MODULE 6

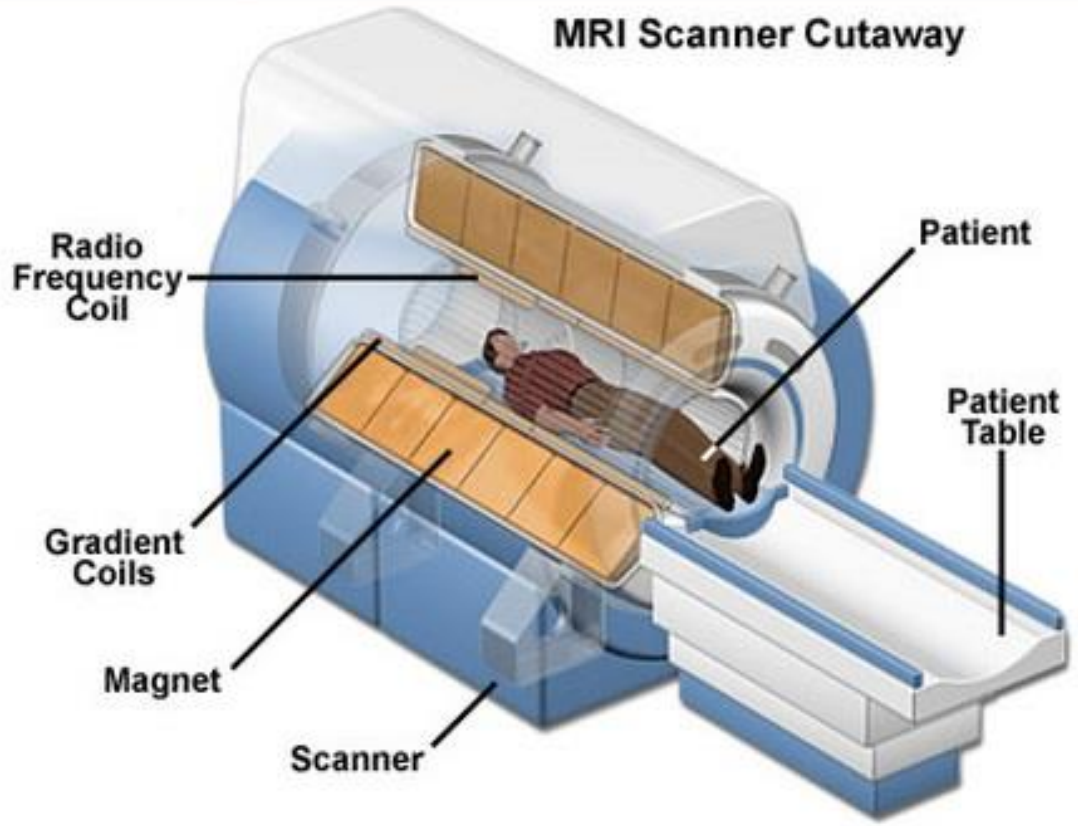
MAGNETIC RESONANCE IMAGING – MRI SCAN

INTRODUCTION

- Magnetic resonance Imaging is an advanced technique of medical imaging that is now widely used for the diagnosis of various diseases.
- It is commonly used in radiology to visualize the internal structures and functions of the body.
- It may also be called Nuclear Magnetic Resonance imaging (NMR)
- An MRI scan is a technique that uses magnetism, radio waves and computers to produce images of body structures.
- The important advantages of MRI over other imaging techniques is that it can provide much greater contrast between the different soft tissues of the body.
- It provides high quality 2-D or 3-D images of organs without using X-Rays or any other radiations.

MRI SCANNER CUTWAY

What is MRI machine? How Does It Work?



PRINCIPLE OF OPERATION

- 70% of human body is made up of water, ie hydrogen and oxygen. The hydrogen atoms in the human body behave as if a small magnets.
- Protons in the hydrogen nuclei behave like a tiny magnet.
- The MRI diagnostic procedure makes use of these abundant hydrogen atoms in the body.
- All biological tissues have large amount of hydrogen in it. Hence plenty of hydrogen in the biological tissue can be seen as randomly orientated tiny magnets represented by vectors as shown in fig 9.11(a)
- The direction of this tiny magnets are randomly oriented shown in fig 9.11(b)
- When this tiny magnets are subjected to external strong magnetic field (Bo), then they will align along the direction of external magnetic field (Bo) is shown in fig 9.11(c)

