# A window into the brain

By Shirleen Holt | Photos by Jerome Hart


Reprinted from *Providence Together* Fall/Winter 2009

PROVIDENCE Health & Services


ABOVE: Daniel Rohrer, M.D., and Pankaj Gore, M.D., are co-medical directors of Providence Cranial Services. RIGHT: The iMRI, housed in a diagnostic bay next door, glides into the operating room through thick stainless steel doors. The air must be "scrubbed" before the doors open to keep the operating room sterile. Once the magnet arrives, the door closes with a vacuum seal.

# A window into the brain

Providence Brain Institute's movable MRI fills a long-standing void: getting precise images of the brain during surgery.

BY SHIRLEEN HOLT
PHOTOS BY PETE STONE

Few procedures are as delicate as brain surgery. Remove too little of a tumor, and it's more likely to grow back. Remove too much, and you risk damaging vital parts of the brain that control speech or movement.

Medical technology has become more sophisticated over the years, refining surgical accuracy to the width of a pin. Yet even today's advanced equipment has its limitations. Take magnetic resonance imaging, or MRI. For three decades this groundbreaking device, which can take pictures of soft tissue inside the body, has helped doctors see the size, shape and location of various tumors and lesions, particularly those embedded deep within the brain.

Yet MRI scans are inexact aids for brain surgery. This is because the images are taken before surgery – before the patient is wheeled to the operating table, before the skull is gently opened, fluids drained and the brain relaxed so the surgeons can do their work. By then, the brain has shifted, and the landscape no longer matches the preoperative pictures.

A new, vastly improved machine is now helping surgeons pinpoint more precisely the location of diseased tissues. It's called a mobile intraoperative MRI, or iMRI, and it was installed at Providence St. Vincent Medical Center in June 2009. The iMRI magnet glides into the operating room as the patient lies stationary on the table. This allows doctors to take precise images before, after and equally important, during surgery without jostling the patient.

Funded through $5 million in private donations to Providence St. Vincent Medical Foundation, the iMRI is housed in a specially constructed operating suite. On one side is a traditional diagnostic bay. On the other is a space-age operating room featuring an advanced surgical navigation system with 3-D visualization, and digital displays for brain scans, live video and data, including real-time pathology reports. It's the most technologically advanced operating suite on the West Coast, and one of fewer than 20 worldwide.

Reports from hospitals using this iMRI system show the clear benefit to patients. More than 30 percent of the time, doctors who took images during surgery found more tumor to remove, which decreased the need for a second or even a third operation. The more tumor that's removed, the better the outcome for the patient.

Such findings, coupled with his own experience, prompted Daniel Rohrer, M.D., co-medical director of Providence Cranial Services at Providence Brain Institute, to champion iMRI technology for Providence. He helped guide the project from inception to installation, a two-year process that involved dozens of supporters, from hospital administrators to medical staff to donors.

Behind the philanthropy, the construction and the endless details involved in a project of this size is something more enduring: the imaginative and inquisitive minds that bring ideas to life.

### Getting the tumor out the first time

Growing up in Pelham, N.Y., Dr. Rohrer had a fondness for beater cars, including his first: a 1965 Valiant convertible he called "The Prince." He would lift the hood, diagnose the problem, and carefully repair the insides until he got the machine humming.

"I was always very hands-on," he says.

It was that tendency that caused Dr. Rohrer, the son of an engineering and architectural controller, to switch disciplines in college from chemistry and biology (where he was likely the only student fluent in Latin) to neurosciences, which he studied at the University of Rochester.

"The M.D.s really liked teaching hands-on undergrads," he says. "They were really into what they were doing and they wanted to share it." Dr. Rohrer went on to do medical research, and his discoveries on the use of cell therapy to treat neurodegenerative disorders were published in major academic journals. Even as a researcher, however, he was designing new surgical procedures and better instrumentation.

As he developed expertise in cranial surgery, Gamma Knife radiosurgery and minimally invasive techniques, he also studied new technologies that would improve the outcomes of these surgeries. In particular, technology that could confirm that as much tumor as possible was removed in a given surgery. This is harder than it seems. While some tumors are evident by look or touch, there are times when it's hard to distinguish the margins of diseased tissue from the healthy folds of the brain.

This was the case with an 18-year-old patient who had a large tumor near the brain stem. Despite operating from two angles, Dr. Rohrer had discovered in postoperative scans that too much tumor remained, making the planned second procedure more difficult. Had Dr. Rohrer been able to take an MRI scan during the first surgery, "we could have taken out more and made it a lot easier on the patient."

