MAGNETIC RESONANCE IMAGING

Magnet
Radio Frequency = Resonance
Imaging

Figure 5

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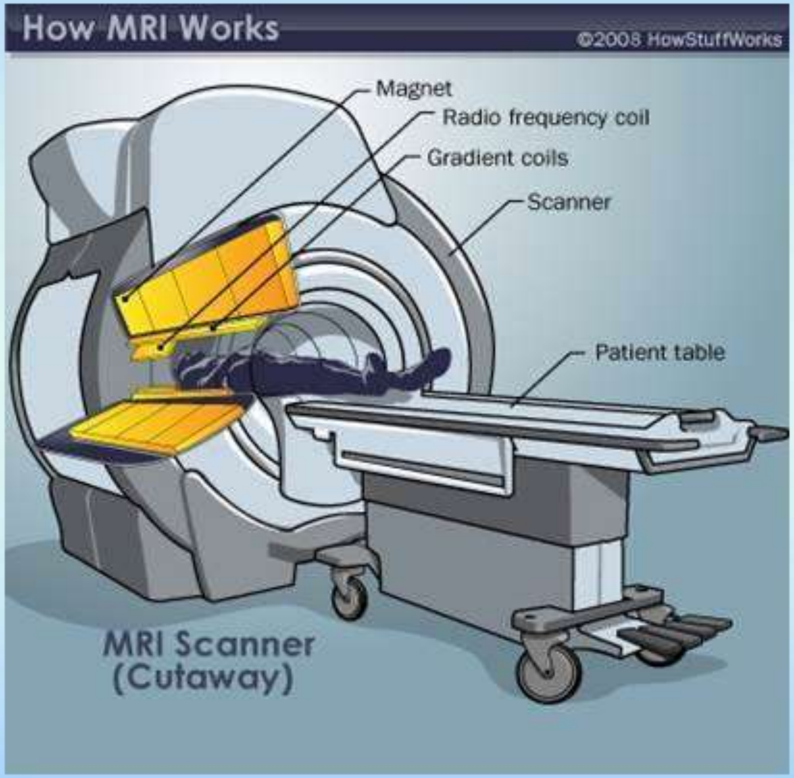
The MRI System

- Inside the MRI system is the magnet.
- These powerful magnets are up to 30, 000 times stronger than the earth's magnetic field!
- The strength of the magnet is rated using a the unit "tesla."
- Fringe Field
  - The region surrounding the magnet and exhibiting a magnetic field strength.



Introduction

- **MRI** Stands for **M**agnetic **R**esonance **I**maging; once call Nuclear Magnetic Resonance Imaging. The "Nuclear" was dropped off about 15 years ago because of fears that people would think there was something radioactive involved, which there is not.
- MRI is a way of getting pictures of various parts of your body without the use of x-rays, unlike regular x-rays pictures and CAT scans. A MRI scanner consists of a large and very strong magnet in which the patient lies. A radio wave antenna is used to send signals to the body and then receive signals back. These returning signals are converted into pictures by a computer attached to the scanner. Pictures of almost any part of your body can be obtained at almost any particular angle.
- These "radio wave signals" are actually a varying or changing magnetic field that is much weaker than the steady, strong magnetic field of the main magnet.

One way to think of an MRI scan is a water

‘x-ray’ (although no actual x-rays are involved). Normal x-rays image calcium, so they are good to see bones.

MRI scans image water, which makes them

very useful because all tissues of the body contain various amounts of water. This allows high resolution pictures of many organs and tissues to be taken that are invisible to standard x-rays.

HISTORY

- **NMR** was discovered simultaneously by two physicists, Felix Bloch and Edward Mills Purcell, just after the end of World War II. Bloch trained in quantum mechanics and was involved with atomic energy and then radar counter-measures. At the end of the war he returned to his earlier work in the magnetic moment of neutron. Purcell was involved with development of microwave radar during the War then pursued radio waves for evaluation of molecular and nuclear properties. They received the Nobel Prize in Physics in 1952 for this discovery.
- **MRI**, the use of NMR to produce 2D images was accomplished by Paul Lauterbur, imaging water and Sir Peter Mansfield who imaged fingers of a research student, Dr Andrew Maudsley in 1976. Maudsley continues to make a significant contribution to MRI R&D. Raymond Damadian obtained human images a year later in 1977. Lauterbur and Mansfield received the Nobel Prize in Physiology or Medicine in 2003 for their development of MRI.

