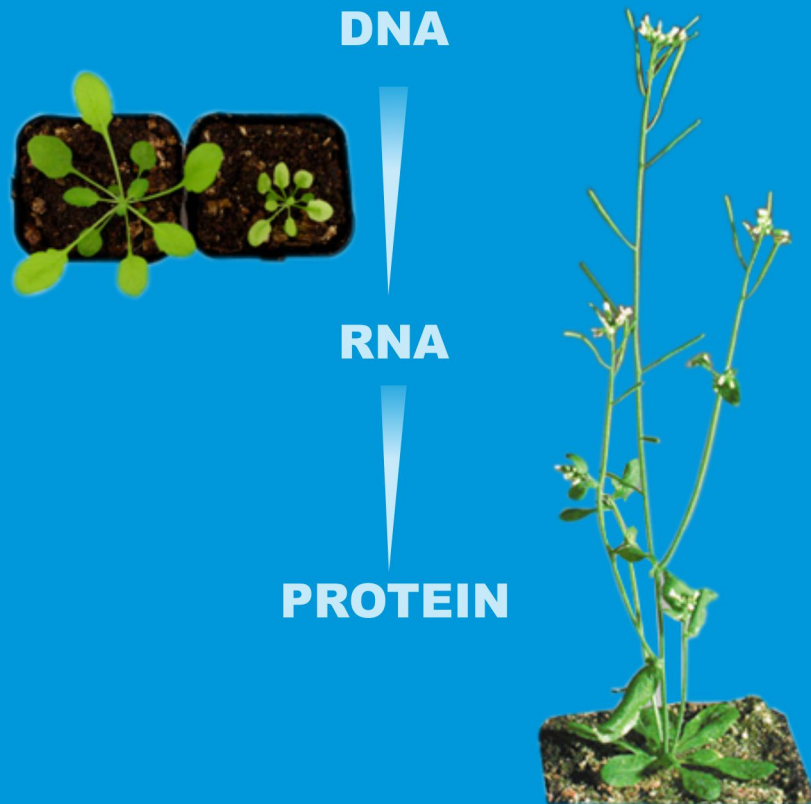


Plant Molecular Genetics

Supriyo Chakraborty



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PLANT MOLECULAR GENETICS

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*Dedicated to
my school teachers*

*Mr. Manoj Kumar Adhikari
and
Mr. Ramakanta Dey*

FOREWORD

The knowledge of plant molecular genetics is basic to genetic modification of plants for meeting diverse human needs. The ultimate goal of this subject is to explain various hereditary mechanisms and patterns of variation in plants at DNA level. From 1953 when the double helix model of DNA was discovered, progress in plant molecular genetics has been phenomenal. The spectacular growth of plant genetics over the last few decades has in turn made possible transfer of genes across plant species even with sexual barriers.

Indiscriminate use of pesticides in crop fields pollutes our environment and poses a great threat to human and animal health. Rapid replacement of numerous locally adapted primitive varieties of crops with one or two high yielding strains in large areas not only narrows down genetic diversity but also results in the spread of serious diseases capable of wiping out entire crops. Plant molecular genetics has now come-up with several sophisticated methods of tailoring plant genome. Using these methods, plants have been developed having resistance to various biotic (insects, diseases, nematodes etc.) and abiotic stresses (heat, cold, drought, flood etc.) and having improved photosynthetic ability. Plants resistant to herbicide have been produced in potato, tomato and *Brassica napus* using the tools of plant molecular genetics to combat weed menace in commercial cultivation. Genes for seed storage proteins from both cereals and legumes have been successfully transferred and expressed in tobacco endosperm. The base sequence of rice genome has already been worked out. These are just a few examples of the invaluable contributions of plant molecular genetics to mankind. It is easy to comprehend that

the market price of a single gene could be in billion dollars should the gene in question confer resistance to a particular disease or insect-pest and should it avert a crop failure in a continent or a country. In the coming years, we should increasingly strengthen the teaching of plant molecular genetics in our universities and allocate more funds for research on various aspects of plant genetics. This is the clarion call of the present time to reduce the widening gap in harnessing genetic manipulation techniques between our country as a developing nation and other developed nations in the world. This book "Plant Molecular Genetics" is hence a timely contribution to generate more human resource skilled in plant genetic manipulations in our country.

I congratulate Dr. Supriyo Chakraborty for this endeavour and I express my sincere thanks to him for the trouble he has taken to compile valuable information on various topics of plant molecular genetics and to present them in a readable manner. I hope, it will be of great help to the students and the research workers alike.

