

Magnetic Resonance Imaging (MRI)

- Founders
- History
- How does it work?
- Advantages/Disadvantages
- Fun Facts!



Felix Bloch (Harvard) and Edward Purcell (Stanford)

- Both discovered the magnetic resonance phenomenon independently in 1946
- Both awarded Nobel Prize in Physics 1952



Photos courtesy of nobelprize.org

Early Stages

- Originally based on Nuclear Magnetic Resonance (NMR) techniques
 - Decided to call it simply “Magnetic Resonance Imaging” due to the negative connotations associated with the word “nuclear” in the 1970’s
 - 1950-1970: NMR was developed and used for chemical and physical molecular analysis
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A Medical Turn

- 1971 - Raymond Damadian showed that the nuclear magnetic relaxation times of tissues and tumors differed
 - This motivated scientists to consider magnetic resonance for the detection of disease
 - 1973 - the x-ray-based computerized tomography (CT) was introduced by Hounsfield
 - This was important as it showed hospitals were willing to invest large amounts of money into medical imaging hardware
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Richard Ernst

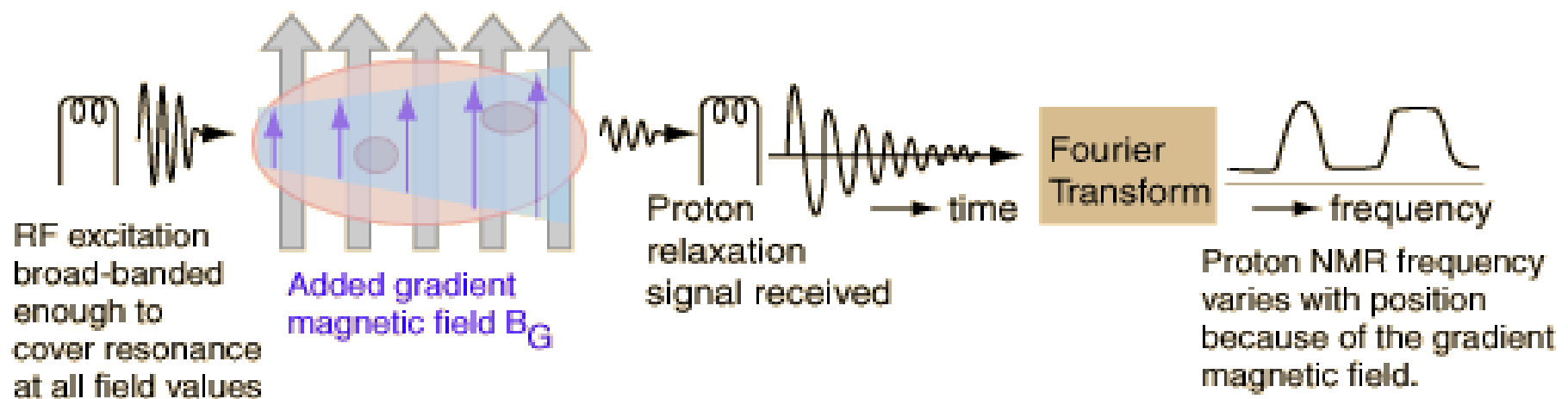
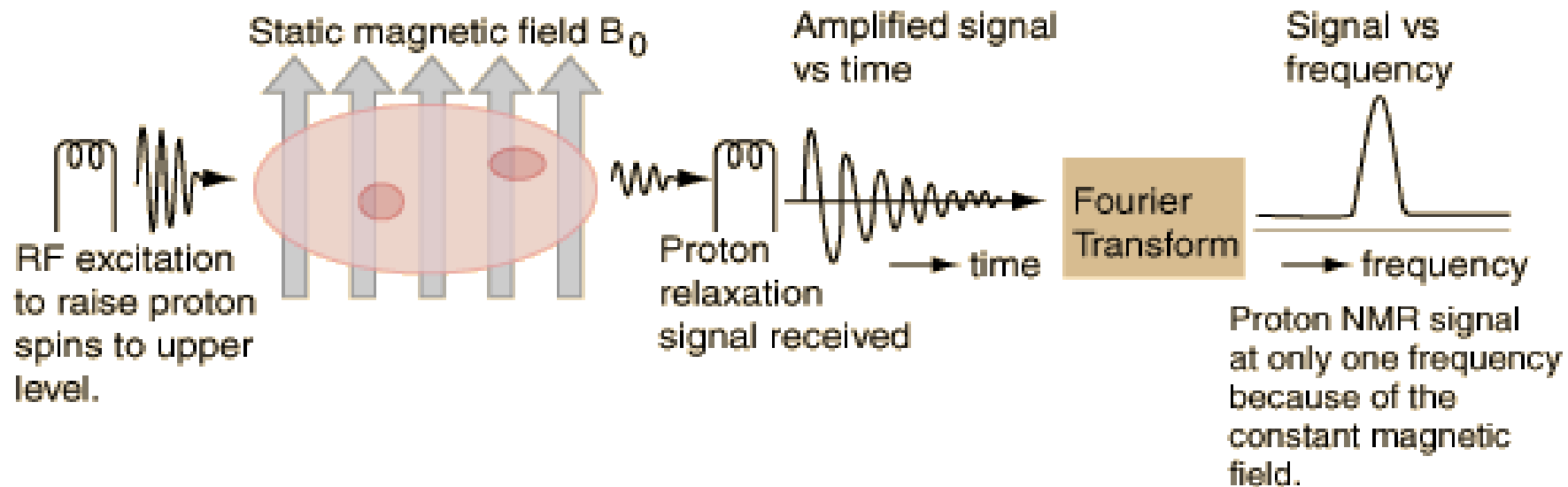
- 1975 - proposed magnetic resonance imaging using phase and frequency encoding, and the Fourier Transform
 - 1980 - Edelstein and coworkers demonstrated imaging of the body using Ernst's technique
 - Showed a single image could be acquired in approximately five minutes
 - 1986 - the imaging time reduced to about five seconds, without sacrificing too much image quality
 - 1991 - Nobel Prize in Chemistry for his achievements in pulsed Fourier Transform NMR and MRI
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How does it work???

