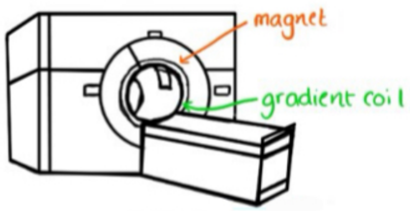
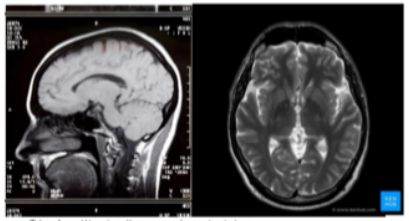
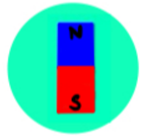
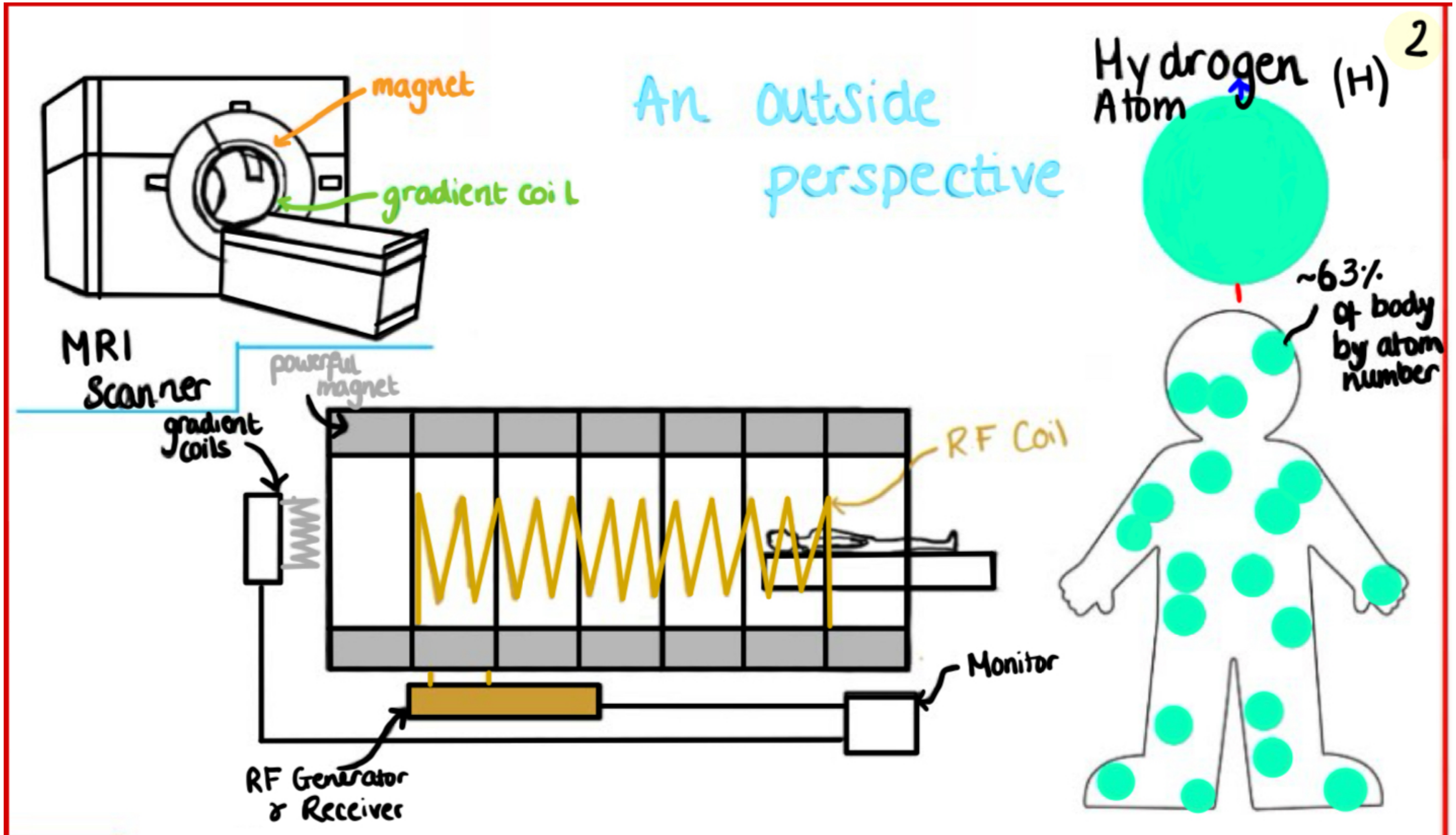
AN INTRODUCTION TO MAGNETIC RESONANCE IMAGING (MRI)



