

NMR...MRI? What's the Difference?

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Purpose: To inform the general public about the NMR and the MRI by unfolding the similarities of both machines, their techniques and contributions to society.

History: Nobel Prize

Isidor Rabi



- 1937: Discovered the NMR
- 1944: Awarded the Nobel Prize in Physics "for his resonance method for recording the magnetic properties of atomic nuclei"

Edward Purcell (left) and Felix Bloch (right)



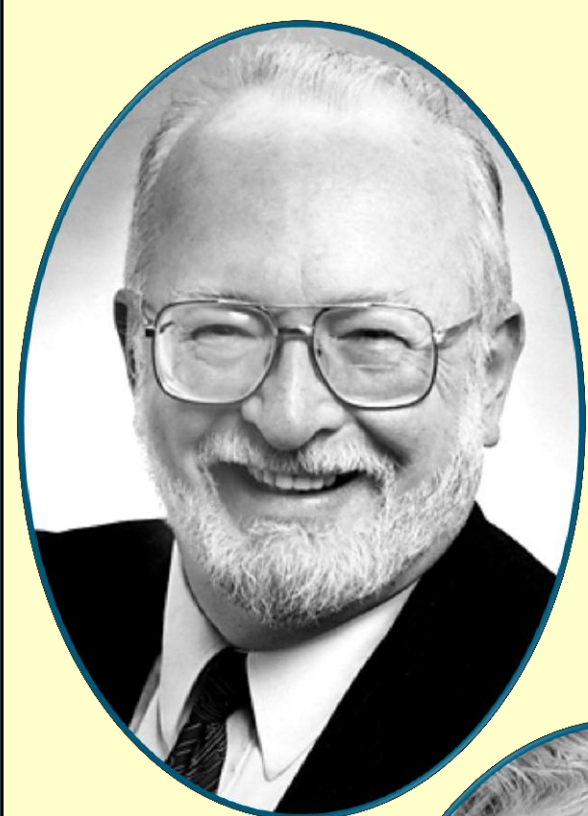
- After the end of WWII independently discovered the NMR
- 1952: Jointly received the Nobel Prize in Physics "for their development of new methods for nuclear magnetic precision measurements and discoveries in connection therewith"

Kurt Wüthrich



- 2002: Awarded the Nobel Prize in Chemistry "for his development of nuclear magnetic resonance spectroscopy for determining the three-dimensional structure of biological macromolecules in solution"

Paul C. Lauterbur (left) and Sir Peter Mansfield (right)



- 1976: NMR used to produce 2-D image
- 2003: received Nobel Prize in Medicine "for their discoveries concerning magnetic resonance"

NMR Spectroscopy:

