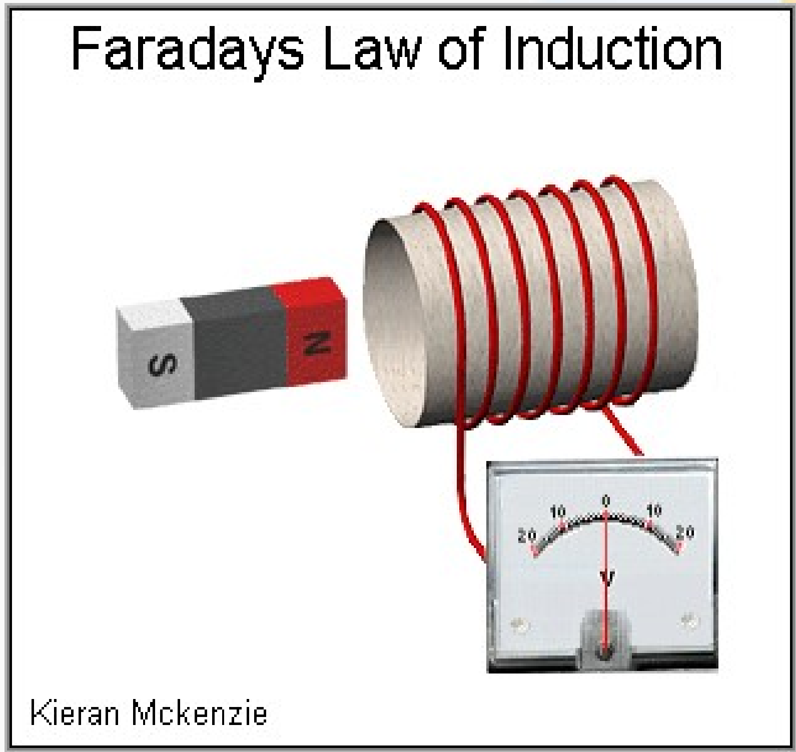
Magnetic Resonance Imaging(MRI)

Induction of Magnetic Resonance Signals:

The MR signal is a small electrical current induced in the receiver coil by the precession of the net magnetization (M) during resonance. This is a manifestation of Faraday's Law of Induction, Wherein a changing magnetic field induces a voltage in a nearby conductor. The faraday-Lenz principle of Magnetic induction.

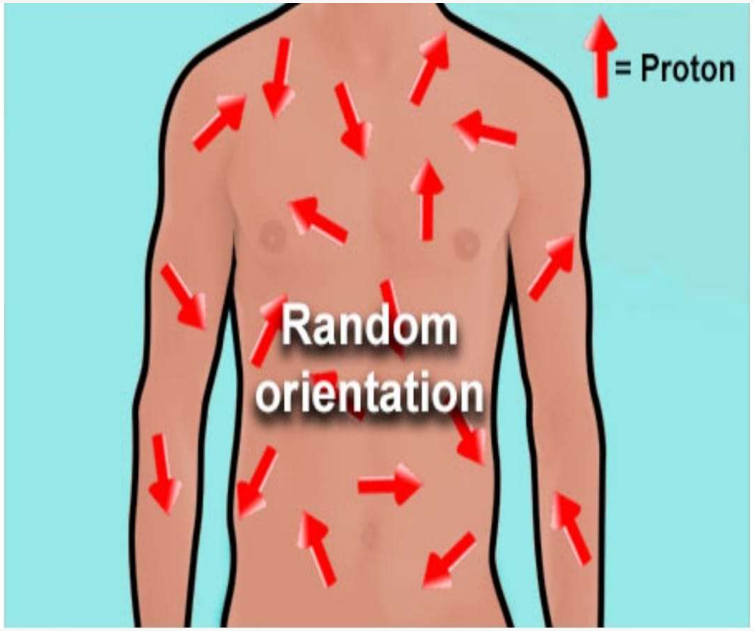


What is a magnetic resonance signals:

- To produce ‘signal’, the MRI scanner interacts with protons in the body. Randomly orientated protons become aligned with the powerful magnetic field in the bore of the scanner.
- A rapidly repeating sequence of radiofrequency pulses - produced by the scanner - then causes ‘excitation’ and ‘resonance’ of protons.
- As each radio frequency pulse is removed, the protons ‘relax’ to realign with the magnetic field, and as they do so they give off radio frequency ‘signal’ which is detected by the scanner and transformed into an image.
- proton excitation and relaxation During scanning, signal is produced by the repeated process of alignment, excitation/resonance, and relaxation of protons in the body.