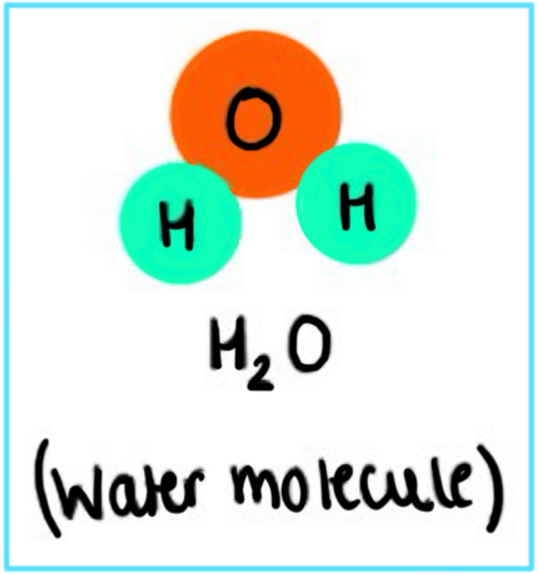


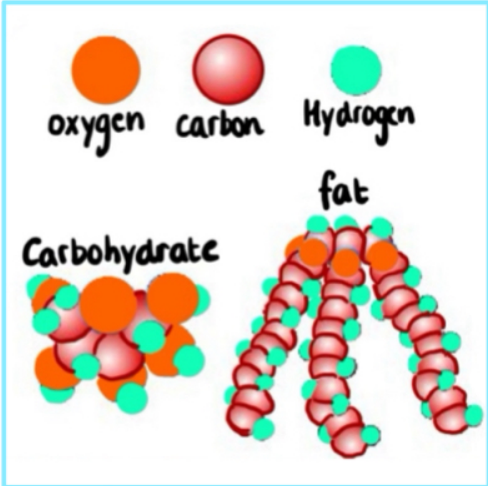
Taken from: Www.headline.com and www.kenhub.com

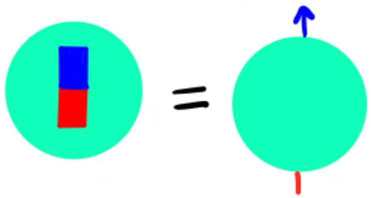


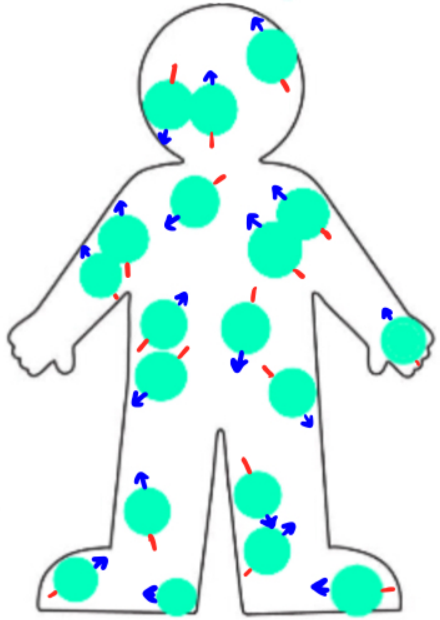


Magnetic Resonance Imaging (MRI) scanners are extremely important in the medical sector as they can take images of any part of the body, and provide a good contrast of soft tissue. Unfortunately, an issue with MRI scanners is that they can be noisy, patients must lie still and they can't have an MRI scan if they have metal implants. This short introduction aims to explain what MRI is and how it works. The picture shows that in the machine we have a strong magnetic field and a system that allows for 'pulses' of radio frequency light to be transmitted. Simply, in MRI we detect hydrogen. Approximately 63% of the number of atoms in the human body are hydrogen atoms.