PURPOSE

MRI is used for a variety of purposes, including the following:

- Diagnosing diseases of the central nervous system, including the brain and spine
- Detecting musculoskeletal disorders and injuries
- Identifying complications of infectious diseases, such as those associated with **Lyme disease** or acquired **immunodeficiency** syndrome (AIDS)
- Imaging the cardiovascular system
- Detecting congenital heart defects in neonates
- Determining the stage of certain types of **cancer**
- Evaluating bone marrow disease
- Assessing blood vessels in the brain for **stroke** and other abnormalities
- Assisting in the planning of surgery and cancer treatment
- evaluating the urinary tract

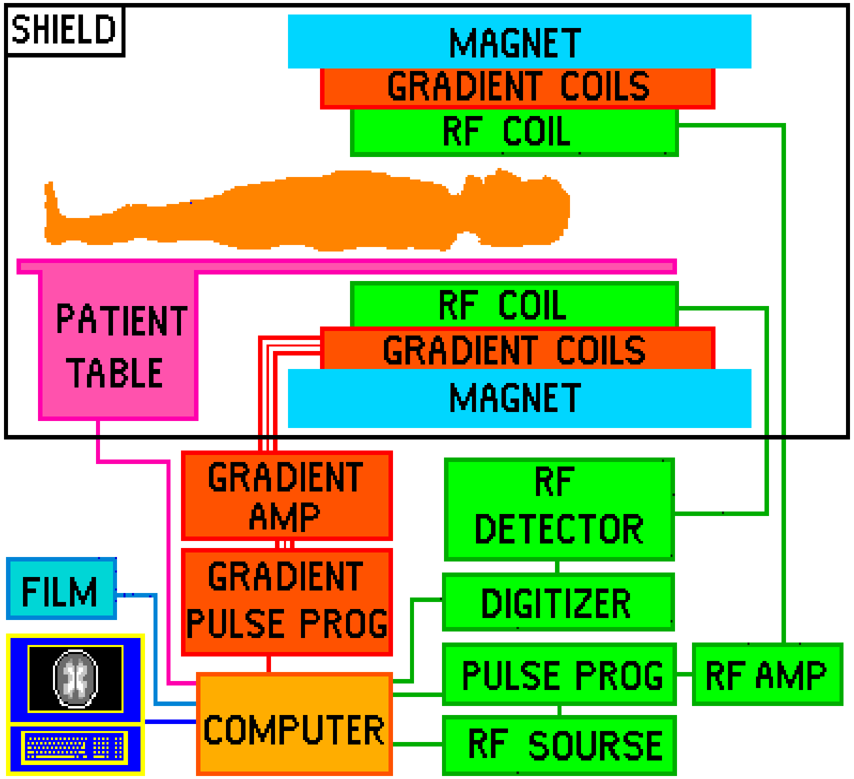
REFERENCE :http://www.healthofchildren.com/M/Magnetic-Resonance-Imaging.html#ixzz3RVmFNfTE

MAGNETIC RESONANCE - BASIC PRINCIPLES

Magnetic resonance imaging (MRI) makes use of the magnetic properties of certain atomic nuclei. An example is the hydrogen nucleus (a single proton) present in water molecules, and therefore in all body tissues. The hydrogen nuclei behave like compass needles that are partially aligned by a strong magnetic field in the scanner. The nuclei can be rotated using radio waves, and they subsequently oscillate in the magnetic field while returning to equilibrium. Simultaneously they emit a radio signal. This is detected using antennas (coils) and can be used for making detailed images of body tissues.

The frequencies used (typically 40-130 MHz) are in the normal radiofrequency range, and there are no adverse health effects.

Parts of an MRI:



The Components

- A magnet which produces a very powerful uniform magnetic field.
- Gradient Magnets which are much lower in strength.
- Equipment to transmit radio frequency (RF).
- A very powerful computer system, which translates the signals transmitted by the coils.