So when Canadian manufacturer IMRIS started to market an intraoperative MRI, Dr. Rohrer looked into it. He tapped retired mechanical engineer and kindred spirit William Reiersgaard, who serves as a trustee for Providence St. Vincent Medical Foundation.

Reiersgaard, former president of Gaard Automation, had developed robots for the aviation, automotive, high-technology and space industries. Reiersgaard's specialty was turning ideas into applications, and like Dr. Rohrer, he's a hands-on specialist with a curious mind.

"I can show you the scars on my hands where I put a drill through them trying to make something work," Reiersgaard says.

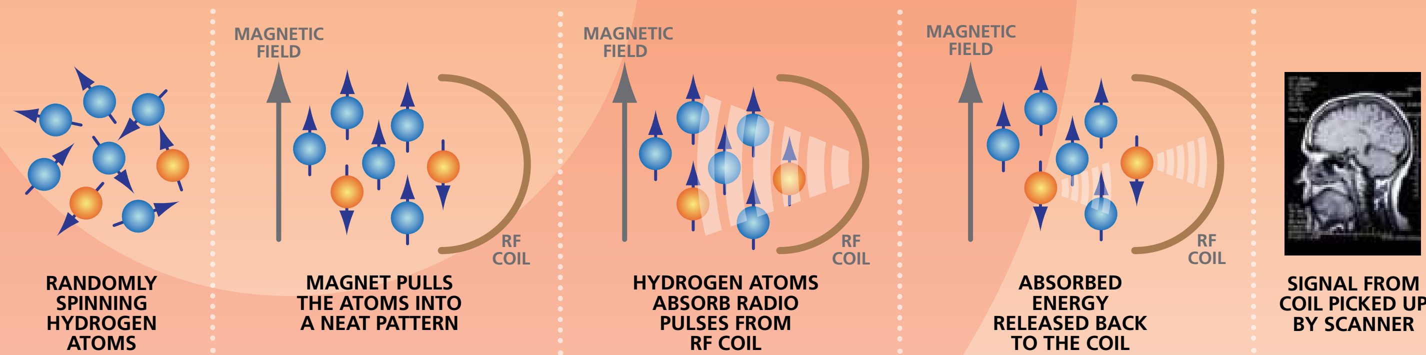
In 2007, Reiersgaard accompanied Dr. Rohrer and others from Providence on a trip to Winnipeg, Manitoba, to examine how an operating room could house both sophisticated navigational and surgical equipment

## How they built it

**RIGHT: How do you bring a magnet as heavy as an elephant into a hospital? An elevator was out of the question, so crews punched a hole into the side of Providence St. Vincent Medical Center's concrete exterior. Inside, they had to shore up the floor to support the magnet's 7.5 tons.**

**BELOW: Construction coordinator Ken Brooks, left, with Alex Jackson, associate administrator for Providence St. Vincent Medical Center. The entire iMRI suite – floors, walls, ceiling and pipes – is lined with copper to block outside radio waves from interfering with scans. The project required 1.15 million square inches of copper and 15,000 feet of solder.**

# How an MRI works




**Unlike refrigerator magnets that are made of alloys, magnetic resonance imaging uses a superconducting electromagnet. Electrical currents move through wire coils inside the magnet's cylinder while the machine's "umbilical cord" – tubes containing minus 452-degree liquid helium – freeze surrounding atomic particles. The purpose is to slow those particles to a fraction of the speed of a garden snail so they don't impede the electrons.**

**The MRI's magnetic field pulls the body's randomly spinning hydrogen atoms into a neat pattern, similar to the way metal shavings stand on end when a magnet is passed overhead.**

**To get an image, something called an "RF coil" – a sort of radio transceiver – is positioned beneath the patient. That coil emits harmless radiofrequency pulses (during which the machine makes a loud knocking) controlled by an MRI technologist in another room.**

**The body's molecules absorb the pulses. When the waves stop, the released energy emits a signal back to the coil that can be picked up by the scanner. Hydrogen nuclei in diseased tissue, such as tumors, return to equilibrium at a different rate than in healthy tissue. The resulting contrast allows doctors to pinpoint the size and location of lesions.**

SOURCE: NATIONAL HIGH MAGNETIC FIELD LABORATORY

and a magnet strong enough to suck a stray oxygen tank into its center.

"My questions were, 'Where have these been used? For how long? What are your safeguards?'" Reiersgaard recalls. "We went into great depth."

The trip satisfied both Dr. Rohrer and Reiersgaard that every detail was considered – from the magnetic fields marked on the floor to the vacuum-sealed door through which the magnet would travel.

In a later visit, Dr. Rohrer had his own head scanned. "I wanted to make sure the equipment worked well."