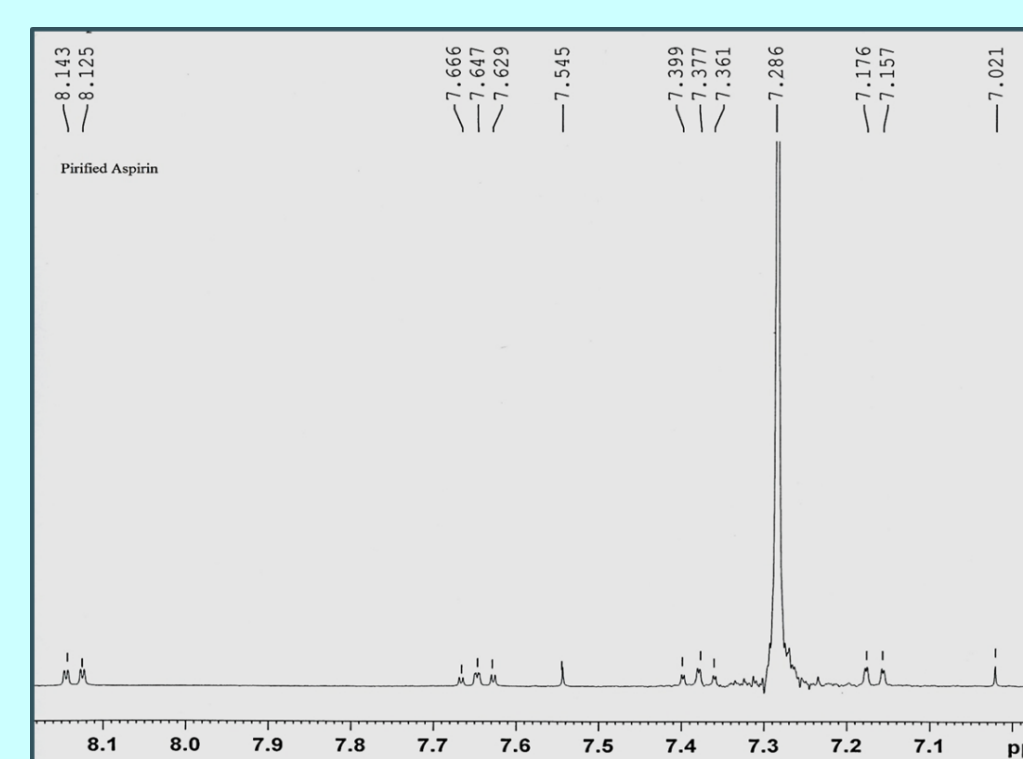


Figure 1: A Spectrum of an organic compound, acetylsalicylic acid commonly known as aspirin.



Figure 2: The NMR spectrometer at Marymount University

- Used as an analytical tool to obtain chemical structural information and formation of compounds
 - Ex: drugs
- Currently the only method by which high resolution biomolecular structures can be determined at atomic resolution
 - Proteins, RNA, DNA, sugars
- Significant in understanding molecular structural abnormalities which cause disorders
 - Ex: prion-based diseases
- Valuable tool in the pharmaceutical industry

MRI:



Figure 3: An MRI scanner

- Non-invasive method to examine the inside of the body, determining tissue or organ abnormalities
- MRI signals are based on nuclear-magnetism of hydrogen in water located in the human body
- The signals are converted and compiled into pixels with gray scale intensity
- Relaxation times in tissues vary, used to generate image contrast
- Diseases tissues have longer relaxation times

