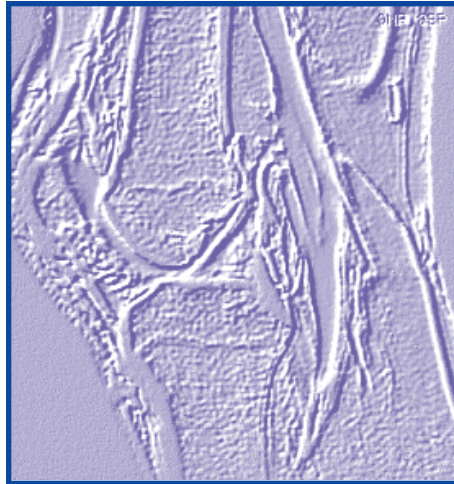


The Job Future for MRI Physicists

by Wlad T. Sobol

In the past two decades, the role for physicists in magnetic resonance imaging (MRI) grew from experimental to expansive, but it is decelerating. Let's face it, narrow subspecialties in any field are vulnerable to the vagaries of the marketplace. So what's an MRI specialist

Demand for MRI expertise is rapidly shifting from R&D to applications and clinical support



to do, now that the market has slowed? The basic strategy is to diversify—but before I discuss specifics, let me review the brief history of MRI physics.

In 1983, the Food and Drug Administration approved MRI scanners for sale in the United States, which spawned the commercial MRI market. During the mid-1980s, the explosively growing market produced a new specialty—the MRI scientist. That new profession attracted people with various backgrounds, including biochemistry, chemistry, computer science, engineering, and physics. Members of that mixed group soon learned that they needed a good understanding of the physical mechanisms underlying MRI, and some had to learn them quickly.

Soon, the specialty became the MRI physicist—someone with a broad background in nuclear magnetic resonance (NMR) physics, biophysics, and medical physics, as well as proficiency in basic medical sciences including human anatomy, physiology, and pathology. In addition, an MRI physicist must possess a good understanding of relevant engineering issues, including familiarity with advanced hardware (such as large superconducting magnets), high-power radio frequencies, fast digital data acquisition and processing, and remote sensing and control. Moreover, an MRI physicist must exhibit excellent computer skills, because the profession requires an in-depth understanding of such issues as control systems with real-time telemetry feed-

back, array processors, multitasking operating systems, and distributed processing. Programming skills are necessary because MRI systems use specialized software that includes custom hardware drivers, fast conversion of analog signals into digital data, and image processing. The industry is moving away from proprietary (or closed) minicomputer architectures and toward open systems, with C as a dominant programming language.

Wide-ranging roles

MRI physics offers various employment opportunities. An industrial MRI physicist can work in an R&D laboratory, where assigned tasks include implementing new applications and providing support for installed equipment. For instance, an industrial MRI physicist may participate in the development of specialized equipment, including coils that generate an image of a specific location, such as a knee or a wrist. In addition, such a physicist may work in repair and service environments to develop equipment-troubleshooting methods. Outside the industry, an MRI physicist can work in a university laboratory. Projects there consist of basic research in new areas such as MRI spectroscopy, functional imaging, or echo-planar imaging. An MRI physicist can also work for a health-care provider—usually at a major medical center—and participate in clinical research and teaching.

In the mid-1980s, the “MRI rush” created a plethora of opportunities for specialists in the field. Both industrial and medical professionals were laboring to improve technology and struggling to develop markets. To remain competitive, vendors needed specialists capable of quickly developing MRI technology.

Research dollars fueled the rapid commercial growth. The federal government—mostly the National Institutes of Health—provided generous funding to underwrite a large part of the cost associated with MRI-technology development. The medical community, which at that time operated fully in a fee-for-service environment, quickly identified the high revenue potential of MRI services and responded by purchasing systems in large numbers. Moreover, MRI users needed assistance in developing revenue-generating applications that incorporated the new technology. So generous funding was available from many sources—government, corporate, and private sectors of the economy, as well as in-house resources. During the early growth days, in fact, the motivation for quick learning proved so strong that some observers were saying, “If you know how to pro-

MRI sections of the head provided by the Hospital of the University of Pennsylvania, Department of Radiology, Philadelphia.

gram an MRI machine, you can practically write your own salary ticket.”