Dr. Rohrer envisioned the seamless integration of technologies all in one room. This includes an iMRI-compatible navigation system that provides three-dimensional images, helping surgeons to see around corners in the brain.

"The integration was a really big point for me. It's like opening a door and walking into a room," Dr. Rohrer says, "rather than standing outside the door and looking in from a distance."

## Drawing other curious minds

Pankaj Gore, M.D., co-medical director for Providence Cranial Services, was just 2 years old when MRI scans were first used in 1977. But at 34, he is one of the few neurosurgeons to have gained experience on an intraoperative MRI.

This was at Barrow Neurological Institute in Arizona, where Dr. Gore was serving a fellowship. That model had its limitations, however. The magnet was fixed, and housed right next to the operating room. To take images mid-surgery, the team often had to close the skull, gently move the patient to the machine for scans, and then bring the patient back to the operating room, where the skull would be reopened and the procedure resumed.

When he was pondering the next step in his career, the fact that Providence would have a movable iMRI made Portland more attractive. He joined Providence Brain Institute in 2008.

Recruiting talent is another valuable, if secondary, benefit of having next-generation medical technology. Dr. Gore has served three fellowships in brain and spine surgery, one of them in Australia under the leadership of Charles Teo, M.D., a motorcycle-riding iconoclast who has earned international fame (and generated some controversy) for treating tumors that other physicians deem inoperable.

At Barrow in Arizona, Dr. Gore studied with another noted neurosurgeon, Robert Spetzler, M.D., known for helping to develop the modern "cardiac standstill," a bold surgical technique in which the heart is stopped so surgeons can repair a life-threatening aneurysm.

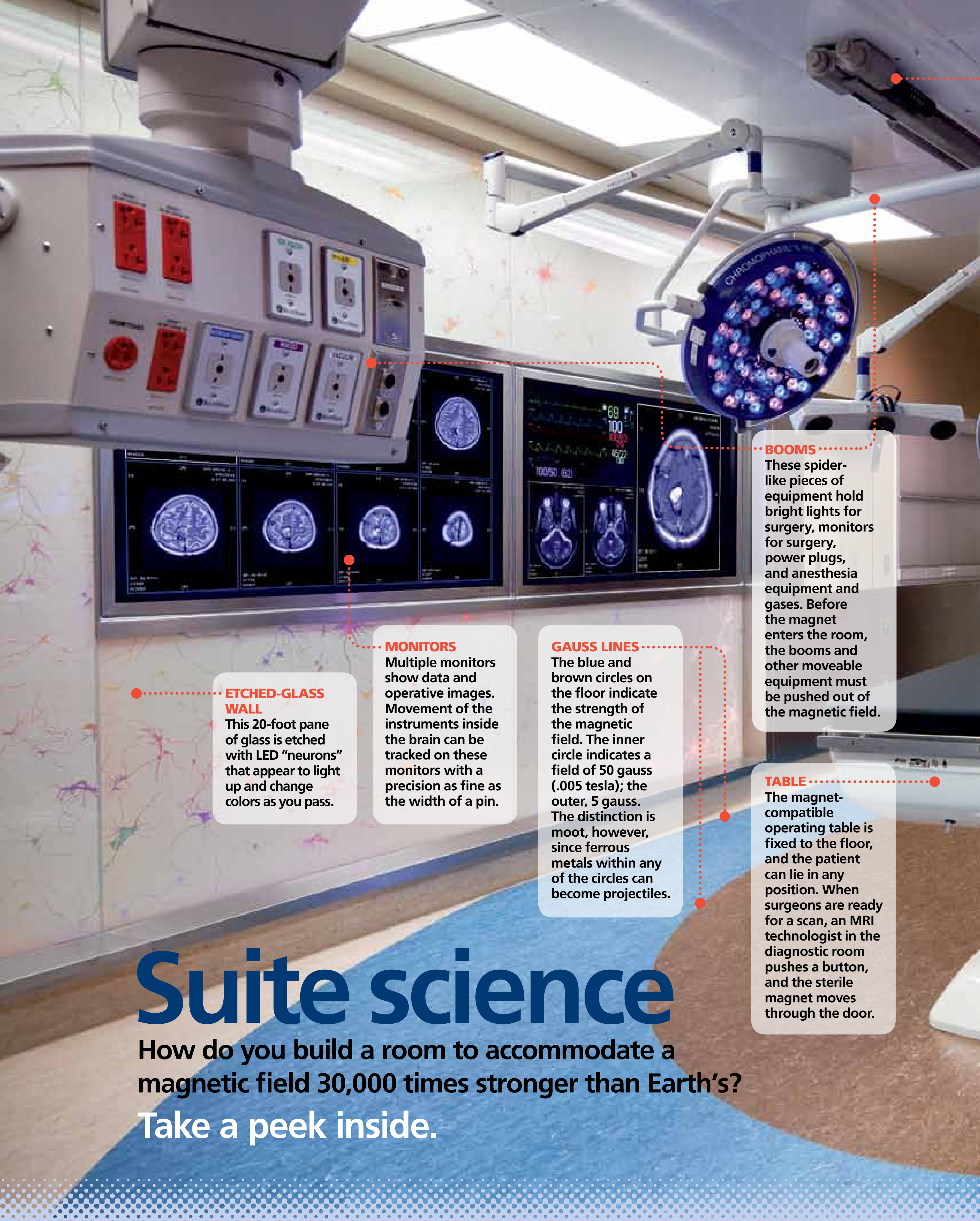
"The iMRI is state of the art now," Dr. Gore says, "but eventually this may become the standard of care. There's a role for it in epilepsy, Parkinson's disease, high-cervical spine surgery."

