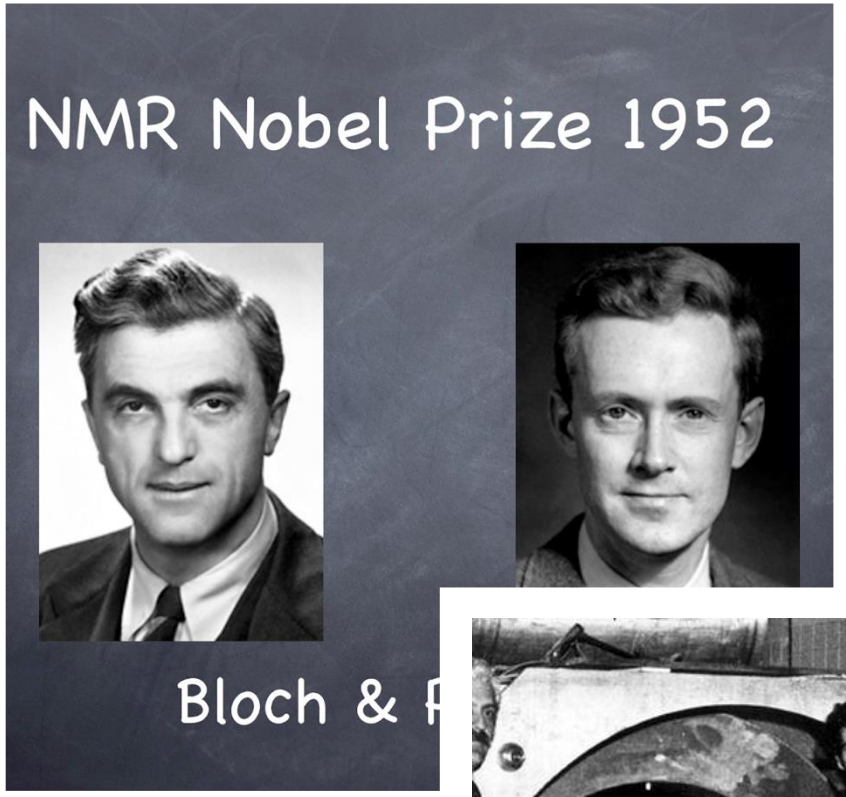
MRI BASICS

Virali Shah, MBA RT(T)(MR)