- Popular science said that you can not image objects smaller than the wavelength of the energy being used to image
- MRI gets around this limitation by producing images based on spatial variations in the phase and frequency of the radio frequency energy being absorbed and emitted by the imaged object

What does this mean?

- The human body is approximately 63% hydrogen atoms
 - primarily fat and water which have many hydrogen atoms
 - Hydrogen nuclei will partially polarize with strong magnetic fields in either a stable or unstable way
 - Flipping of the proton or “exciting” it from one magnetic alignment to the other by the radio waves is known as the resonance condition
 - depends on having exactly the right combination of external magnetic field and radio frequency
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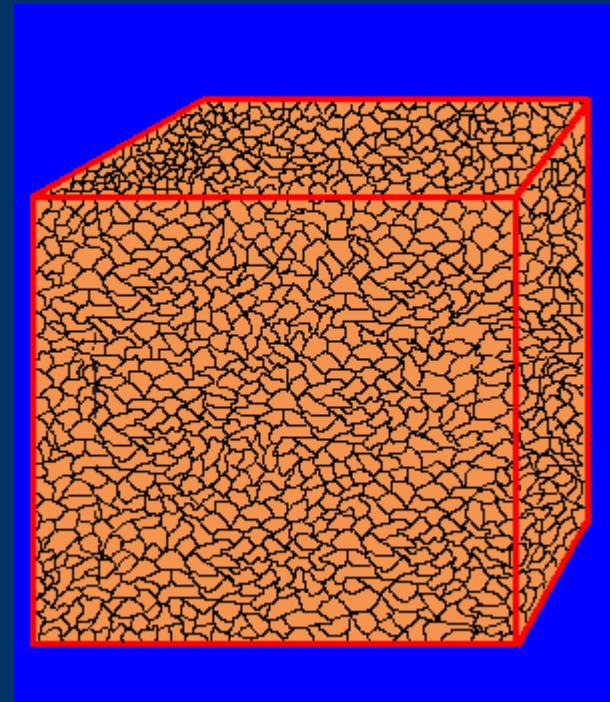
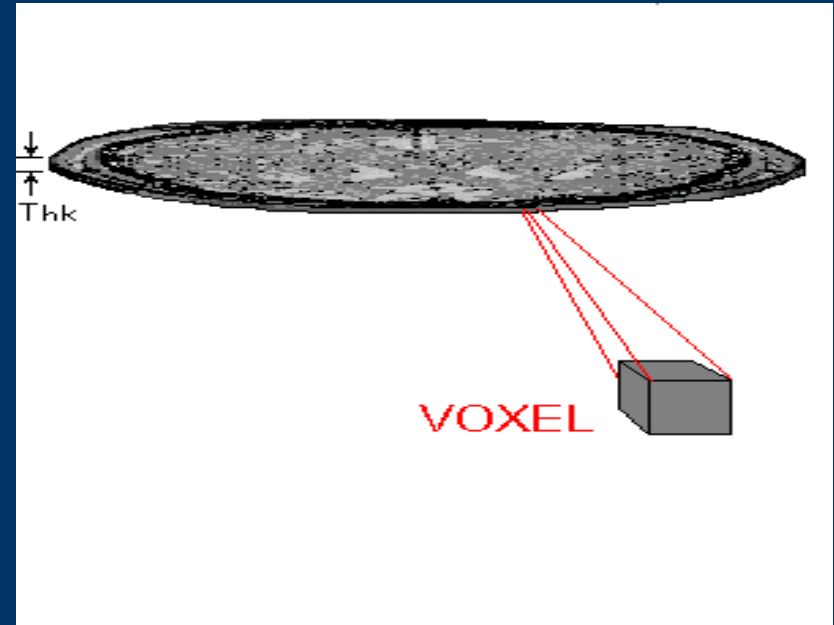
The First Machine