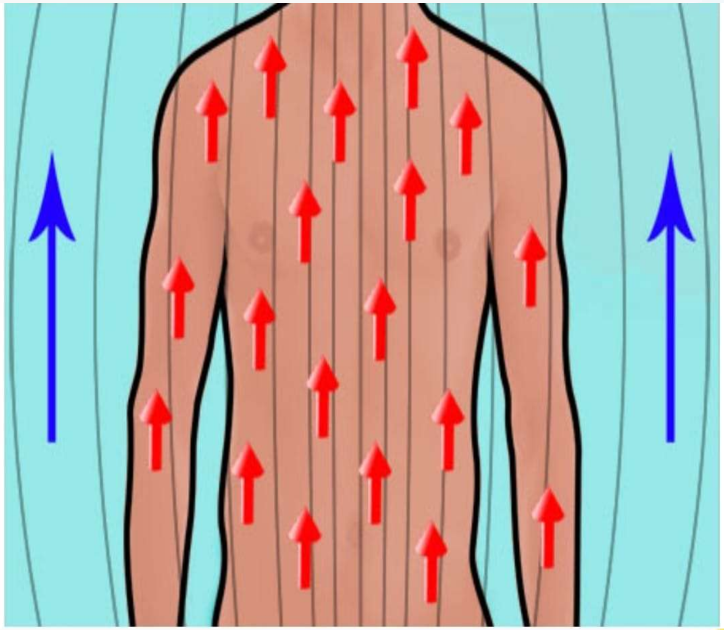
Free protons in body

- Free protons within molecules of the body are orientated randomly, spinning on a North-South magnetic axis



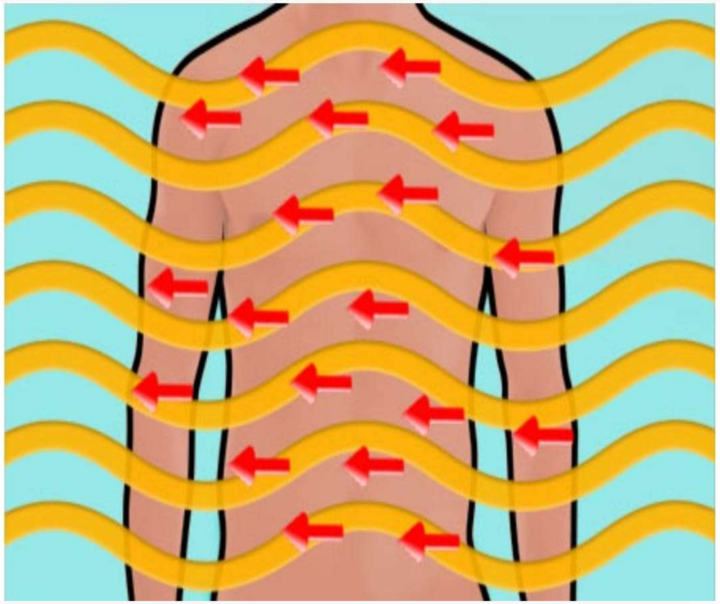
protons aligned in scanner

- On entering the scanner, the protons align with the axis of the magnetic field (blue arrows) within the bore of the scanner.



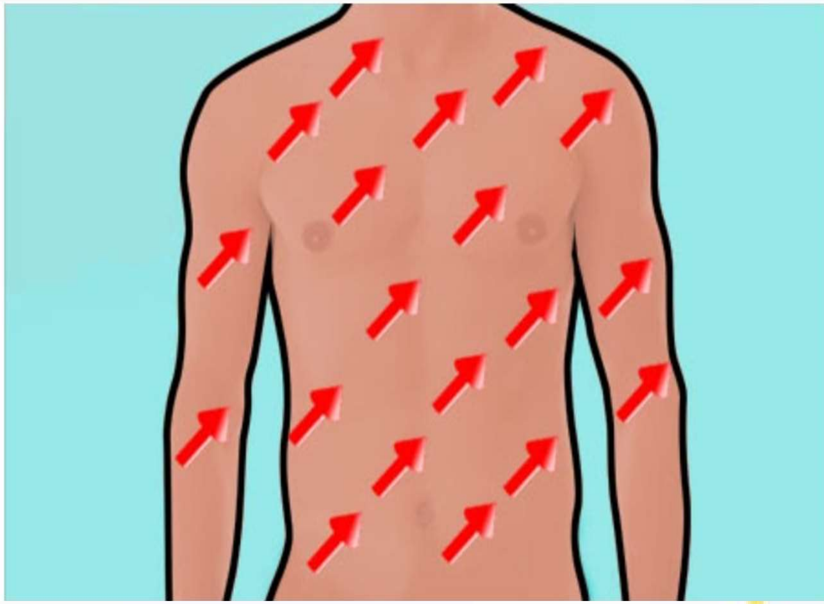
Radiofrequency pulse

- A radiofrequency pulse is applied to ‘excite’ the protons
- Protons are aligned at an angle to the magnetic field
- The radiofrequency pulses also cause the protons to spin in phase with each other creating 'resonance'