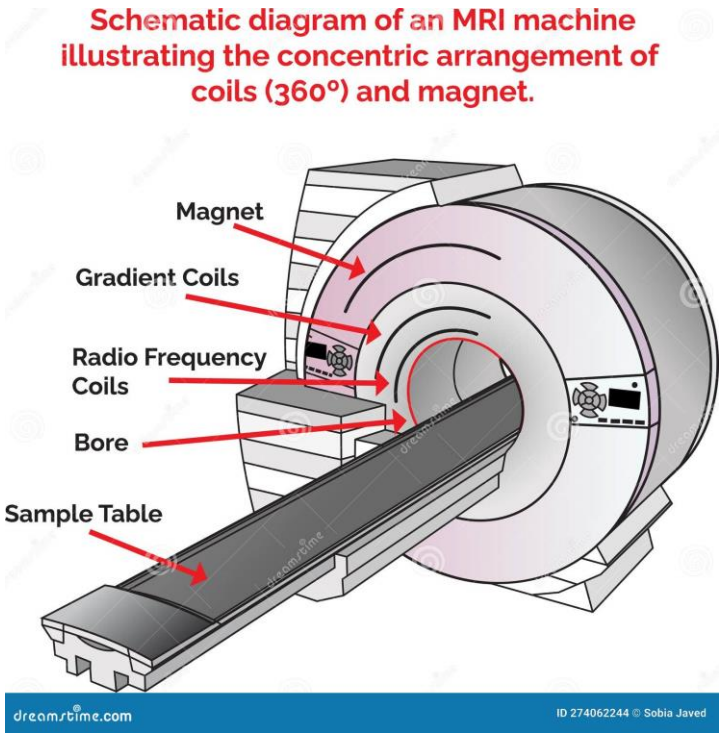
February 5, 2026

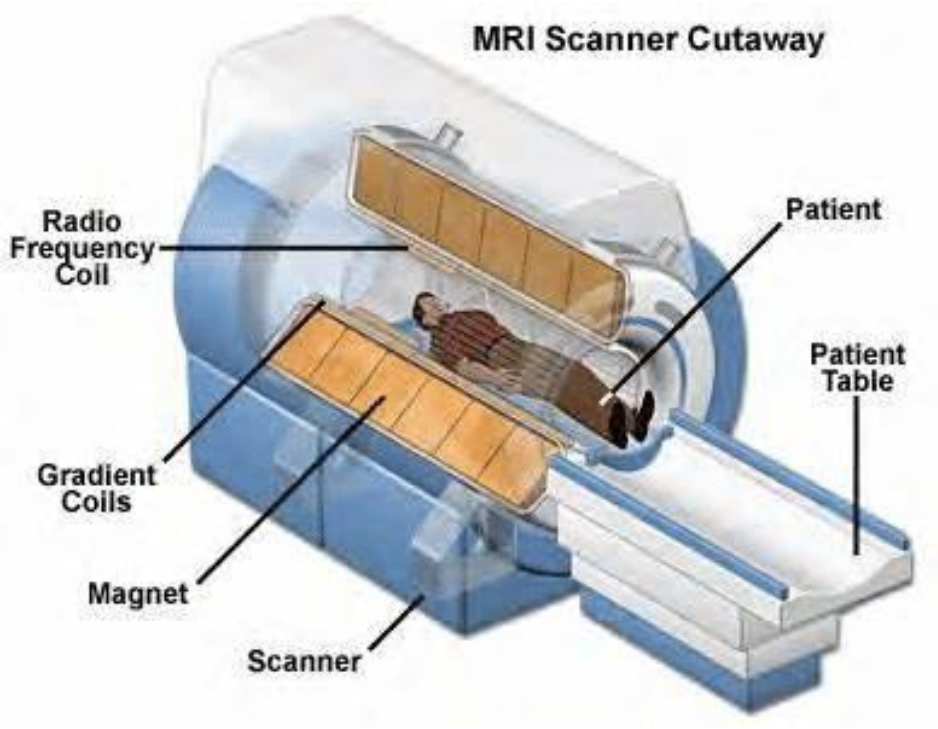
Historic Perspective

- 1946-Nuclear Magnetic Resonance Phenomenon
  - Bloch and Purcell
- The First MRI Scanner was built by Dr. Raymond Damadian in 1971
- First clinical MRI was produced in Nottingham and Aberdeen in 1980 [1]