- 1977 - Doctors Lawrence Minkoff, Michael Goldsmith and Dr. Damadian went on to build the first MR scanner named “Indomitable”
- Has since found its way into the Smithsonian

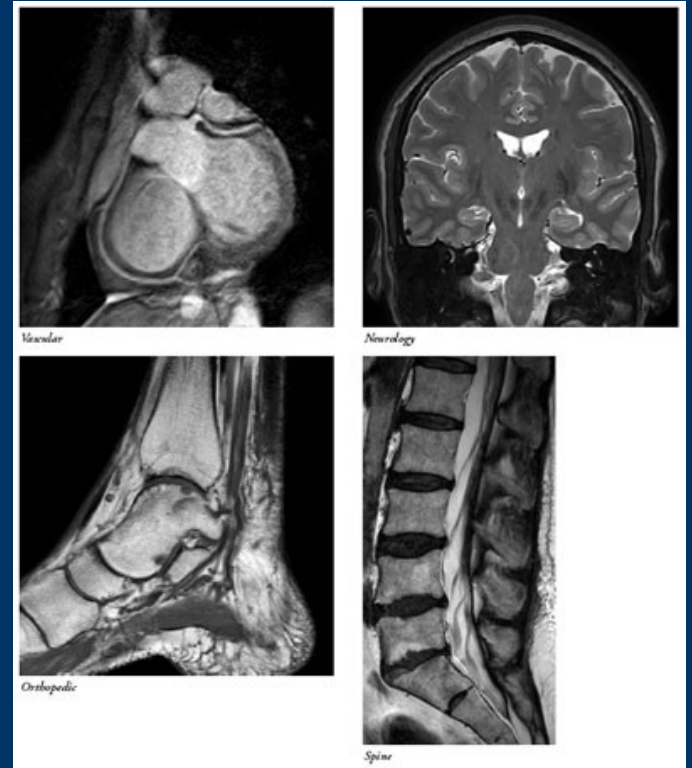


Output

- Each image is 2-dimensional of thickness (Thk)
- The volume of Thk is measured in Voxels
- Each Voxel is approximately 3mm^3 and contains one or more tissue types with many cells seen here