THERE ARE THREE TYPES OF MAGNETS:

- Resistive Magnets
- Permanent Magnets
- Superconducting Magnets

Resistive magnets: The resistive magnet has many coils of wire that wrap around the bore, through which electrical currents are passed, creating a magnetic field. This particular magnet requires a large amount of electricity to run, but are quite cheap to produce.

Permanent Magnets:

The permanent magnet is one that delivers a magnetic field, which is always on at full strength and therefore, does not require electricity. The cost to run the machine is low due to the constant magnetic force. However, the major drawback of these magnets is the weight in relation to the magnetic field they produce.

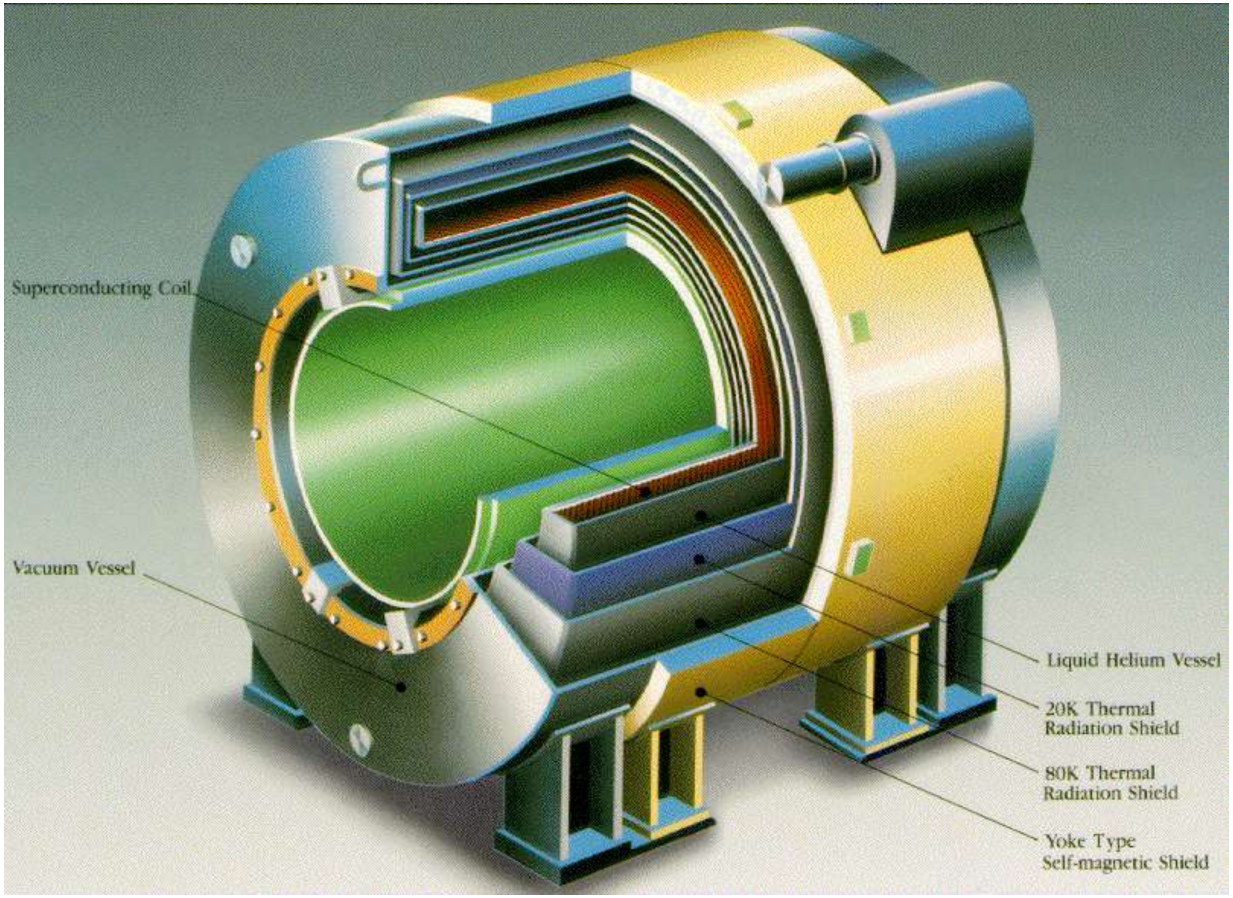
Superconducting Magnets: The superconducting magnets are very similar to the design of the resistive magnets, in that they too have coils through which electricity is passed creating a magnetic field.