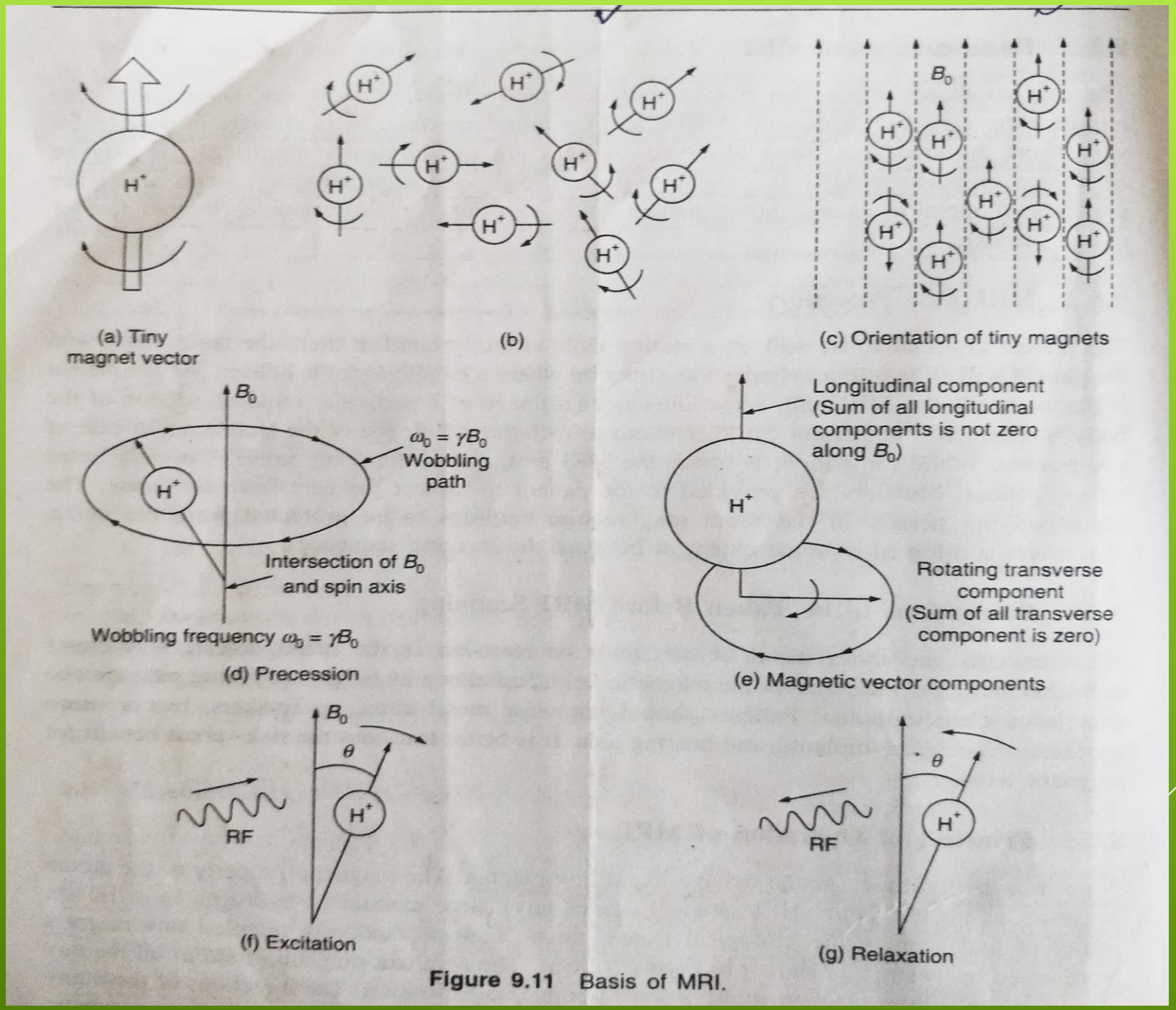


Figure 9.11 Basis of MRI.

- Some of the tiny magnets align parallel along the external magnetic field (Bo) and some align anti parallel to the external magnetic field.
- Tiny magnets are wobbling about the axis of the external magnetic field (Bo) so as to describe a cone as shown in fig 9.11(d). This wobbling is called precession and its frequency ω0 is proportional to (Bo)
- An RF signal is then turned on which causes the protons to change their alignment relative to the Radio Frequency field.
- There is a modification of spin equilibrium due to the absorption of RF signal by tiny magnets. This energy transfer is called Excitation shown in Fig 9.11(f).
- Again when this field is turned off the protons return to the original magnetization alignment. The tiny magnets return to the normal state (relaxation) shown in Fig 9.11(g) there is an emission of RF electromagnetic energy.
- This RF electromagnetic energy emission is called the NMR signal.
- These NMR signal detected by the scanner and is converted into digital images with the help of a computer