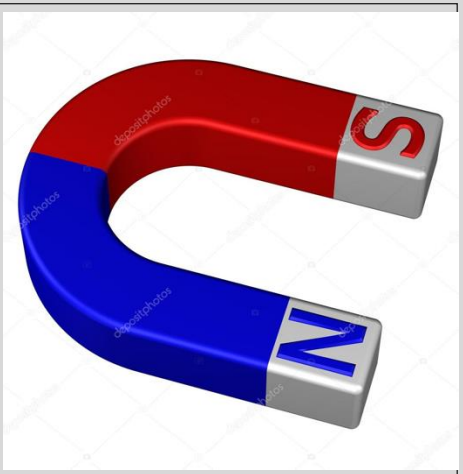


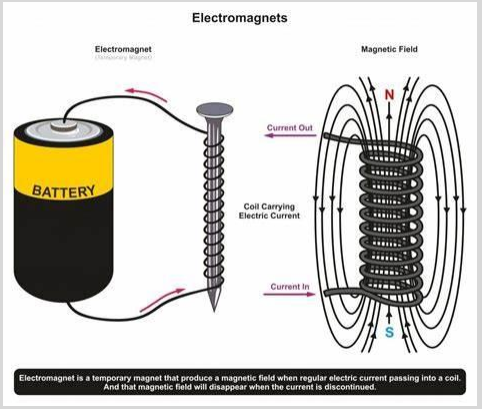


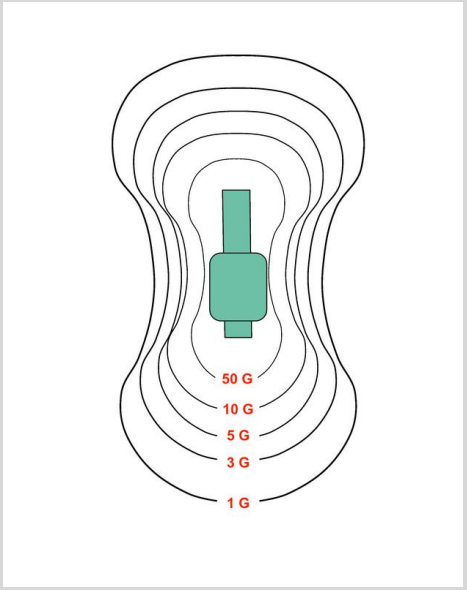
ANATOMY OF MRI

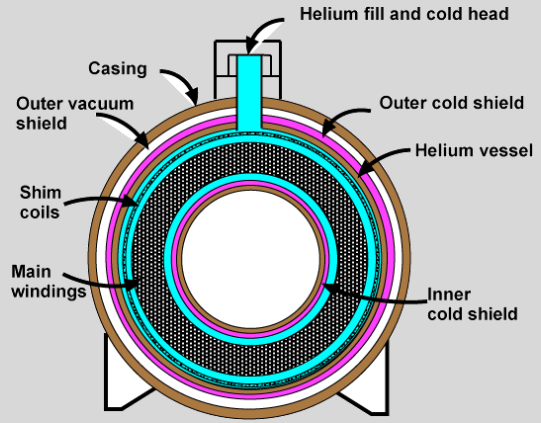
Types of Magnets

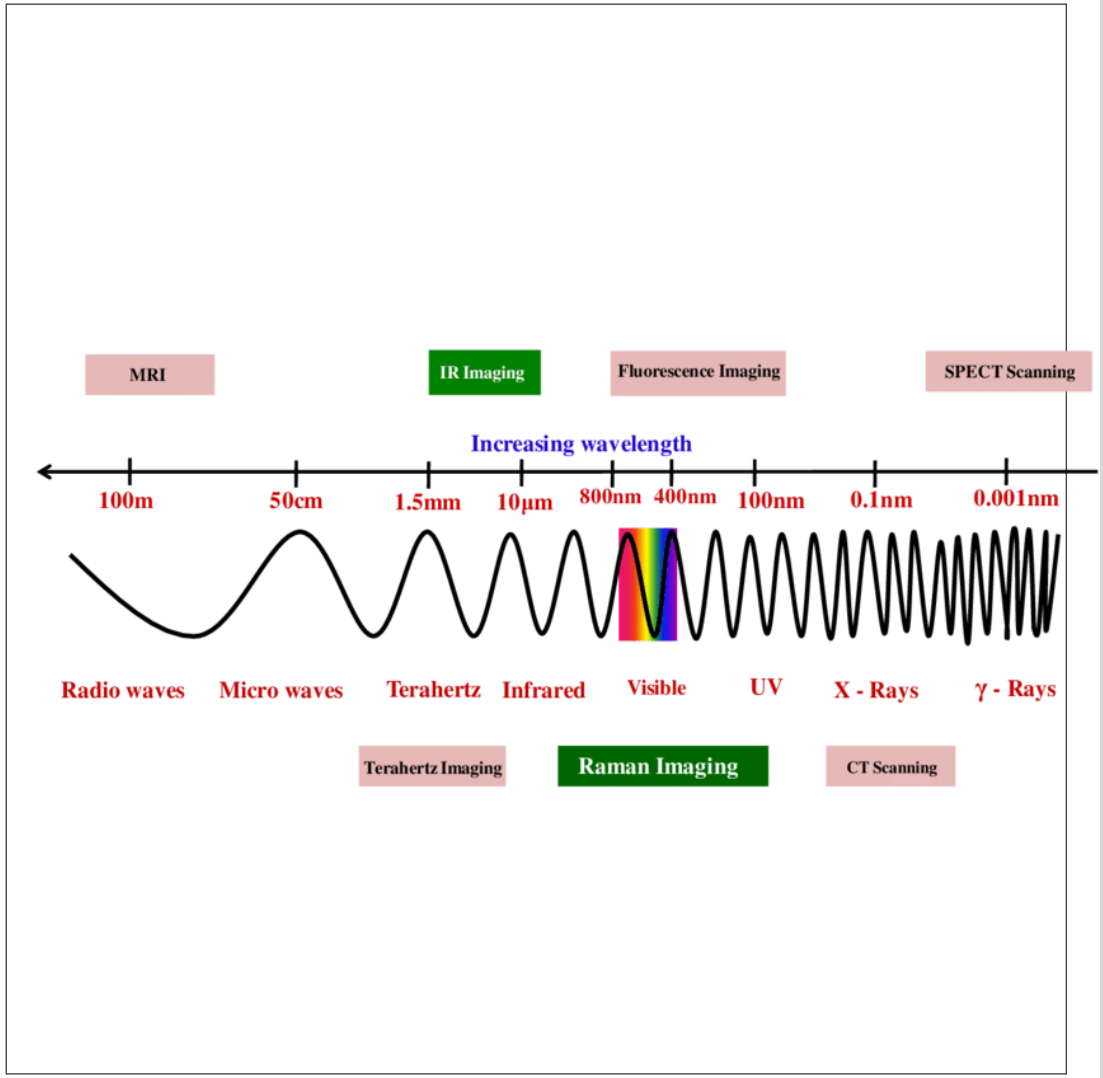
1. Permanent:
   - Extremely rare, almost non-existent today
   - When placed in brick sized pattern, can cause strong magnetic field
   - Large and heavy and have a weak magnetic fields
   - Singal-to-Noise ratio (SNR) is at premium
   - Cannot be turned off
2. Resistive
   - Large coil of wire with lots of electricity passing through
   - Can generate magnetic field of 0.5-0.7 T
   - Generate a lot of heat
3. Superconducting
   - Resistive magnet but with cooled liquid helium or a cryogen
   - Can create stronger magnetic field
   - 1T-4T for clinical Research magnets can go up to 7-9T
   - Large fringe field











Static Magnetic Field

- 20 to 60 thousand or more times stronger at isocenter than the earth's magnetic field
- Unlike x-rays Magnetism does NOT follow inverse square law.
  - Follows Cubic exponential relationship of attraction
  - What does it mean? Half the distance and 8 times the force

In MRI, it is important to measure the magnetic field and create safety zones

How are they created?

Gauss Line!!



5 Gauss Line

- Gauss measure magnetic flux or magnetic density within the magnetic field
- 1T=10,000 Gauss
- So 5 Gauss line refers to 0.5miliTesla
- Beyond this point the magnetic field is significantly strong
- It is unsafe for pacemakers, deflators etc. are unsafe to enter beyond the 5 Gauss line

The Gradient Magnetic Field

- A gradient is actually a hill or an incline.
- How does that relate to MRI?
  - It is a magnetic hill
  - One side is made **briefly** stronger than the other.
- This is what causes loud noises in MRI as the gradients are turned “on” and “off”
- The stronger the gradient the louder the noise (1.5 T is less noisy than 3T machine)
- Also known as moving magnetic field
- These gradients are used to create small current in the nerves to create
  - DWI, perfusion, functional FSE images
  - As the fields size narrows you can have a sharper current causing more accurate image production for these specific sequences