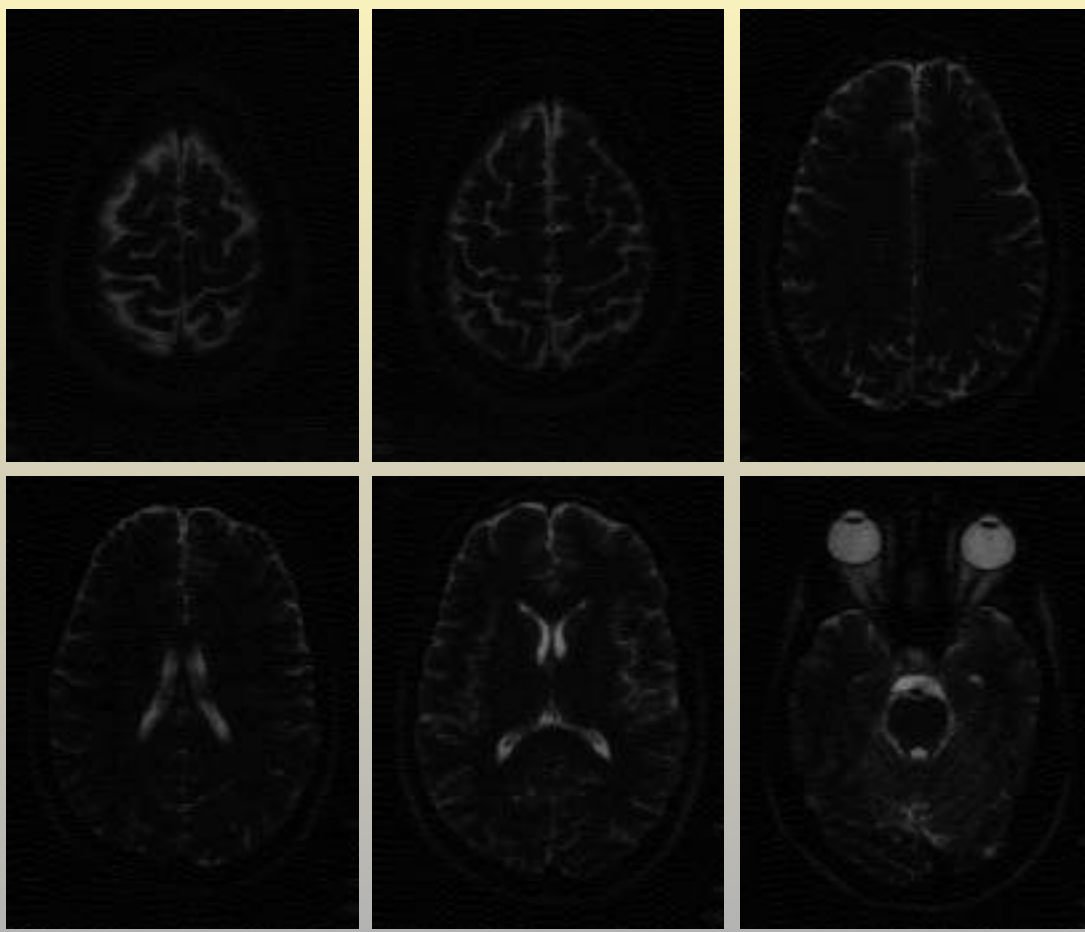
Bubble bursts

In the 1990s, however, things started to change. As it turned out, the MRI market entered its late growth phase precisely at the time when the health-care industry experienced turmoil triggered by the national debate about health-care reform. The U.S. MRI market—the revenue from equipment sales, service contracts, software upgrades, and so on—peaked at over \$1 billion in 1992, and then the market

plunged to about \$600 million by 1994, with less than \$400 million in sales of new units. Sales increased slightly in 1995 by focusing on the replacement market and accessories such as specialty coils.

Currently, the job market for MRI physicists appears

oversaturated. The 1995 membership of the Society of Magnetic Resonance, which accounts for the vast majority of MRI professionals, included 3,000 North American members. By conservative estimates—ones that exclude MRI clinicians, students, and technolo-



How MRI works

Magnetic resonance imaging (MRI) generates cross-sectional images of the human body by using nuclear magnetic resonance (NMR). The process begins with positioning the imaged body (a) in a strong, uniform magnetic field, which polarizes the nuclear magnetic moments of water protons by forcing their spins into one of two possible orientations (b). Then an appropriately polarized radio-frequency field, applied at resonant frequency, forces spin transitions between orientations (c). Those transitions create a signal (d)

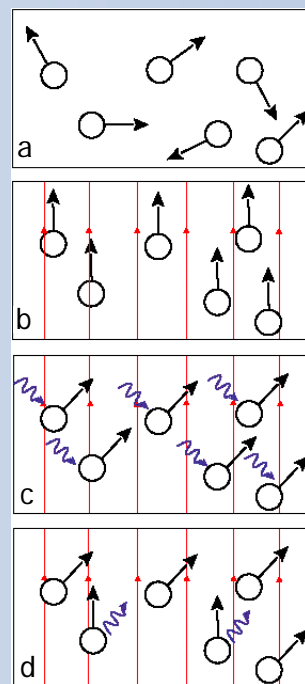
(which is an NMR phenomenon) that can be detected by a receiving coil.

