The Chemistry of Molecular Imaging

Despite advances in biomedicine, particularly in diagnosis and therapy, cancer and neurodegenerative and cardiovascular disorders still have a significant impact on human health, and are the leading causes of mortality and morbidity in developed countries. This situation has generated the need for worldwide multidisciplinary research to understand the mechanisms underlying the onset and progression of these diseases, to identify pathogenic biomarkers, and to develop methodologies for early diagnosis, as well as targeted and individualized therapeutic regimens. Within this framework, molecular imaging—the real-time in vivo visualization of biochemical processes—has become an indispensable tool in research and medical practice, and is now a key aspect of health and life sciences. Several imaging modalities are regularly applied in the clinical environment, and their success is strongly dependent on the continuing improvements in equipment and signal processing, and on the availability of effective imaging probes. The specificity, selectivity, and sensitivity of such probes are critical factors in molecular imaging, as success depends on their specific delivery to achieve contrast of the target of interest relative to the background. Such probes can be designed for one particular imaging method, but their efficiency can be improved by providing additional imaging tags, which are detected by more than one imaging modality, leading to multimodal probes. The design of the probes is a complex and multidisciplinary task based on innovative chemistry, bioconjugation, radiochemistry, radiopharmacy, solid phase peptide syntheses, phage display, and knowledge of molecular and cellular biology.

This book, which contains 16 chapters, provides an introduction to the imaging techniques regularly used for diagnosis, reviews the chemistry supporting each modality, and shows its importance for the evolution of molecular imaging. Chapter 1 reviews the most common imaging modalities in clinical use, discusses their basic principles, advantages, disadvantages, and complementarity, and shows how imaging technology has made it possible to develop multimodal imaging methods. Chemical and biochemical conjugation strategies to synthesize imaging tools, based on small molecules, macromolecules, or nano-platforms, are described in Chapter 2. The chemical approaches used to label small or large biomolecules with the short half-life PET isotopes ^{18}F, ^{11}C, ^{13}N, and ^{15}O are discussed in Chapters 3 and 4. The importance of technology that ensures the safe and reliable synthesis of such probes is also emphasized. Chapters 5–7 review and discuss the chemistry of the most relevant metal radioisotopes for PET, SPECT, and theranostics. Special attention is given to stability constants, kinetic inertness, and redox and hydrolysis properties. The chapters describe the radiopharmaceuticals in clinical use, and the chemistry performed with these radionuclides in the last two decades. Chapters 8–10 present an overview of the contribution of magnetic resonance techniques to diagnostic medicine, and review the basic concepts underlying the use of gadolinium, magnetic nanoparticles, and diamagnetic and paramagnetic CEST contrast agents for MRI. The latest research aimed at improving the effectiveness of these agents, with regard to targeting, sensitivity, and multimodality, is also discussed. Organic molecules, d- and f-block metal complexes, and nanoparticles for optical imaging are reviewed in Chapters 11–13. In Chapter 14, the application of micro-bubbles in ultrasound imaging and MRI is discussed and reviewed. As discussed in Chapter 1, the different imaging modalities used in the clinical environment have intrinsic advantages and limitations, such as differences in sensitivity, spatial and temporal resolution, tissue penetration, and costs. For improving efficiency, hybrid equipment has been developed, and efforts have been made to design molecular or nanosize multimodal probes based on small molecules, peptides, or antibodies. These studies are reviewed and discussed in Chapters 15 and 16.

In summary, this book gives the reader a wide-ranging view of the hot topic of molecular imaging. All the chapters have been written by well-known scientists and experts in their respective fields, and the chemistry discussed is not confined to the authors' own work but also covers work by other scientists. Slight general criticism concerns that for some of the imaging modalities discussed in the book a significant number of probes are now in clinical practice, so it would have been interesting to include in those chapters some images obtained with such probes. Furthermore, not all the chapters have a list of abbreviations.

The book is well produced, is easy to read, and clearly shows the importance of chemistry for the evolution of molecular imaging. It is a valuable resource for organic and inorganic chemists, pharmacists, biochemists, and biologists who want to apply their knowledge to molecular imaging, and provides an inspiration for further studies.

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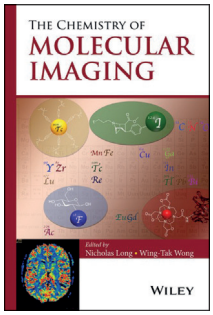

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