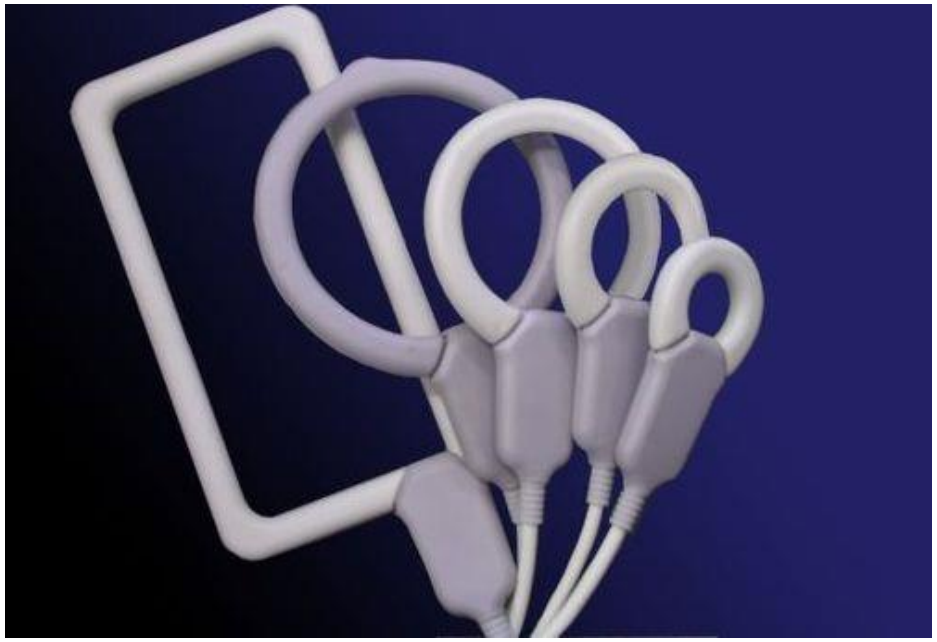
Specific Absorption Rate (SAR)

- SAR is the amount of power (heat) deposited in tissue by RF irradiation per unit mass
- SAR depends on: tissue conductivity, body weight, RF flip angle
- Radio Frequency (RF) used in MRI are close to microwave range
- This is what causes heating in patient
- The amount of RF utilize depends on the sequences
- The body part getting scanned will also have an impact on the RF pulse
- The coil type used will also have an impact on RF Pulse
- Requires Faraday shielding throughout the room
  - Failure to have RF shielding will result in image artifact



Coils

- Various coils for type of organ getting imaged
- They are specific to Tesla energy
- Use the smallest coil available for best signal to noise due to better SNR (Signal to Noise Ratio)
  - Smaller coil does NOT produce more signal but creates LESS noise
- Coils are always placed n X/Y or transverse plane