An MRI scanner applies the radio-frequency field as finely crafted pulses, which excite only protons whose resonant frequencies fall within a fairly narrow range. Applying magnetic-field gradients during the radio-frequency pulse creates resonant conditions for only the protons that are located in a thin, predetermined slice of the body. Orientation and thickness of this slice can be selected arbitrarily in the imaged body. The NMR signal encodes positional information across the slice by using a method known as the “spin warp,” and a two-dimensional Fourier Transform extracts that positional

information. The process creates a data matrix in which each element represents an NMR signal from a single, localized volume element, or voxel, within the imaged slice. A two-dimensional display of this matrix’s contents creates a human-readable image of the selected slice. Each image element, or pixel, represents the NMR signal strength that was recorded for its corresponding voxel.

An MRI image provides unmatched soft-tissue contrast. When compared with other medical-imaging techniques, MRI provides several significant advantages: noninvasiveness, safety (because it uses non-ionizing radiation), and superb soft-tissue contrast,

generated by an NMR signal’s sensitivity to tissue morphology and pathology.



gists—about 1,500 MRI physicists live in the United States. Moreover, the American Association of Physicists in Medicine estimates that it takes ten MRI units to generate one full-time job for a clinical MRI physicist. So the roughly 4,000 clinical MRI units in the United States will support about 400 full-time MRI physicists. The remaining 1,100 MRI physicists must rely heavily on research funding. Government funding for MRI-related projects has decreased in recent years, and industry has responded to market conditions by drastically reducing R&D programs.

What does the future hold for MRI physicists? As for other highly but narrowly trained professionals, the biggest concern should always be marketability—focusing on recognition, adaptability, and diversification. Professional recognition, the first step toward ensuring a specialty's well-being, consists of two elements: a definition of a qualified expert in the field and a qualification process. For example, the American Society of Radiological Technologists has already recognized these issues and quite recently has started offering registry examination in MRI.

Clinical and other tasks

An MRI physicist needs adaptability, especially with the demand for MRI expertise shifting rapidly from R&D to applications and clinical support. In the clinical arena, an MRI physicist may work on optimizing protocols and improving patient throughput. Other tasks include involvement in sales and marketing (pre-sale support, bid development and evaluation, facility planning, and site preparation), participation in service activities (acceptance testing, quality assurance, evaluation of service contracts, and cooperation with service providers), and teaching (training radiology residents and technologists, as well as involvement in continuing medical education programs for physicians).

MRI physicists also need adaptability to broaden the scope of their clinical responsibilities and to improve their public-relations skills. These skills would be particularly valuable now, when the American College of Radiology is designing a voluntary MRI-accreditation program for clinical sites. Although it remains unclear how MRI


physicists will be involved in this program, they should make an effort to develop a strong role.

For MRI physicists, the time has come to adapt—to learn the language of physicians, administrators, accountants, architects, lawyers, managers, and technologists. MRI physicists must start cultivating a working relationship with the diverse professionals who are involved in today's health care, thereby building a mutual understanding with them. Ideally, today's practical physicist should have the ability to make this technology comprehensible to the people who need it.

Combine skills

As described above, narrowly focused subspecialties of physics live and die with shifts in market conditions and the political mood. So MRI physicists should diversify by combining narrow professional skills with proficiency in tasks that traditionally have been considered to lie outside a physicist's domain. For example, a physicist could collaborate with architects and contractors, and the results might save thousands of dollars in unnecessary costs.

In collaboration with subcontractors, a physicist might generate substantial savings by streamlining a process of design and construction of highly specialized structures, including magnetic and radio-frequency shielding, fire-protection installations, and communications equipment and networks. In financial matters, an MRI specialist's involvement in the bid process—starting with bid specification, evaluation of vendor responses, and advice to the decisionmakers—may well produce measurable monetary savings.

In medieval Europe, skilled craftsmen worked quietly in their shops, waiting for customers. In those days, people considered it in bad taste to market one's services. In today's world, a successful MRI physicist must communicate well, work well with others, see the big picture, and be able to facilitate consensus opinions. Those who do not learn lessons from the past are bound to suffer. 

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