Magnetic Resonance Imaging

- Tube shaped machine
- Uses a magnetic field and radio frequency waves
  - Body chemical composition and tissue structure contribute to form image contrast
  - Computer generated image
- **Special terms**
  - High signal (white or bright), Low signal (dark grey or dark), Isointense (equal density)
Magnetic Resonance Imaging

• Advantages:
  – No ionizing radiation (no x-rays)
  – Sensitive to slight chemical difference
  – Three dimensional study
  – Capable of showing fine anatomic structure
  – Angiography can be done non-invasively

3-T MRI scanning
MRI Principles

- Hydrogen ions in the magnetic field of the MRI machine align with a small net dipole (1).
- Application of a radio frequency causes ions to move to a higher energy state (2-3) (Blue arrow).
MRI Principles

- When the frequency is removed the ions begin to return to prior state releasing energy (4 – 5).
- Resulting radiofrequency is measured and localized to create an image (changing blue arrows).

MRI Sequences

- T1- Weighted – short TR short TE – Fat Bright
- T2- Weighted – long TR, long TE – Water Bright
- Proton Density- Weighted or balanced imaging – long TR, Short TE
### MRI Image Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>T1 Weighted Image</th>
<th>Proton Density-Weighted Image</th>
<th>T2 Weighted Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR (msec)</td>
<td>≤500</td>
<td>≥2000</td>
<td>≥ 2000</td>
</tr>
<tr>
<td>TE (msec)</td>
<td>≤ 25</td>
<td>≤ 40</td>
<td>≥ 75</td>
</tr>
</tbody>
</table>

**TR** = Time of repetition of the radio-frequency pulse  
**TE** = Time of echo, the time of collecting the signals

### Signal Intensity of Certain Tissues

<table>
<thead>
<tr>
<th></th>
<th>T1-Weighted</th>
<th>Proton Density-Weighted (balanced)</th>
<th>T2-Weighted</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSF</td>
<td>Dark gray or Black</td>
<td>Dark gray</td>
<td>“White” or light</td>
</tr>
<tr>
<td>White Matter</td>
<td>“White” or light</td>
<td>Dark gray</td>
<td>Dark gray</td>
</tr>
<tr>
<td>Gray Matter</td>
<td>Gray</td>
<td>Light gray</td>
<td>Dark gray</td>
</tr>
</tbody>
</table>
MRI Normal Brain Midline T1

- Scalp
- CSF
- Corpus Callosum
- Vermis
- Cerebellum

Brain MRI Normal Axial T1

- Ventricles
- White Matter
- Grey Matter
- Scalp fat
Brain MRI Normal Flair

- T-2 Sequence
- Special technique suppresses CSF signal
- Allows better evaluation of areas adjacent to CSF spaces
- Excellent for evaluation of Multiple Sclerosis

Brain MRI Normal T2
Brain Coronal T1

Lumbar Spine MRI

T1  Proton Density  T2

Arrow at disk
MRI Thoracic Spine

- Intramedullary Spinal Cord Lesion

MRI Thorax
Cardiac MRI

MRI Abdomen
MR Angiogram Cerebral

MRI into the Future
Cardiac Function and Perfusion

- Advanced Cardiac evaluation
  - Perfusion
  - Function

CAD Enhanced Prostate MRI

Courtesy of Dr. Kevin DeMarco
Motion Correction

1024 MR Angiography Exceeds DSA resolution (no contrast)

8-Channel head coil

Increased Resolution

MRA

Courtesy of Jim Potchen, MD
Nerve Track Imaging

Brain Functional Imaging
Listening to Brahms

Music Therapy Professor  Musically Naive Engineer

Courtesy of Jim Potchen, MD
Brain Functional Imaging

Listening to Someone
Reading Prose

Music Professor
Engineer

Courtesy of Jim Potchen, MD