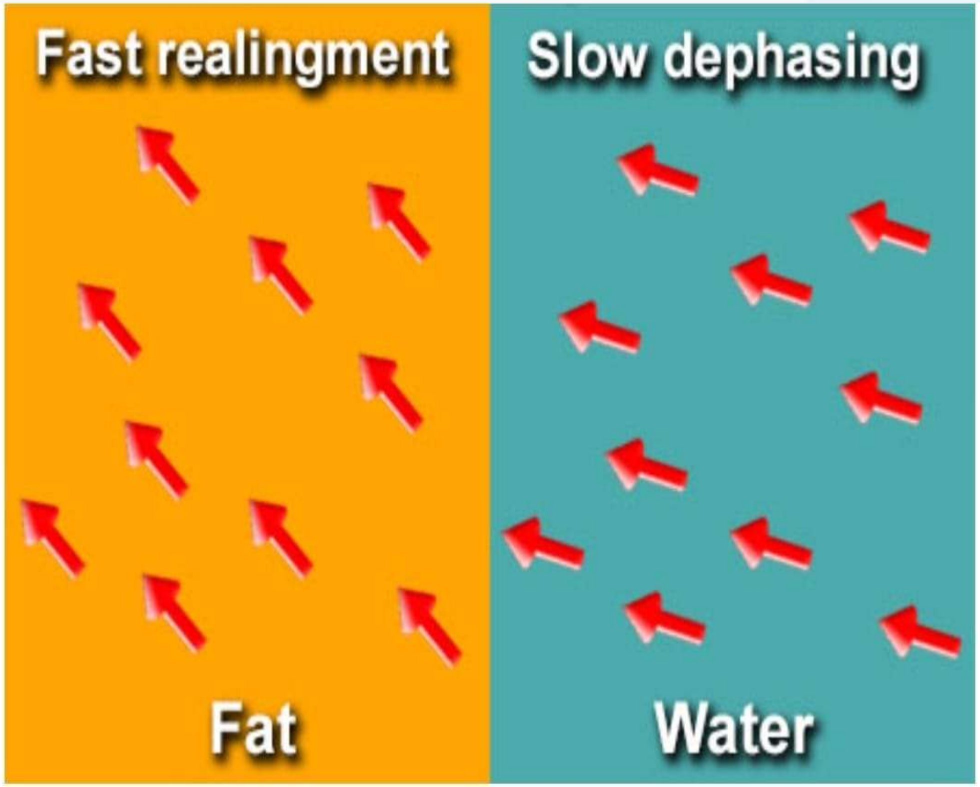
Signal creation

- Milliseconds after removal of each radiofrequency pulse the excited protons 'relax', giving off radiofrequency signal which is detected by the scanner
- Two types of relaxation occur - 1. Realignment of protons with the magnetic field and - 2. Dephasing of spinning protons (loss of resonance)