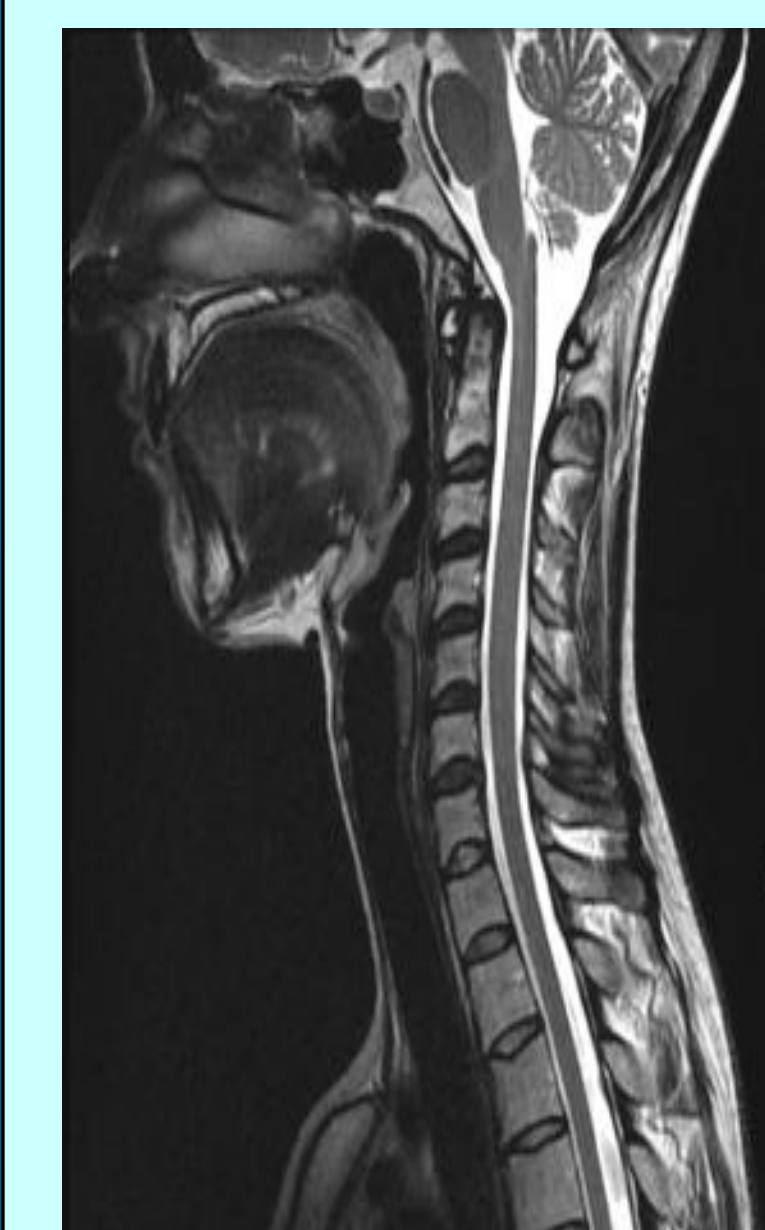
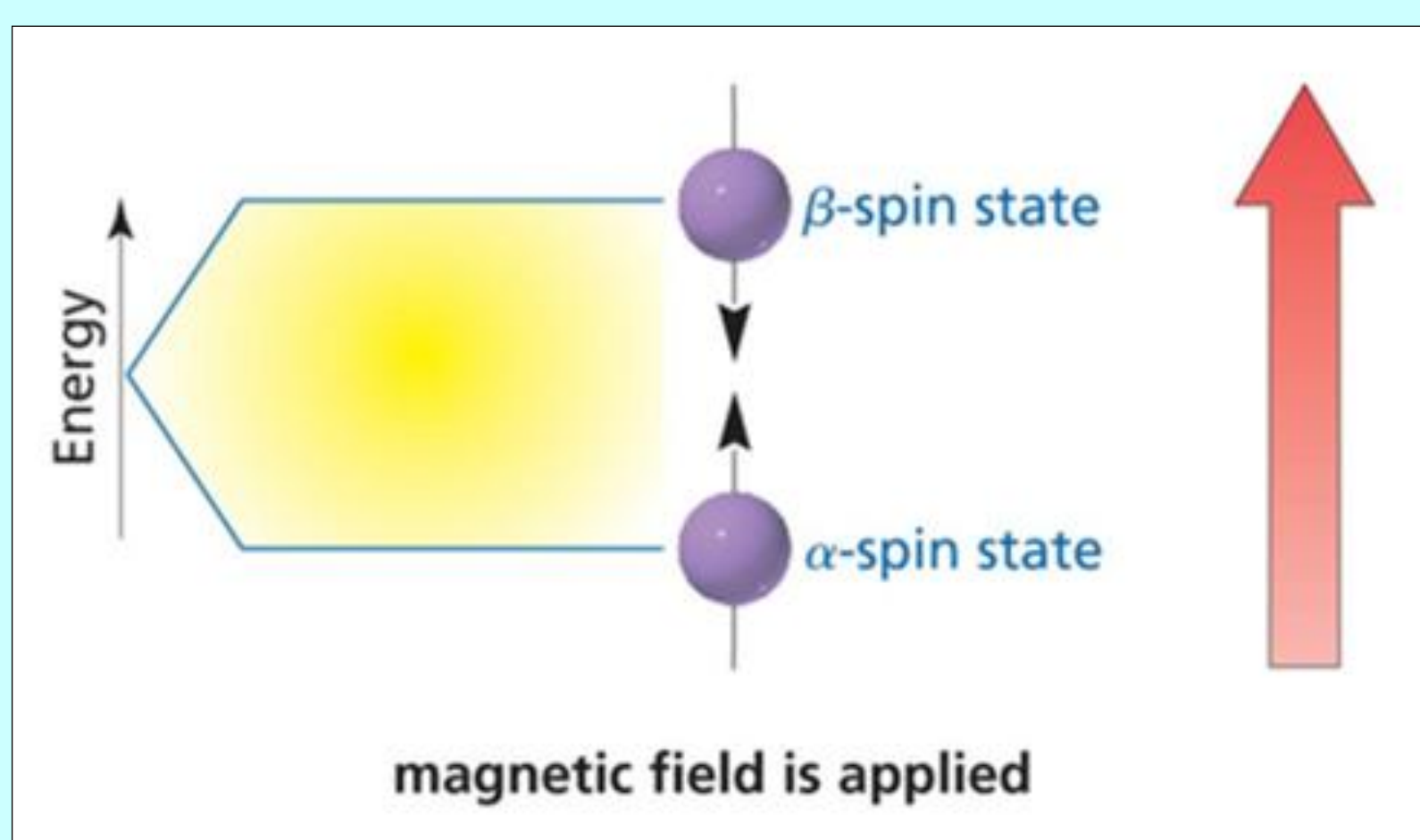
