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DEPARTMENT OF BIOMEDICAL ENGINEERING

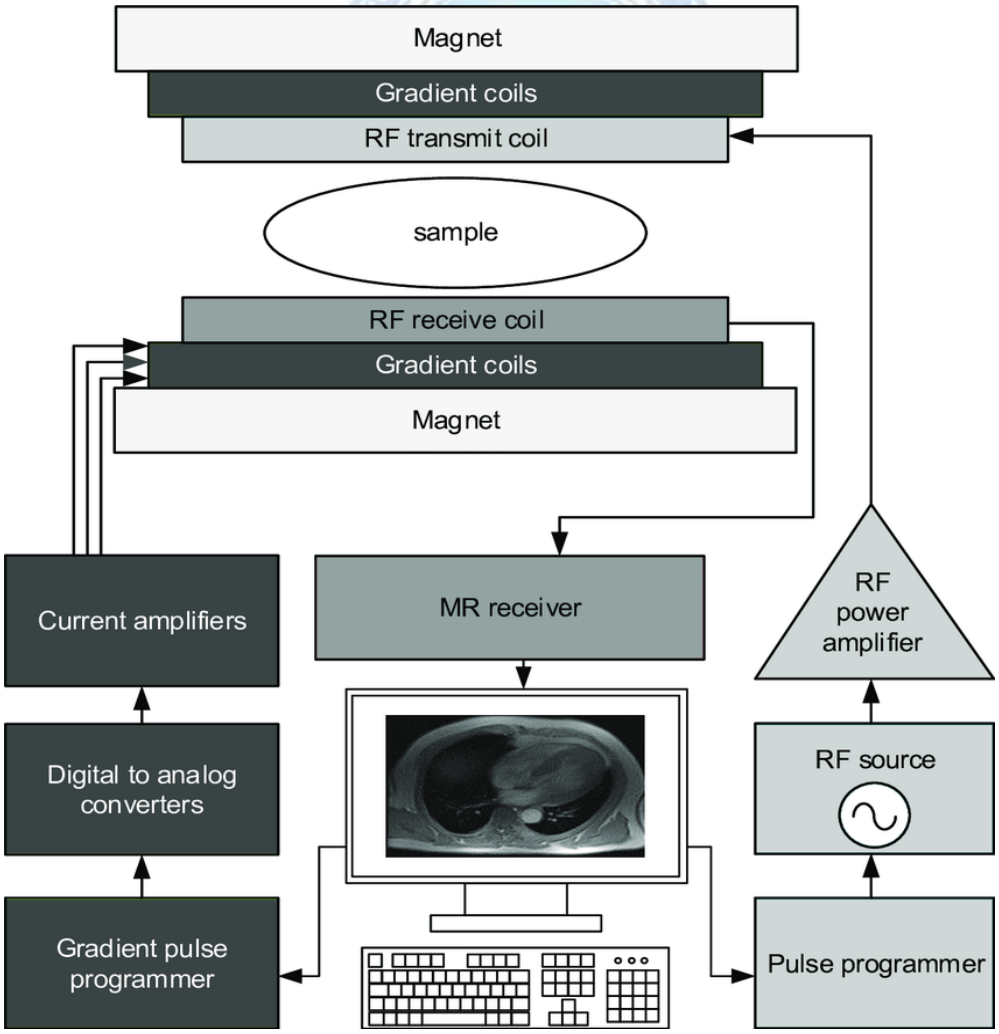
VII Semester

OBT357 BIOTECHNOLOGY IN HEALTH CARE

UNIT- 5 BASICS OF IMAGING MODALITIES

5.3. Magnetic Resonance Imaging (MRI)

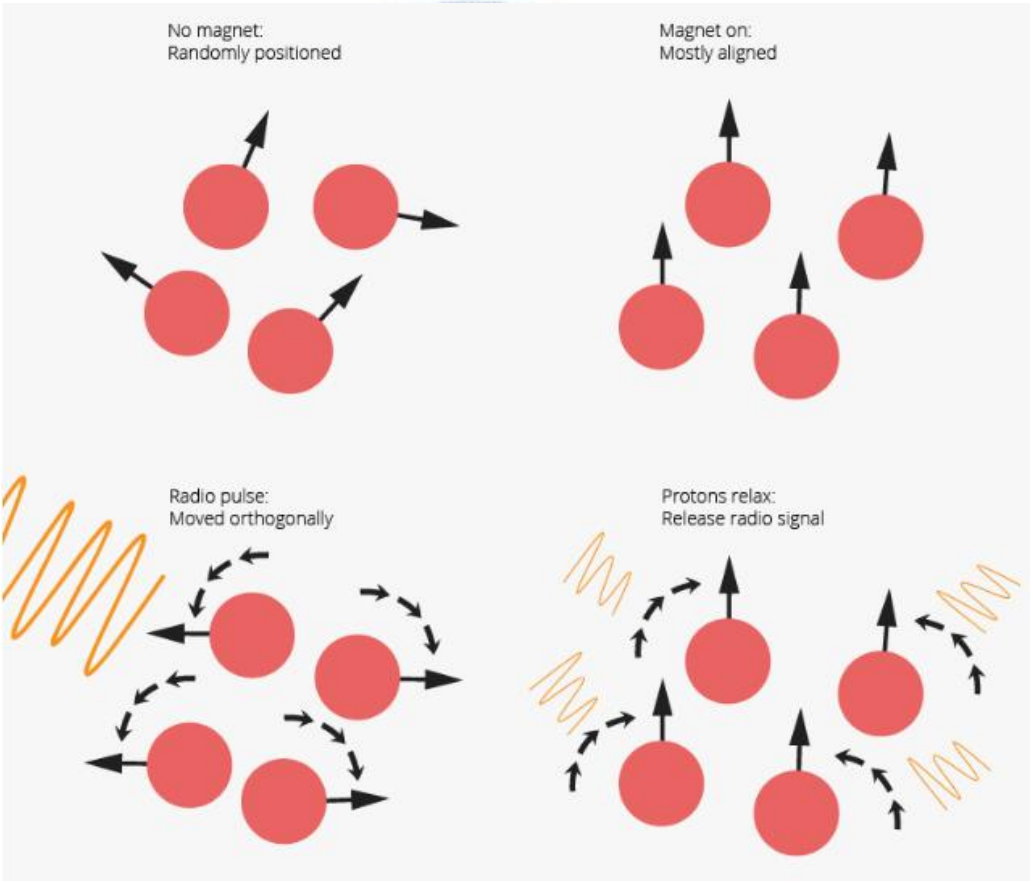
Magnetic Resonance Imaging (MRI) is a non-invasive medical imaging technique used to visualize detailed internal structures of the body. It works by using strong magnetic fields, radio waves, and gradient coils to generate images of organs, tissues, and bones.



Basic Principle:

- Magnetic Resonance Imaging (MRI) is based on the principle of nuclear magnetic resonance, where hydrogen protons in the body align with a strong external magnetic field.
- When radiofrequency (RF) pulses are applied, these protons are temporarily displaced from alignment. As they relax back to their original position, they emit signals that are detected by the scanner.
- Differences in relaxation times (T1 and T2) and proton density in various tissues generate contrast, which is processed by a computer to create detailed cross-sectional images of the body without using ionizing radiation.

The diagram illustrates the components and working of an MRI (Magnetic Resonance Imaging) system.



- As the protons relax, energy is released which can be detected by sensors in the MRI machine. Through some calculations, the computer can determine what the tissue looked like, depending on this energy that is released, and show us an image of the tissue.

Components:

1. **Magnet Coils**: Generate a strong, uniform magnetic field to align the sample's protons.
2. **Gradient Coils**: Create varying magnetic fields to spatially encode the signal from the sample.
3. **RF Transmit Coil**: Emits radiofrequency (RF) pulses to excite the protons in the sample.
4. **RF Receive Coil**: Detects the RF signals emitted by the sample after excitation.
5. **Sample**: The object (e.g., a human body part) being imaged.
6. **MR Receiver**: Processes the detected RF signals for image formation.
7. **RF Power Amplifier**: Amplifies the RF pulses from the RF source for transmission.
8. **RF Source**: Generates the initial RF pulses.