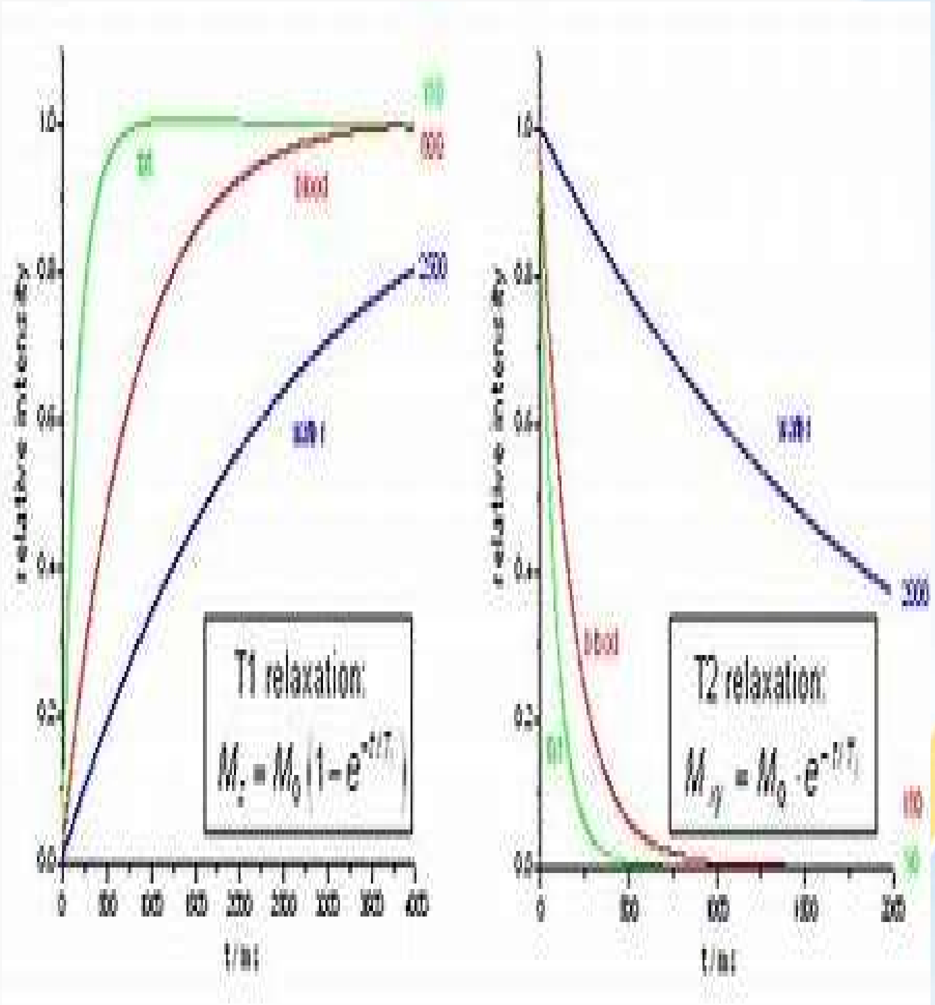
Tissue differentiation - Fat v water

- Protons in the body realign and dephase with varying rapidity depending on the tissue type
- Detecting the signal after different time intervals allows different tissue types to be highlighted
- Protons in fat realign quickly with high energy and produce high T1 signal – this phenomenon is exploited to produce 'T1-weighted' images which highlight fat in tissues of the body
- Protons in water dephase slowly – this phenomenon is exploited to produce 'T2-weighted' images which highlight water in tissues of the body



T1 AND T2 RELAXATION

- When RF pulse is stopped higher energy gained by proton is retransmitted and hydrogen nuclei relax by two mechanisms
- T1 or spin lattice relaxation- by which original magnetization (Mz) begins to recover.
- T2 relaxation or spin spin relaxation - by which magnetization in X-Y plane decays towards zero in an exponential fashion. It is due to incoherence of H nuclei.
- T2 values of CNS tissues are shorter than T1 values



BULK MAGNETIZATION OF GRAPHENE:

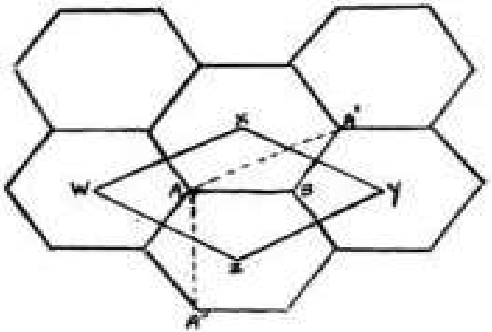


FIG. 1.

1 conduction electron for each C atom in the $2pz$ state.

Unit cell (WXYZ) contains 2 atoms (A and B).
$a_1 = a_2 = a = 2.46$ Å
(foundamental lattice displacement).

The base functions are periodical functions with the same periodicity as the (2D) lattice. $\boldsymbol{k}$ is a wave vector. It defines a reciprocal lattice and acts as a kind of quantum number.

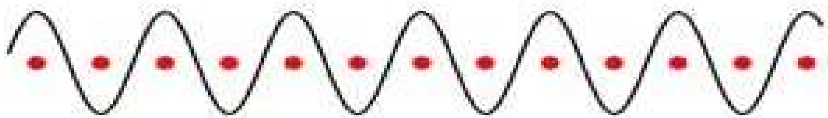
Tight binding approximation: the mobile electrons are always located in the proximity of an atom, and then are conveniently described by the p_z atomic orbital of the atoms it touches.

$X(r)$: normalized $2p_z$ wavefunction for an isolated atom.

$$\psi_k(r) = \varphi_1(r) + \lambda\varphi_2(r)$$

$$\varphi_1(r) = \sum_A e^{2\pi i \boldsymbol{k}\cdot\boldsymbol{r}_A} X(\boldsymbol{r} - \boldsymbol{r}_A)$$

$$\varphi_2(r) = \sum_B e^{2\pi i \boldsymbol{k}\cdot\boldsymbol{r}_B} X(\boldsymbol{r} - \boldsymbol{r}_B)$$



Extended wave function

A. Barbon, Corso di Magnetochimica. A.A. 2013-14. Graphene

THANK YOU