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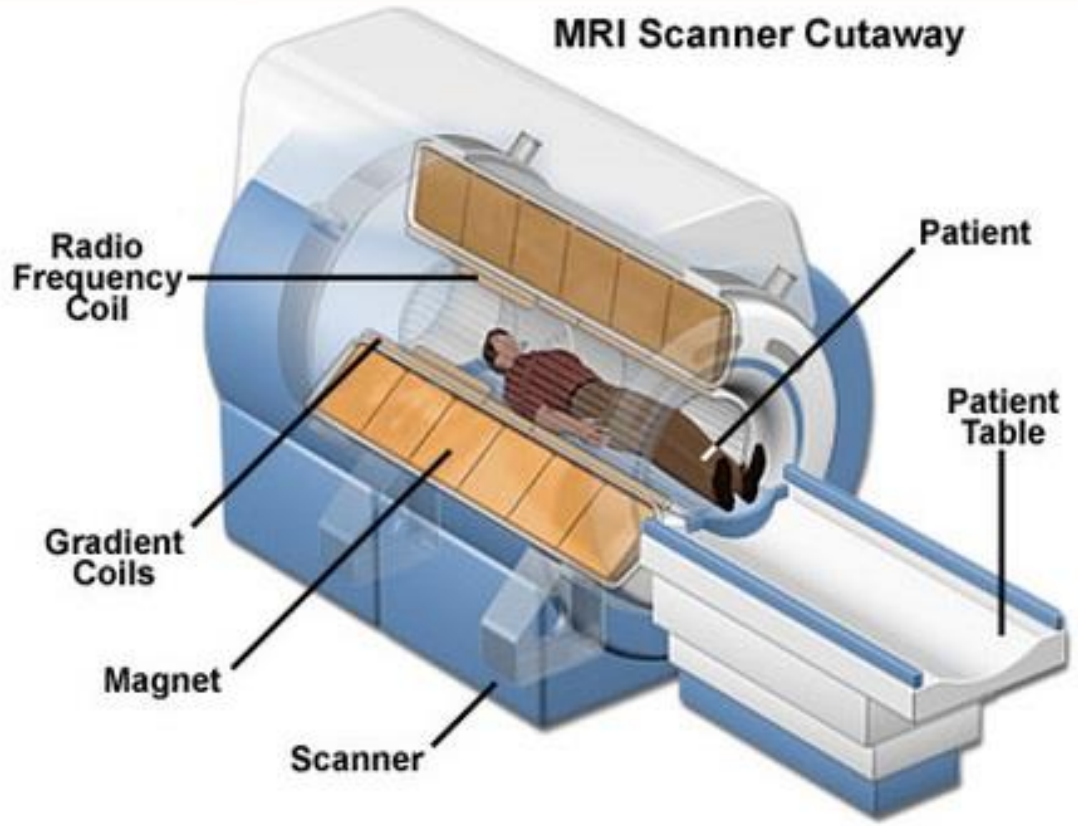