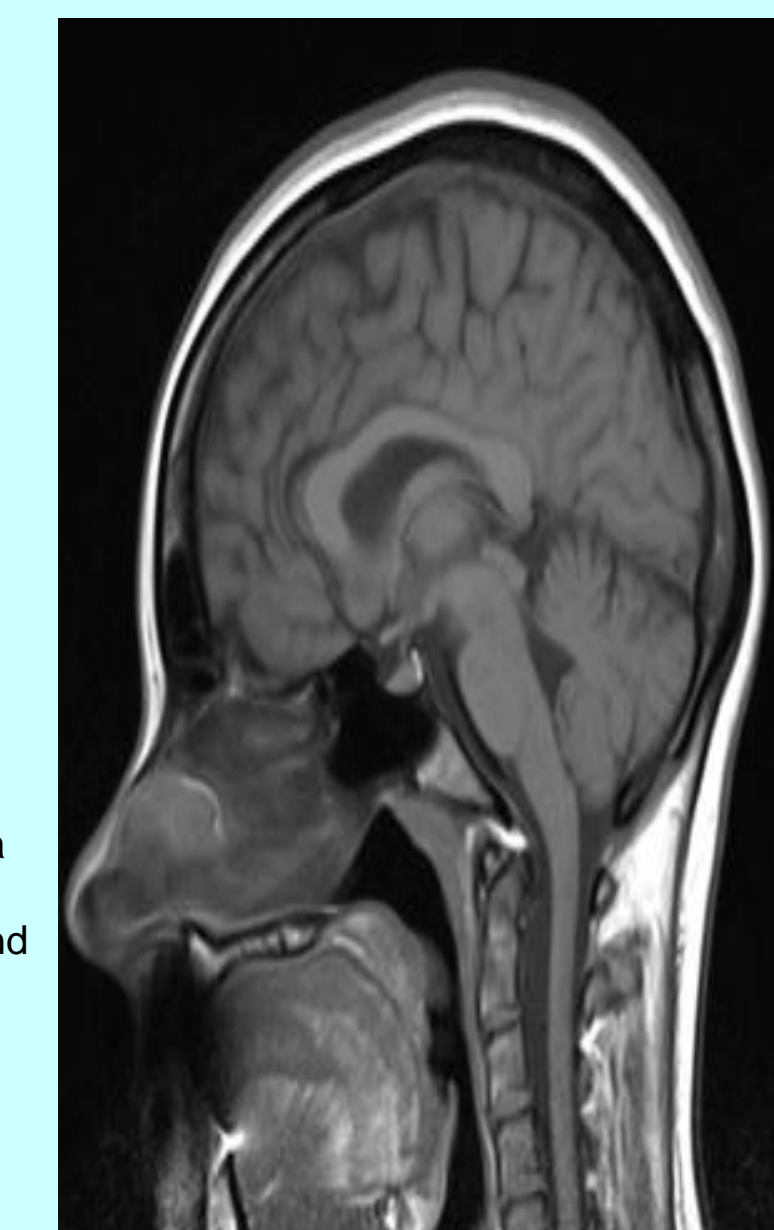