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PREFACE

Genetics is the study of heredity and variation. The science of genetics was born in the spring of 1865 to an Austrian monk Gregor Johann Mendel only to be immediately driven to the bookshelf for storage for the next 35 years. It was rediscovered in 1900 by three independent workers named Carl Correns, Hugo de Vries and Erich von Tschermak. Since then genetics has made very rapid stride with time at a pace possibly unmatched even by the fast growing science of electronics and space science. The beginning of the 21st century has been marked by the spectacular and unimaginable achievements in genetics. Knowledge of genetics is basic to progress in agriculture, biology and medicine. Since 1953 when the double helix structure of DNA molecule was discovered, progress in plant molecular genetics has been phenomenal. Plant molecular genetics directly deals with the study of DNA for understanding the hereditary mechanisms in plants. Advances in plant molecular genetics have in turn made possible the transfer of useful genes across sexual barriers. It has also paved the way for developing sophisticated methods of genetic engineering for gene transfer.

Global population has been increasing at an alarming rate. In the continents of Asia, Africa and South America the population growth rate is enormously high and most of the countries belonging to these three continents are characterized by developing economy. Nearly 800 million people of the world do not get sufficient food to eat and about 1.3 billion people spend just less than a dollar a day per capita to support life. Amongst the world's poverty stricken people, nearly 50 per cent live in Asia, 25 per cent in Africa and 12 per cent in South America. In order to feed the teeming millions, the global food

production has to be increased by utilizing the available resources.

Of the world's available land area (14 billion ha), only around 3.2 billion hectares is arable with minimal environmental modification. Out of the total arable land, approximately 25 per cent is subject to excess salinity and another 25 per cent subject to soil acidity and are not suitable for agricultural production. On the other hand, only 14 per cent out of the world's 1.4 billion hectares of land currently under cultivation is irrigated and it produces nearly half of the world's food. Increasing food production further by bringing more area under cultivation is not feasible. Agricultural scientists have, therefore, been left with the only option of increasing food production by raising crop productivity *i.e.* production per unit of land. One of the ways of raising crop productivity is the development of high yielding varieties by geneticists and breeders followed by their wide cultivation.

Agricultural production throughout the world is limited by abiotic and biotic stresses. Every year agricultural production is reduced by nearly 33 per cent by biotic stresses alone which include insect-pests, pathogens, nematodes and weeds. Crop plants grown under stress environments result in poor yield since they, usually lack the inherent mechanism to grow well under stress. To address the situation of low yield, the science of plant molecular genetics is possibly the only means. Recent advances in plant molecular genetics have elucidated the genetic mechanisms conferring resistance to plants against various abiotic and biotic stresses. Its improved techniques have enabled plant geneticists and breeders to modify crop plants through artificial transfer of genes to suit the changing environment under stress and to produce high yield.

It is an enormous task to compile all the information generated till todate on plant molecular genetics in a single volume. It requires immense talent, diligence and considerable skill for handling varied subjects of plant molecular genetics like an expert. I do not even dare to tread the path of that enormous task of compilation. Rather I have chosen some specific topics of plant molecular genetics that are directly related to food production for this textbook and tried to compile as much basic information as possible for students and the

researchers. This textbook contains several important topics like gene cloning in plants for resistance to insects, viruses and herbicides. It also includes chapters like photosynthetic genes, defense response genes, heat-shock protein genes, molecular genetics of cold tolerance and apomixis in crop genetic improvement.

Plant molecular genetics is now taught at both undergraduate and postgraduate courses of biological science in traditional and agricultural universities of India and other SAARC countries. The teachers and the students have to refer various books and periodicals to collect the basic information on different topics of plant molecular genetics since there is no textbook covering the major topics in a comprehensible manner. I have written the present textbook to satisfy the needs of the students and the teachers. In my opinion as an author (perhaps my opinion may differ from others), no textbook can claim originality either in contents or in presentation. The present textbook too is not an exception and it draws information from several research papers by renowned workers, books and articles. I have tried to use a simple language for presenting the contents step by step for easy understanding of a beginner on the subject. At the end of each chapter a list of references have been given.

I can only hope that the students will find this book very useful taking their course examinations for obtaining degrees and for appearing in competitive examinations like civil services, NET, ARS etc. for placement. I take this opportunity to welcome suggestions from teachers and students to make the book more useful in subsequent editions.

Many of my colleagues have encouraged me to develop this text for the benefit of the students. I am grateful to all of them: particularly to Dr. B.K. Borah, Dr. B. Guha and Dr. P. C. Sarmah of Assam Agricultural University. I express my sincere gratitude to my parents, parents-in-laws, sibs, sibs-in laws, my friends and well wishers who helped me build up confidence for writing this textbook. I am grateful to Mr. Bijoy Paul and the publishers for their untiring efforts to present my work in print before a wide section of students and research workers.

I cannot but express my sincere gratitude to my wife Sumita who has helped me get over the anxiety that goes with

such work despite her busy work schedule at home and in school. I am thankful to my 3-year old son Srinjay who at times interrupted my attention calling me “papa” for placing his demand for toys and thereby indirectly reinvigorated my mind to resume my work with a renewed zeal despite his interruptions.

Dr. Supriyo Chakraborty

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