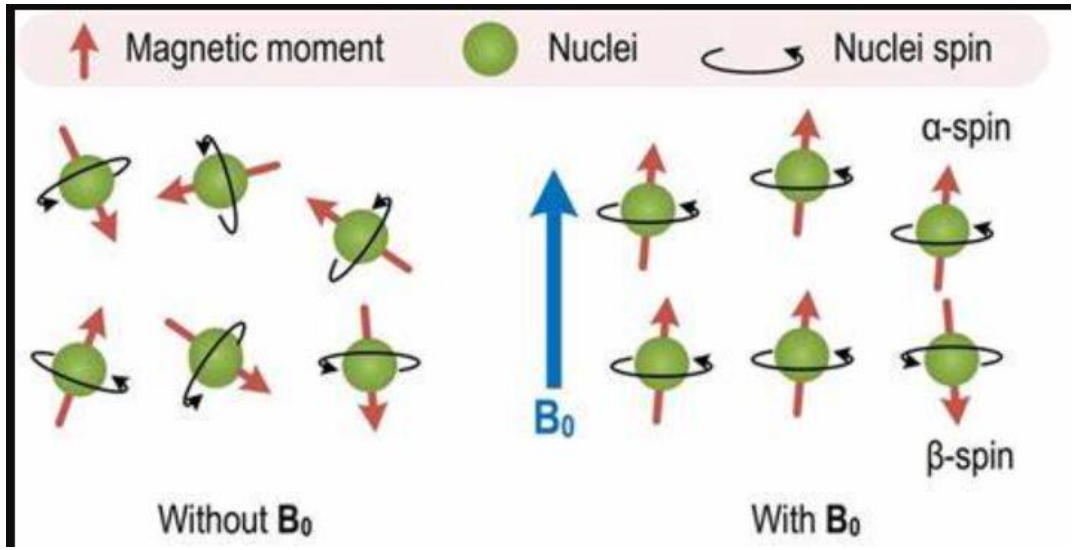
Receive only Coils

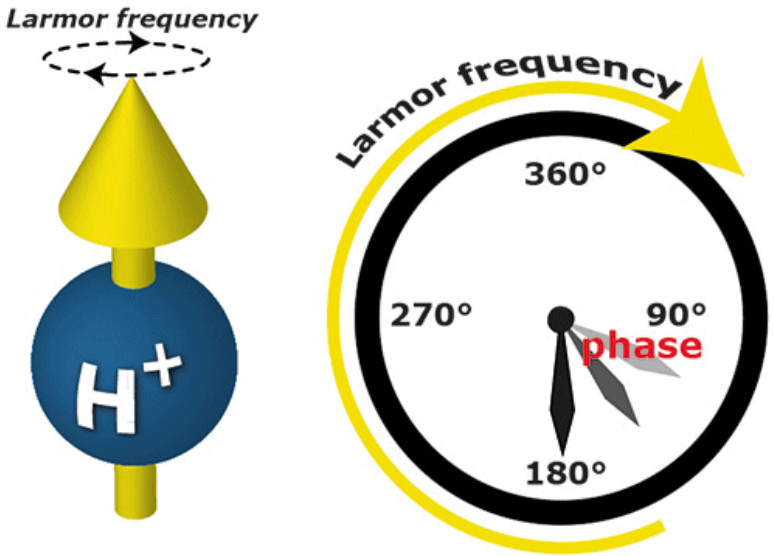
- These coils can have wrap or aliasing artifact
- Uses the inherent body coil to transmit RF



Transmit/Receive coils

- Transmits the RF to the body part, then turns off as a transmitter and becomes the receiver to acquire the signal
- Implant images are required to be imaged with T/R coils
- Usually large/bird cage type coils
- Distance from body to the coil is important to note to increase SNR



