

Preface

RNA molecules participate in and regulate a vast array of cellular processes besides being the physical link between DNA and proteins. They play several other key roles, which include RNA catalysis and gene regulation mediated mainly by noncoding RNAs. This regulation occurs at some of the most important levels of genome function, such as chromatin structure, chromosome segregation, transcription, RNA processing, RNA stability, and translation. Further, harnessing the potential of RNA as a therapeutic or diagnostic tool, or as a central player in a fundamental biological process is becoming increasingly important to the modern day scientific community. Previously scientists imagined that there was an “RNA World,” in which primitive RNA molecules assembled themselves randomly from building blocks in the primordial ooze and accomplished some very simple chemical chores. But these molecules were thought only to be carrying information from DNA to ribosomes. Discovery of catalytic RNAs changed this idea and opened up a wealth of opportunities to allow investigators to modulate gene expression post-transcriptionally using ribozymes and derivatives. In addition to ribozymes, a new RNA-based strategy for regulating gene expression in mammalian cells has recently been described. This strategy is known as RNA interference (RNAi). Although much is known about the mechanisms of RNAi, there lie a number of hurdles that need to be overcome along the applicative path of gene-silencing technology which includes the activation of innate immunity, off-target effects, and in vivo delivery.

Currently, high-throughput sequencing, bioinformatic and biochemical approaches are identifying an increasing number of regulatory RNAs. Unfortunately, our ability to characterize the detailed story of regulatory RNAs is significantly lacking. Extensive research of these RNAs is an emergent field that is unraveling the molecular underpinnings of how RNA fulfills its multitude of roles in sustaining cellular life. The resulting understanding of the physical and chemical processes at the molecular level is critical to our ability to harness RNA for use in biotechnology and human therapy, a prospect that has recently spawned a multibillion-dollar industry.

Nevertheless, RNA research can be daunting, and without a thorough understanding of the challenges and complexities inherent in handling this fragile nucleic acid, forays into the RNA world can be quite frustrating.

In this book, we have made an attempt to bring together the contributions of the leading noncoding RNA researchers to embellish the story of regulatory RNAs and provide a snapshot of the current status of this dynamic field.

The book consisting of 21 chapters offers a comprehensive overview of our current understanding of the regulatory noncoding RNAs, namely, small interfering RNAs (siRNAs), microRNAs (miRNAs), Piwi-interacting RNAs (piRNAs), small nucleolar RNAs (snoRNAs), long noncoding RNAs (lncRNAs), small RNAs (sRNAs), etc., and their applications in understanding biological systems and diseases, including therapeutics. This book is divided into three major sections as per its title. The first section “Basics” consists of eight chapters (Chaps. 1–8). The first chapter gives an overview of the entire landscape of noncoding RNAs, mainly highlighting their history and functions with a focus on the current status of research and future perspectives. This is followed by chapters on discovery, biogenesis, evolution, regulatory functions, and molecular mechanisms of different category of noncoding RNAs.

The “Methods” section provides state-of-the-art experimental and computational methodologies for noncoding RNA detection using different techniques and experimental analysis of noncoding RNA regulatory networks in different systems. This part includes Chaps. 9–15 and provides different bioinformatic, high-throughput RNA sequencing, ncRNA-specific microarrays, and biochemical approaches to identify these RNAs as well as protocols for transfection, gene knockout experiments, and regulatory RNA-based cellular reprogramming and pathways in different species. Further, some chapters are devoted to methods and protocols that have been developed by the authors themselves.

The “Applications” section includes Chaps. 16–21, which cover applicative areas of various noncoding RNAs within a biological system. These serve as biomarkers for different diseases like cancer, target cancer stem cells, act as regulators in cell lineage determination, etc. Further, RNAi therapeutics is applied against solid organ malignancies, cellular reprogramming, and stem cell-based regenerative therapy.

We are grateful to our friends and colleagues who have encouraged and supported us in many ways towards preparation of this book. We acknowledge them, with sincere thanks and appreciation. We take this opportunity to thank all the authors who have contributed excellent chapters to this book and the reviewers for their critical comments to improve the quality and integrity of the chapters. Their special effort has made this book a valuable resource for scientists and aspiring research students interested in the intersection of RNA biology and clinical research. We would like to express our sincere appreciation to Sabine Schwarz and Ursula Gramm of Springer Heidelberg for their invitation to initiate this book and their continuing support and commitments in making this book a reality and to other staff members involved in the production of the book.

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Regulatory RNAs

Basics, Methods and Applications

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