Figure 4-5: An MRI of a normal sagittal T2-cervical spine (right) and midline sagittal T1-weighted brain image (left)



- The nuclear spin generates a magnetic moment
- In the absence of a magnetic field, protons orientate randomly
- When an external magnetic field is applied protons assume α or β state
- Electromagnetic radiation and the right combination of magnetic field can flip the proton from α to β or β to α , known as resonance
- Absorption of energy is detected by the NMR Spectrometer
- Protons resume normal spin state known as relaxation
- T1 and T2 relaxation times are used for the MRI

Various kinds of electromagnetic radiation:

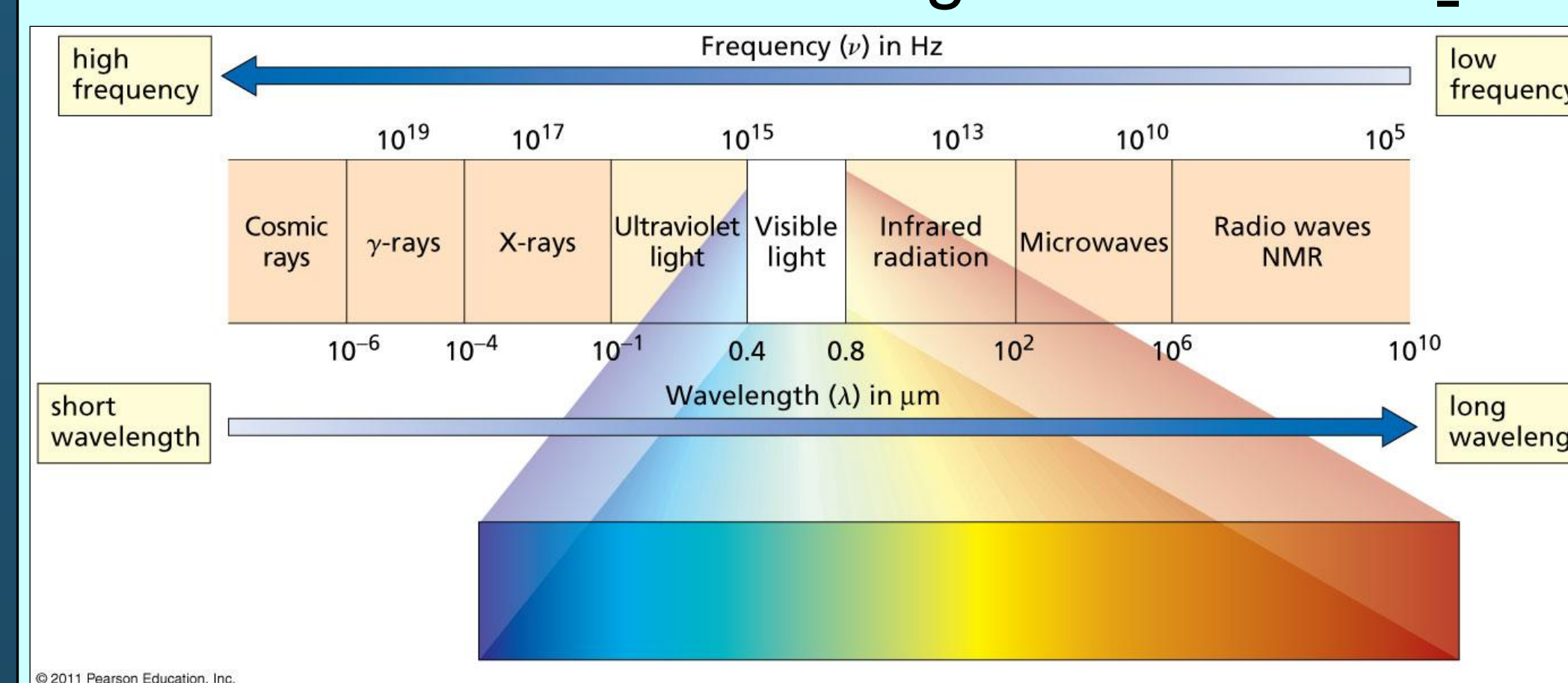


Figure 6: The electromagnetic spectrum

- Energy emitted from a source is referred to as radiation
- High frequency causes ionizing radiation (atoms become charged)
- X and gamma rays are very high energy ionizing radiation
- Elevated exposure to ionizing radiation can cause harm to human health
- Radio waves are the lowest energy and are harmless: used for the NMR and the MRI

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