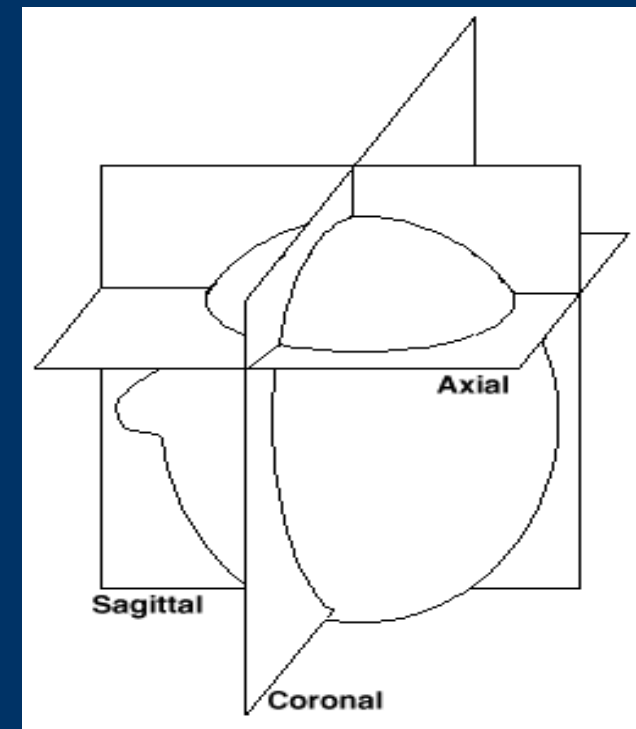
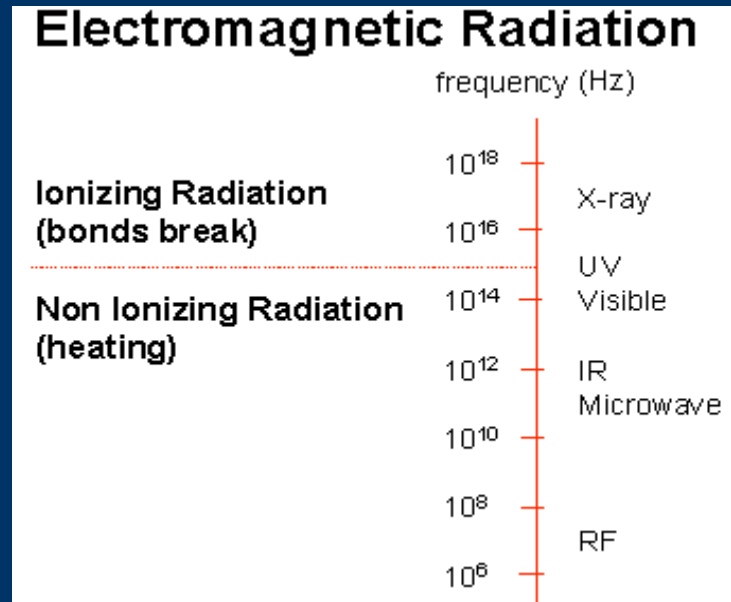


Examples of Images:



Advantages

- Radio Frequency extremely safe
- Images very detailed
 - Observe tissue or blood
 - Can be taken in any plane



Disadvantages

- Average cost \$1500 per scan, according to BCBSNC
- Metal objects present hazard as well as tattoos containing iron
- Claustrophobia
- Pacemakers
- Obesity
- Noise
- Importance of holding Still



More Fun Facts!

- In 2003, there were approximately 10,000 MRI units worldwide, and approximately 75 million MRI scans per year performed
 - FONAR has created open air standing and sitting machines making great advances in the study of scoliosis
 - Functional MRI (fMRI) can actually take video of blood flow in the brain
 - Used for many psychological studies
 - Used on monks serving under the Dalai Llama to study the control they exert over mental processes through meditation
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Resources

- *FONAR. 2003-2006. FONAR. 08 Feb. 2008* <
<http://www.fonar.com/history.htm>>
- *Gould, Todd. "How MRI Works." HowStuffWorks, Inc. 1998-2008. How Stuff Works, Inc. 7 Feb. 2008.* <
<http://www.howstuffworks.com/mri.htm>>
- *Hornak, Joseph P., Ph.D. "The Basics of MRI." J.P. Hornak. 1996-2007. Center for Imaging Science. 7 Feb. 2008.* <<http://www.cis.rit.edu/htbooks/mri/inside.htm>>