The superconducting magnet is the most commonly used in machines today, giving the highest quality images of all three magnet types.

Permanent Magnets

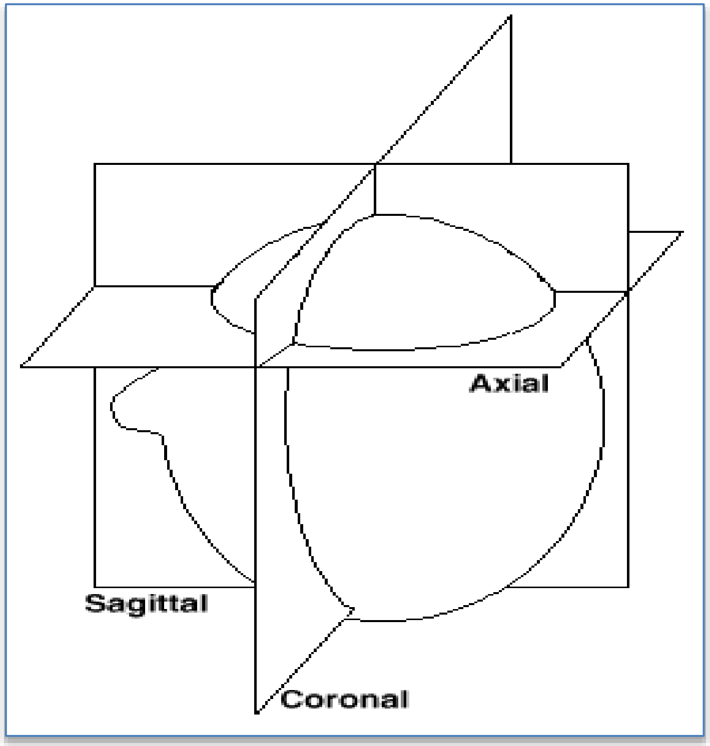
Resistive Magnets

Superconducting Magnets:



There is another type of magnet that is found in all MRI machines, called gradient magnets

These magnets are responsible for altering the magnetic field in the area to be scanned and can magnetically “slice” the tissue to be examined from every angle.



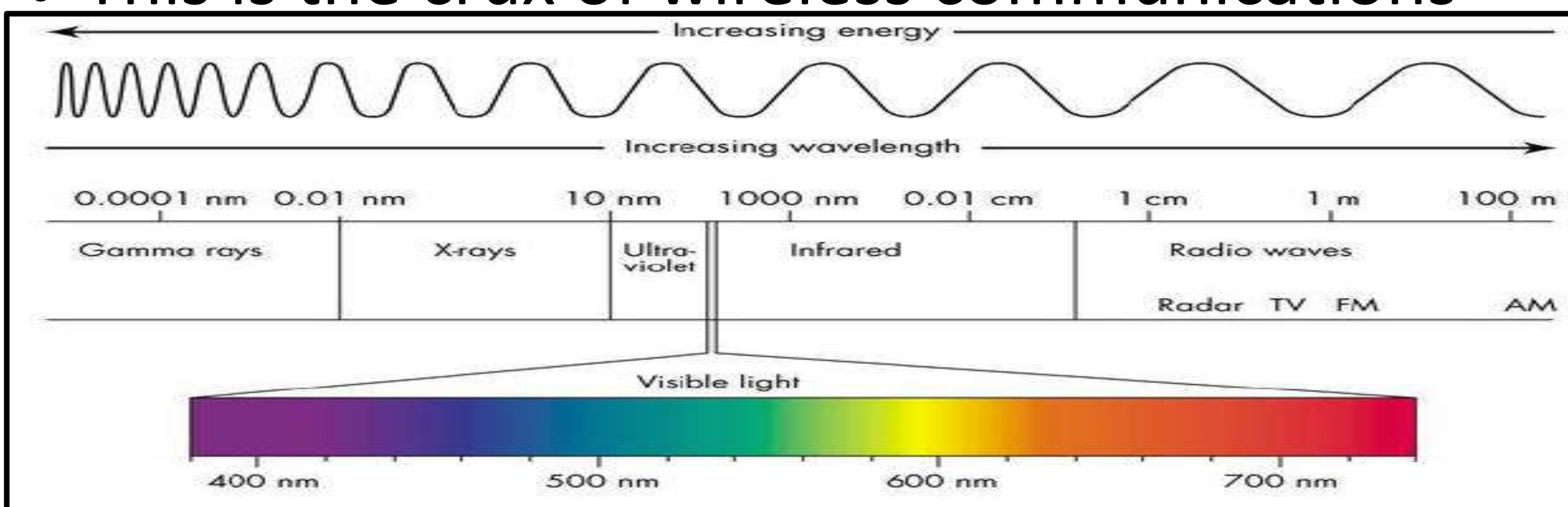
Now, its time to listen to radio in RESONANCE