9. **Pulse Programmer**: Controls the timing and sequence of RF and gradient pulses.
10. **Gradient Pulse Programmer**: Manages the gradient coils' activation.
11. **Digital to Analog Converters**: Convert digital signals to analog for controlling hardware.
12. **Current Amplifiers**: Amplify currents to drive the gradient coils.

Working:

1. The magnet coils create a static magnetic field, aligning the protons in the sample.
2. The gradient coils add spatial variation to this field, enabling precise location mapping.
3. The RF transmit coil, powered by the RF source and amplifier, sends pulses to flip the proton spins.
4. After the pulse, the protons return to alignment, emitting RF signals detected by the RF receive coil.
5. The MR receiver processes these signals, which are then used to construct an image on the display.

6. The pulse programmer and gradient pulse programmer coordinate the timing and sequence of all operations, with digital-to-analog converters and current amplifiers ensuring proper signal delivery.

Advantages of MRI:

1. **High Precision**: MRI machines scan specific body portions with gradient magnets.
2. **Safety**: MRI scans pose no long-term harm, and magnetic field effects are well-studied.
3. **Early Disease Detection:** MRI aids early detection of diseases like cancer and multiple sclerosis.
4. **Minimally Invasive Procedure:** MRI is safe and comfortable, unlike surgery, benefiting children and the elderly.

Disadvantages of MRI:

1. **Cost:** MRI machines are expensive to purchase and maintain, leading to high diagnostic costs for patients.
2. **Discomfort and Claustrophobia:** Patients must lie still for extended periods inside the MRI machine, which can be uncomfortable, especially for claustrophobic individuals.
3. **Limited Imaging Capability**: MRI struggles to image certain tissues like bone, air, and some types of implants effectively due to their physical properties.
4. **Strong Magnetic Fields**: The powerful magnetic fields used in MRI can pose potential risks for patients with certain medical implants (e.g., pacemakers) or metallic objects lodged in their bodies.

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