
Preface

The concept of spatially localized nuclear magnetic resonance (now called magnetic resonance imaging or MRI) evolved in the early 1970s. Like many developments in science, these early suggestions were considered esoteric and it took almost a decade before industry recognized their diagnostic potential. Over the last two decades, MRI has matured into a versatile diagnostic imaging modality within radiology, and is accepted as the gold-standard in several areas by virtue of its exquisite anatomical depiction of soft tissue. The recent Nobel Prize in Physiology or Medicine was awarded to two scientists responsible for the development of nuclear magnetic resonance into an imaging technique. Not surprisingly, neither is a medical professional: Professor Paul Lauterbur is a chemist, and Professor (Sir) Peter Mansfield, a physicist. The applications of their work also extend well beyond the field of clinical diagnosis and into the realm of basic science, in particular biology.

A major strength of MRI is its sensitivity to a plethora of physiological factors. This makes MRI extraordinarily versatile, and provides a fertile ground for innovative academic research into novel applications. Coupled with technological advancements in basic hardware, it has led to an expanding role for MRI as an experimental tool. A unique attribute of MRI is its capacity for translation all the way from cellular suspensions to in vivo human studies. MRI is no longer considered only as a clinical diagnostic imaging modality, but also as a key tool in biological research. This is evidenced by the fact that all major academic universities currently have active basic science MRI facilities in addition to clinical research MRI centers. The major pharmaceutical companies have also invested in imaging divisions that include MRI.

The primary objective of *Magnetic Resonance Imaging: Methods and Biologic Applications* is to introduce MRI to biological scientists. Chapter 1 provides an overall introduction of MRI to a relative novice. Dr. Storey has taken a tremendous interest and spared no effort in putting this chapter together. The technical and mathematical details were kept to a minimum without compromising the description of the various concepts involved. The specific technical challenges that MRI faces when applied to microscopic resolutions are discussed in Chapter 2. Each of the succeeding chapters highlights unique attributes of MRI and introduces current works-in-progress in newly evolving areas of molecular and cellular imaging. Methodological details are provided where possible. We have focused on three major features of MRI and organized the chapters along these lines:

1. Exquisite anatomical detail.

Chapters 3 and 4 discuss the applications of MRI to developmental biology and mouse phenotyping. Chapter 5 illustrates the use of diffusion tensor imaging, a technique that is unique to MRI, for understanding fiber architecture and its relationship to brain function.

2. The ability to provide information regarding the “functional status” of tissue by using endogenous contrast mechanisms.

At least two endogenous contrast mechanisms have evolved for routine use in evaluating brain function based on regional blood flow. These are discussed in Chapters 6 and 7. The same mechanisms have also been applied to the kidney, as discussed in Chapter 8. Magnetic resonance spectroscopy also provides unique biochemical signatures that can be used to evaluate functional or physiological status of tissue, as discussed in Chapter 9. A major advantage of MRI is that it is noninvasive, allowing anatomical and physiological investigations of healthy subjects. Another important aspect of any diagnostic imaging modality is its ability to characterize pathophysiology. Chapters 10 and 11 discuss the application of MRI to neuropathology and tumor biology. Since drug development is intricately related to pathophysiology, there is major interest in the pharmaceutical industry in using imaging methods both for preclinical and clinical testing purposes. Chapter 12 illustrates the role of MRI within the pharmaceutical industry.

3. The ability to use exogenous contrast material to extract information regarding the spatial distribution, tissue function, metabolic activity, or monitoring of gene expression.

Exogenous contrast agents have become a key feature of diagnostic MRI, and it can be argued that the next revolution in MRI lies in the development of novel contrast materials. A notable milestone was the demonstration of hyperpolarized noble gas imaging, which has applications in functional assessment of the lung (Chapter 13). Recently, contrast materials have been developed for noninvasive evaluation of tissue pH (Chapter 14). Manganese-enhanced MRI (MEMRI) has also been shown to provide a unique probe of physiology and pathophysiology and is discussed in Chapter 15. This is one of the few chapters in this book that follow the customary Methods for Molecular Medicine protocols format.

In the last five years, terms such as molecular and cellular imaging have entered the vocabulary. This refers not to imaging of individual molecules (which is beyond the resolution of NMR), but to imaging of such processes as metabolic activity or gene expression that occur on a molecular level. Chapters 16 and 17 discuss the concepts of targeted contrast agents and “molecular switches.” Finally Chapter 18 provides a hands-on approach to cellular labeling using superparamagnetic iron oxide contrast agents.

Though the initial intent was that *Magnetic Resonance Imaging: Methods and Biologic Applications* be directed towards biological scientists who may

wish to use MRI as a tool in their own research, it became apparent as the contents evolved that even MRI specialists may find the book useful for its methods-oriented chapters. As evidenced by the author list, MRI research involves scientists of very different educational and professional backgrounds. The field is now sufficiently mature that no single MRI scientist or expert can be familiar with all aspects of imaging applications, and it is hoped that each reader may find some aspects of this book useful.

I would like to take this opportunity to thank the entire group of outstanding authors for their valued contributions, as well as my family for their patience and understanding during the course of this project.

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