METHODS IN MOLECULAR BIOLOGY

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Targeted Drug Delivery

Methods and Protocols

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Preface

Our species has long recognized that *where* and *how* a drug is applied to the body will alter its biological potency. Inhalation of nicotine produces mild and transient euphoria; ingestion of the same substance is lethal. An antibiotic washed over the surface of the skin may become ineffective quickly; the same substance administered as a systemic therapy, or released slowly from a carefully prepared topical bandage, can halt a life-threatening infection.

Modern approaches to drug delivery originated in a happenstance experiment performed by the great angiogenesis researcher Judah Folkman. While utilizing Silastic® (silicone rubber) tubing as an arterio-venous shunt in rabbits, Folkman and colleagues noticed that exposing the external surface of the tubing to anesthetic gases produced sedation [1]. Perhaps most significantly, the silastic tubing could be implanted, and altering the thickness of the tubing changed the rate at which molecules were transported through the material. Several years later, a scientist by the name of Robert Langer would conduct postdoctoral research in Folkman's laboratory. In 1976, Folkman and Langer published the first report utilizing polymeric biomaterials to deliver and control the action of macromolecules [2]. Thus the field of drug delivery was born.

From these basic beginnings, drug delivery has become an essential consideration in fields ranging from oncology to infectious disease, endocrinology, and reproductive medicine. Drug-loaded biomaterials are integrated into many kinds of medical practice, with the greatest clinical successes observed for implants and coatings that locally release their active agents. More recent innovations highlight the potential of miniaturizing these biomaterials to serve as circulating or mobile carriers for active agents. Our challenge as scientists invested in the field of nanocarrier drug delivery has become even greater and focused across an even smaller length scale: can we design therapeutic approaches that will redirect drug distribution to target tissue and cellular compartments? Such targeting will enhance drug potency to treat disease while reducing systemic exposure and toxicity.

In this volume on *Targeted Drug Delivery*, we will address important methods that enable therapeutic molecules to be targeted for site-specific delivery. In Part I, we will describe approaches to formulate biologically derived and synthetic nanocarriers. Part II will overview diverse strategies to facilitate nanocarrier targeting to specific cells and tissues. In Part III, we will cover select methods for evaluating delivery and efficacy of these new classes of agents.

As is often observed in the field of bioengineering, these methods will integrate chemistry, physics, and biology to solve important medical problems. It is our hope that this volume will serve as a valuable resource to understand the diversity of scientific methods available to achieve targeted drug delivery.

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References

1. Folkman J, Long DM (1964) The use of silicone rubber as a carrier for prolonged drug therapy. J Surg Res 4(3):139–142
2. Langer R, Folkman J (1976) Polymers for the sustained release of proteins and other macromolecules. Nature 263:797–800

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