MRI INSTRUMENTATION SYSTEM

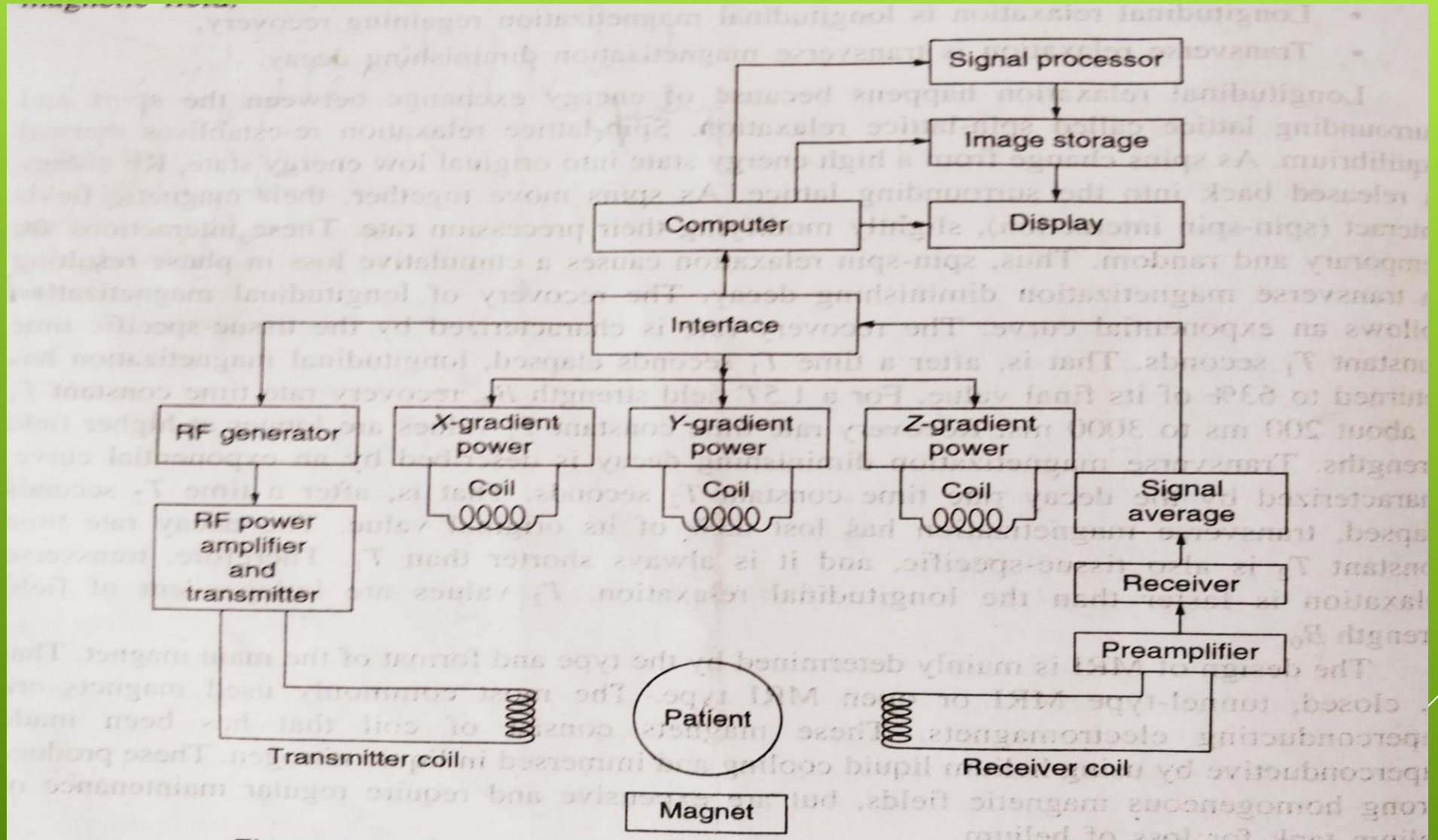

Figure 9.12(a) Block diagram of a MRI instrumentation system.

MRI INSTRUMENTATION SYSTEM

- **Magnet :** A magnet which provides a strong, uniform, steady magnetic field (Bo). Most of the modern NMR machines used superconducting magnets. The commonly superconducting material is Niobium Titanium (NbTi) alloy. These magnets are cooled with liquid Helium at a temperature of -269degree Celsius. These magnets produce better signal to noise ratio and better image quality than the images obtained through conventional magnets.
- **RF Transmitter system:** the system consist of RF generator, RF power amplifier and RF transmitting coils. The RF voltage is gated with the pulse envelopes from the computer interface to generate RF pulses that excite the resonance. These pulses are amplified to several KW and fed to the transmitter coil. The RF receiver coil detect the NMR signal generate from the body and amplified the signal using preamplifier and send to the computer for further processing.

MRI INSTRUMENTATION SYSTEM

- **Gradient coil system:** Three different gradient coil systems produce a time varying, controlled spatial non-uniform magnetic fields in different directions(X,Y,Z).
- There is a superposition of a linear magnetic field gradient on to the uniform magnetic field applied to the patient.
- The patient is kept in this gradient field space. RF transmitter and receiver coils are placed around the patient to construct the image. When this superposition of gradient field on the uniform magnetic filed takes place, the resonance frequencies of the precession nuclei depends primarily on the positions along the direction of the magnetic field gradient.
- This produce a one dimensional projection of the internal structure of the three dimensional object. From the projections at different gradient orientations using X,Y,Z gradient coils, a 2-D or 3-D image can be obtained. The slice of the image depends upon the gradient magnetic field.

MRI INSTRUMENTATION SYSTEM

- The gradient magnetic field is controlled by the computer and the field can be positioned in three independent planes X,Y,Z.
- The transmitter provides the RF signal pulses. The NMR signal generated is picked by the receiver coil and fed into the signal processing unit.
- Two-dimensional Fourier transformation computations are used to construct the image. For this a computer is used and the image is displayed on the TV monitor, either in grey scale or in colour.

ADVANTAGES & APPLICATIONS

- **ADVANTAGES:**
  - Cross section images with any orientation is possible.
  - MRI uses no ionizing radiation. So no hazard to patients
  - MRI provides substantial contrast between soft tissues that are nearly identical in existing techniques.
- **DISADVANTAGES:**
  - It may hazardous to perform MRI in patients with artificial valves, pacemakers, stents and other implants of metallic nature. Some patients may experience claustrophobia.
- **APPLICATIONS:**
  - Molecular Imaging
  - Biomechanical studies
  - To obtain 3D images of organs in human body.