RESONANCE

- Resonance relates to the transfer/exchange of energies between two systems at a specific frequency.
- It is analogous to talking to someone on your cell phone.
- In magnetic resonance, only protons with the same frequency as the RF pulse will respond.
- During RF pulse delivery nuclei become excited and then return to equilibrium.
- During equilibrium, they emit energy in the form of electromagnetic waves.

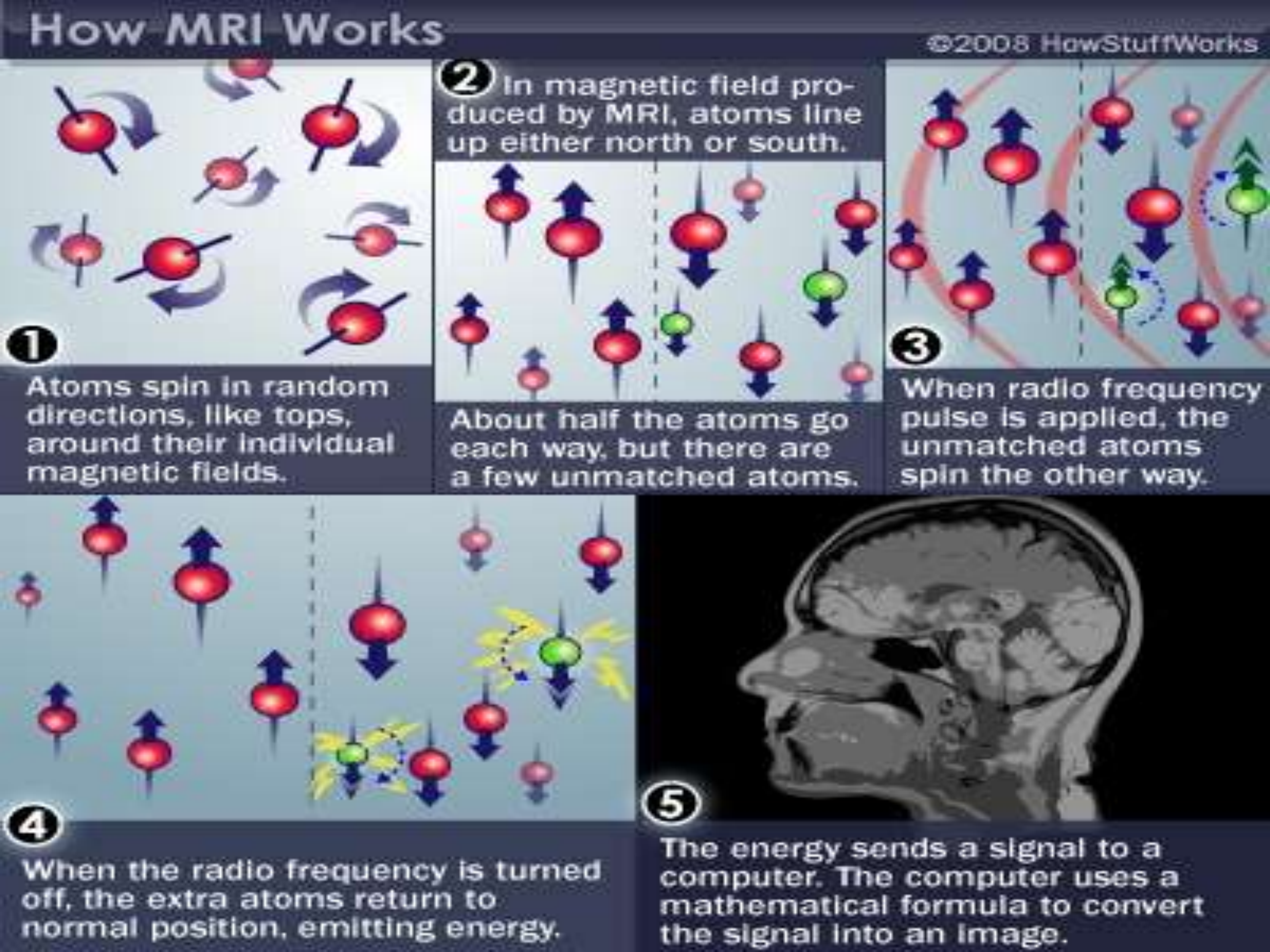
ELECTROMAGNETIC WAVES

- In brief, this can be thought of as the light we see but with different frequencies.
- The frequency is directly proportional to the energy and inversely proportional to the wavelength.
- This is the crux of wireless communications



Now, we re-transmit the energy for image processing

- The emitted energy is too small (despite 2500 times the magnetic field with resonance RF pulse) to convert them into images.
- Hence, repeated “ON-OFF” of RF pulses are required.
- The emitted energy is stored (K-space), analysed and converted into images.


How MRI Works
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1
Atoms spin in random directions, like tops, around their individual magnetic fields.
2
In magnetic field produced by MRI, atoms line up either north or south.