In the future it also may be used for treating conditions beyond the head and neck, such as MRI-guided cryotherapy for liver tumors (using extreme cold to destroy diseased tissue) or minimally invasive replacement of heart valves.

Patients are just now reaping the benefits of Providence's intraoperative MRI. Drs. Rohrer and Gore also are training area surgeons to use the equipment, regardless of their hospital affiliation. This makes the new technology even more important, not only for Oregonians but for people around the world.

Soon this "luminary site" will draw curious minds from up and down the West Coast as well as from Asia, Australia and Europe. These medical experts will come to learn about the technology at Providence, but it's likely their visits will allow Providence physicians to learn from them.

"That's the beauty of medicine," Dr. Gore says. "Even if you're an expert, you're still always learning." ■



# Suite science

## How do you build a room to accommodate a magnetic field 30,000 times stronger than Earth's?

## Take a peek inside.

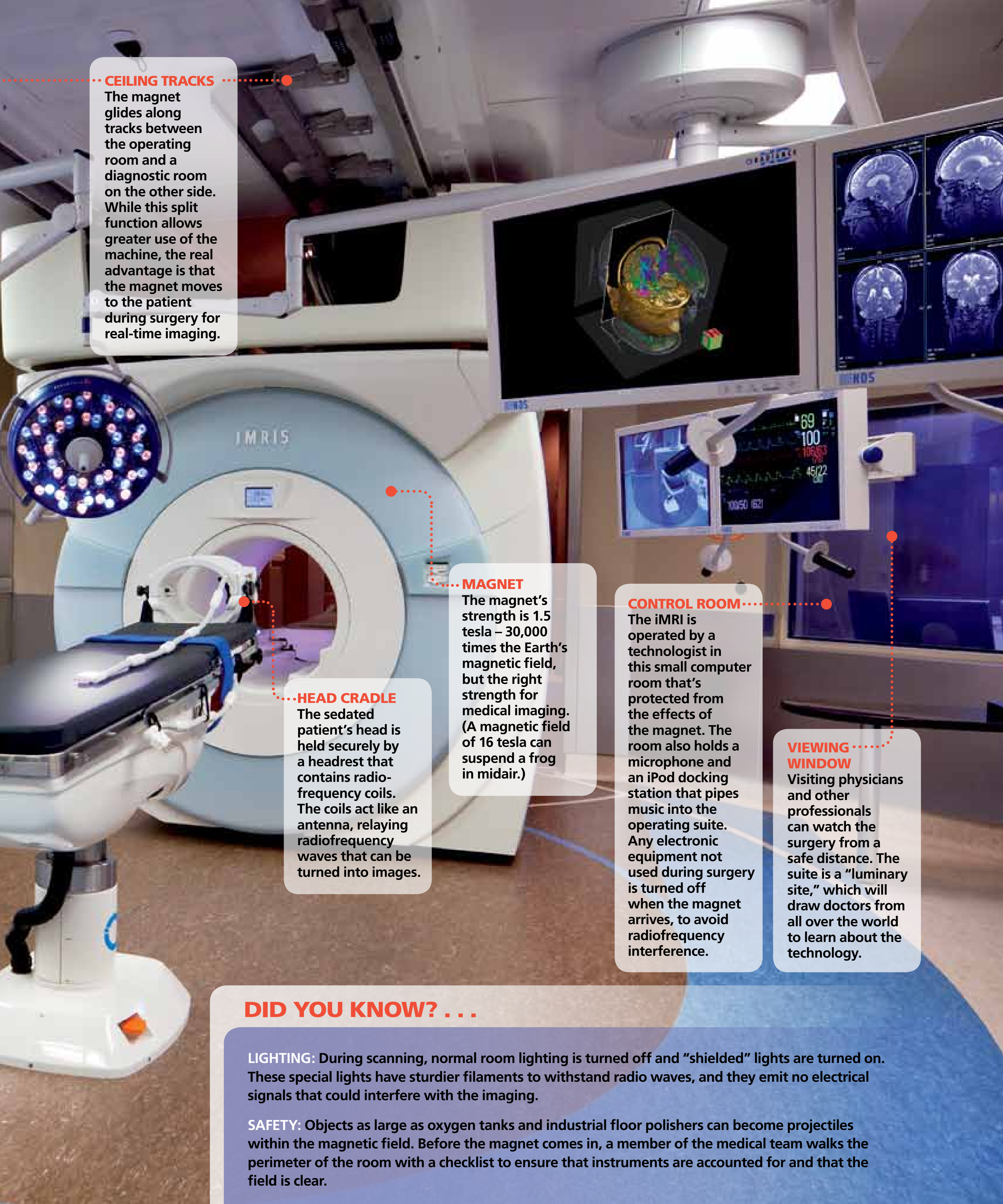
**ETCHED-GLASS WALL**
This 20-foot pane of glass is etched with LED "neurons" that appear to light up and change colors as you pass.