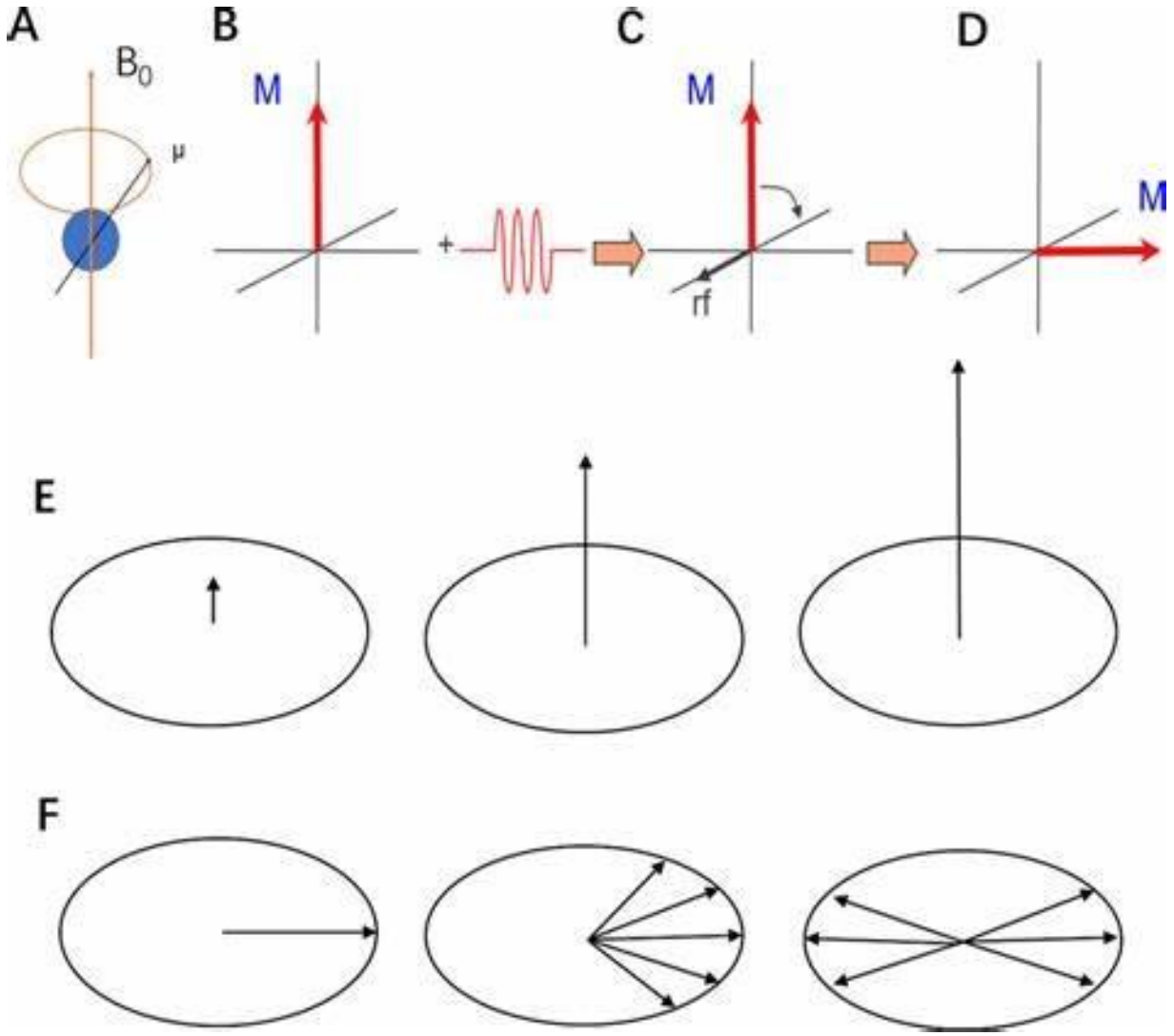


Why Hydrogen Molecules

- Single proton and a single electron
- Due to this it is a small magnet
- Inside the magnet the hydrogen molecules align themselves in scanner's north/south pole
  - This is called Net Magnetization Vector or NMV
- NMV precesses or wobbles on its axis at a rate that is governed by the scanner's magnetic field strength
-

What is next?

- NMV is not in phase, it is just wobbling
- If an RF pulse is sufficient strength/duration at the precessional frequency then NMV will acquire phase and tip into x/y plane
  - Basics of T1 and T2 image formation



Reference

- 1. Grover VP, Tognarelli JM, Crossey MM, Cox IJ, Taylor-Robinson SD, McPhail MJ. Magnetic Resonance Imaging: Principles and Techniques: Lessons for Clinicians. J Clin Exp Hepatol. 2015 Sep;5(3):246-55. doi: 10.1016/j.jceh.2015.08.001. Epub 2015 Aug 20. PMID: 26628842; PMCID: PMC4632105.

- You may also like:
- MRI physics overview | MRI Physics Course | Radiology Physics Course #1
- The Insane Engineering of MRI Machines