About half the atoms go each way, but there are a few unmatched atoms.
3
When radio frequency pulse is applied, the unmatched atoms spin the other way.
4
When the radio frequency is turned off, the extra atoms return to normal position, emitting energy.
5
The energy sends a signal to a computer. The computer uses a mathematical formula to convert the signal into an image.

PRE-TEST CARE:

The MRI (magnetic resonance image) scanner uses an extremely strong magnet , so people with certain types of medical implant cannot be scanned because the magnet can potentially move medical devices with metal in them , or affect their function.

Therefore, before you enter the scanning area you should be asked if you have any medical devices in your body.

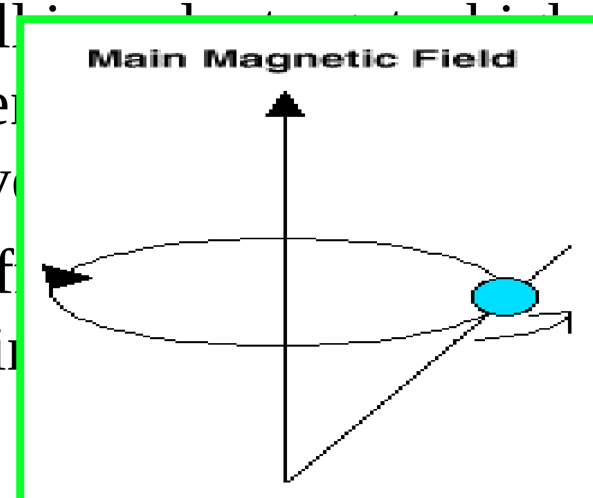
The following is not a definitive list but may help to remind you of the type of things radiographers need to know about:

- Internal (implanted) defibrillator or pace maker.
- Cochlear (ear) implant
- Surgical clips such as those used on brain aneurysms.
- Artificial heart valves
- Implanted electronic device, including a cardiac pacemaker
- Artificial limbs or metallic joints
- Implanted nerve stimulators.
- Pins, screws , stents or surgical staples.