**MONITORS**
Multiple monitors show data and operative images. Movement of the instruments inside the brain can be tracked on these monitors with a precision as fine as the width of a pin.

**GAUSS LINES**
The blue and brown circles on the floor indicate the strength of the magnetic field. The inner circle indicates a field of 50 gauss (.005 tesla); the outer, 5 gauss. The distinction is moot, however, since ferrous metals within any of the circles can become projectiles.

**BOOMS**
These spider-like pieces of equipment hold bright lights for surgery, monitors for surgery, power plugs, and anesthesia equipment and gases. Before the magnet enters the room, the booms and other moveable equipment must be pushed out of the magnetic field.

**TABLE**
The magnet-compatible operating table is fixed to the floor, and the patient can lie in any position. When surgeons are ready for a scan, an MRI technologist in the diagnostic room pushes a button, and the sterile magnet moves through the door.




**CEILING TRACKS**
The magnet glides along tracks between the operating room and a diagnostic room on the other side. While this split function allows greater use of the machine, the real advantage is that the magnet moves to the patient during surgery for real-time imaging.

**MAGNET**
The magnet's strength is 1.5 tesla – 30,000 times the Earth's magnetic field, but the right strength for medical imaging. (A magnetic field of 16 tesla can suspend a frog in midair.)

**HEAD CRADLE**
The sedated patient's head is held securely by a headrest that contains radio-frequency coils. The coils act like an antenna, relaying radiofrequency waves that can be turned into images.

**CONTROL ROOM**
The iMRI is operated by a technologist in this small computer room that's protected from the effects of the magnet. The room also holds a microphone and an iPod docking station that pipes music into the operating suite. Any electronic equipment not used during surgery is turned off when the magnet arrives, to avoid radiofrequency interference.

**VIEWING WINDOW**
Visiting physicians and other professionals can watch the surgery from a safe distance. The suite is a "luminary site," which will draw doctors from all over the world to learn about the technology.

## DID YOU KNOW? . . .

**LIGHTING:** During scanning, normal room lighting is turned off and "shielded" lights are turned on. These special lights have sturdier filaments to withstand radio waves, and they emit no electrical signals that could interfere with the imaging.

**SAFETY:** Objects as large as oxygen tanks and industrial floor polishers can become projectiles within the magnetic field. Before the magnet comes in, a member of the medical team walks the perimeter of the room with a checklist to ensure that instruments are accounted for and that the field is clear.

**PATIENTS:** People with shrapnel, old aneurysm clips, pacemakers or other implanted devices made of ferrous metals are ineligible for MRI scans; however, the magnet can safely be used on people with dental work, stents or other non-magnetic implants.

## OUR MISSION

As people of Providence,
we reveal God's love for all,
especially the poor and vulnerable,
through our compassionate service.

## OUR CORE VALUES

Respect, Compassion, Justice,
Excellence, Stewardship

Providence
**together**

VOLUME 5, NUMBER 2 ▪ FALL**WINTER** 2009



**Providence Together** magazine is published twice yearly by Providence Health & Services in Oregon.

**Providence Together** magazine is produced by the Marketing and Communications and Public Affairs departments of Providence Health & Services. For permission to reprint articles or for more information, please call 503-574-9300.

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