The procedure……

- Once the contrast dye has been injected, the patient enters the bore of the MRI machine on their back lying on a special table.
- The patient will enter the machine head first or feet first, depending on the area to be scanned.
- Once the target is centered, the scan can begin.
- The scan can last anywhere from 20-30 minutes.

- The patient has a coil that is placed in the target area ,to be scanned.
- A radio frequency is passed through the coils that excites the hydrogen protons in the target area.
- The gradient magnets are then activated in the main magnet and alter the magnetic field in the area that is being scanned.
- The patient must hold completely stil
quality image. (This is hard for patie ,
and often times a sedative will be giv
- The radio frequency is then turned-of
protons slowly begin to return to thei



- The magnetic field runs down the center of the patient, causing the slowing hydrogen protons to line-up.
- The protons either align themselves pointed towards the head or the feet of the patient, and most cancel each other out.
- The protons that are not cancelled create a signal and are the ones responsible for the image.
- The contrast dye is what makes the target area stand out and show any irregularities that are present.
- The dye blocks the X-Ray photons from reaching the film, showing different densities in the tissue.

- The tissue is classified as normal or abnormal based on its response to the magnetic field.
- The tissues with the help of the magnetic field send a signal to the computer.
- The different signals are sent and modified into images that the clinician can evaluate, and label as normal or abnormal.
- If the tissue is considered abnormal, the clinician can often detect the abnormality, and monitor progress and treatment of the abnormality.

IMMEDIATELY AFTER THE MRI

- You may be asked to wait while the radiographer checks the quality of the pictures. In some cases,you may be asked to get back into the MRI scanner so that more pictures can be taken. If the pictures are satisfactory, you can get dressed and go home.

- There are no known long term side effects from undergoing MRI.

  The MRI scan does not use ionising radiation to achieve its pictures.
- The MRI scan is a non-invasive, painless and safe procedure that doesn't require any 'recovery time'. Be guided by your doctor but, generally, there are no special after-care instructions.

A radiologist and other specialised doctors will examine and interpret the scan images. A report of the radiologist’s findings is sent to your doctor. You will need to make an appointment with your doctor to discuss the results.The MRI scan will help the doctor to plan appropriate treatment, if necessary.

Advantages + Disadvantages

ADVANTAGES

The advantages of MRI include:

- The ability to image without the use of ionizing radiation (x-ray) unlike CT scanning
- Images may be acquired in multiple planes (Axial, Sagital, Coronal, or Oblique) without repositioning the patient. CT images have only relatively recently been able to be reconstructed in multiple planes with the same spatial resolution
- MRI images demonstrate superior soft tissue contrast than CT scans and plain films making it the ideal examination of the brain, spine, joints and other soft tissue body parts
- Some angiographic images can be obtained without the use of contrast material, unlike CT or conventional angiography
- Advanced techniques such as diffusion, spectroscopy and perfusion allow for specific tissue characterisation rather than merely 'macroscopic' imaging
- Functional MRI allows visualisation of both active parts of the brain during certain activities and understanding of the underlying networks

DISADVANTAGES?

- Claustrophobia. Patients are in a very enclosed space.
- Weight and size. There are limitations to how big a patient can be.
- Noise. The scanner is very noisy.
- Keeping still. Patients have to keep very still for extended periods of time.
- Cost. A scanner is very, very expensive, therefore scanning is also costly.
- Medical Contraindications. Pacemakers, metal objects in body etc.

What are the limitations of MRI of the Body?

- High-quality images are assured only if you are able to remain perfectly still and follow breath-holding instructions while the images are being recorded. If you are anxious, confused or in severe pain, you may find it difficult to lie still during imaging.
- A person who is very large may not fit into the opening of certain types of MRI machines.
- The presence of an implant or other metallic object sometimes makes it difficult to obtain clear images. Patient movement can have the same effect.
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THE FUTURE OF MRI:

- The possibility of having very small machines that scan specific parts of the body.
- The continuing improvements on seeing the venous and arterial systems.
- Brain mapping while the patient does specific tasks, allowing clinician's to see what part of the brain is responsible for that task/activity.
- Improvements on the ability to do MRI's of the lungs.etc..