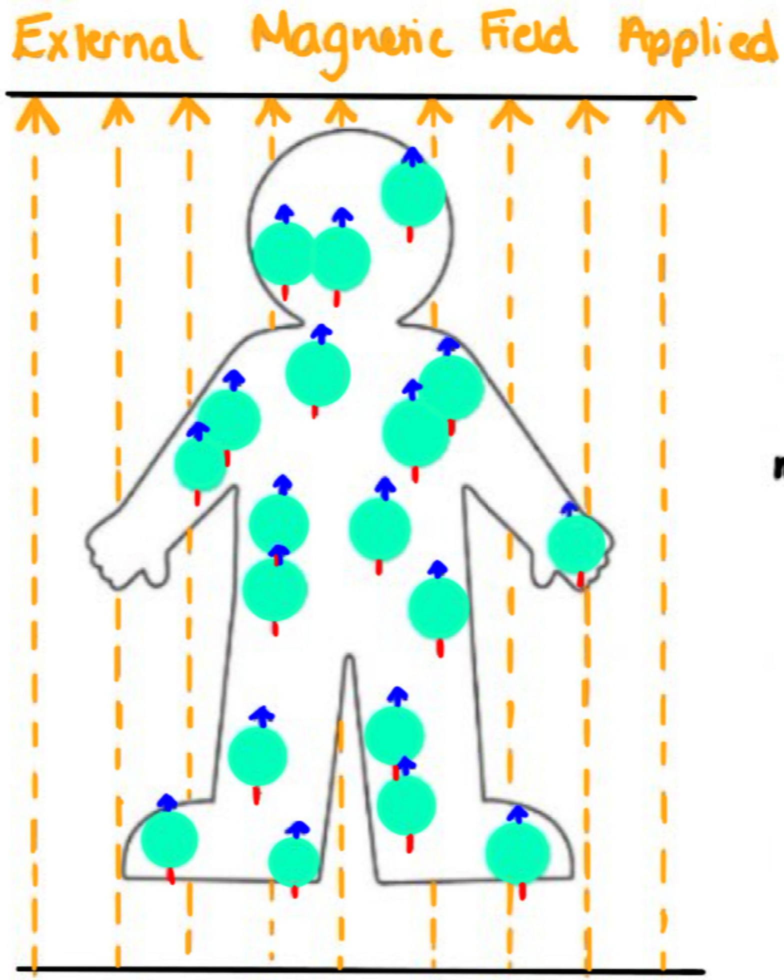


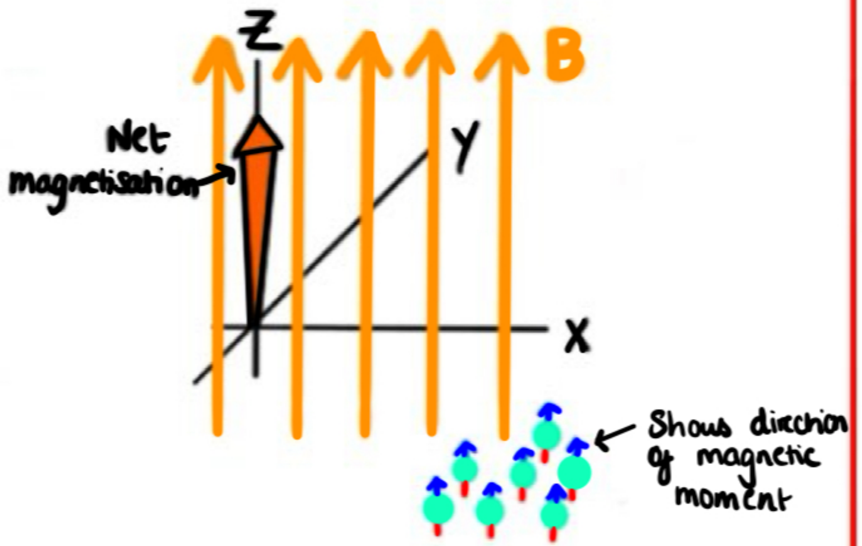




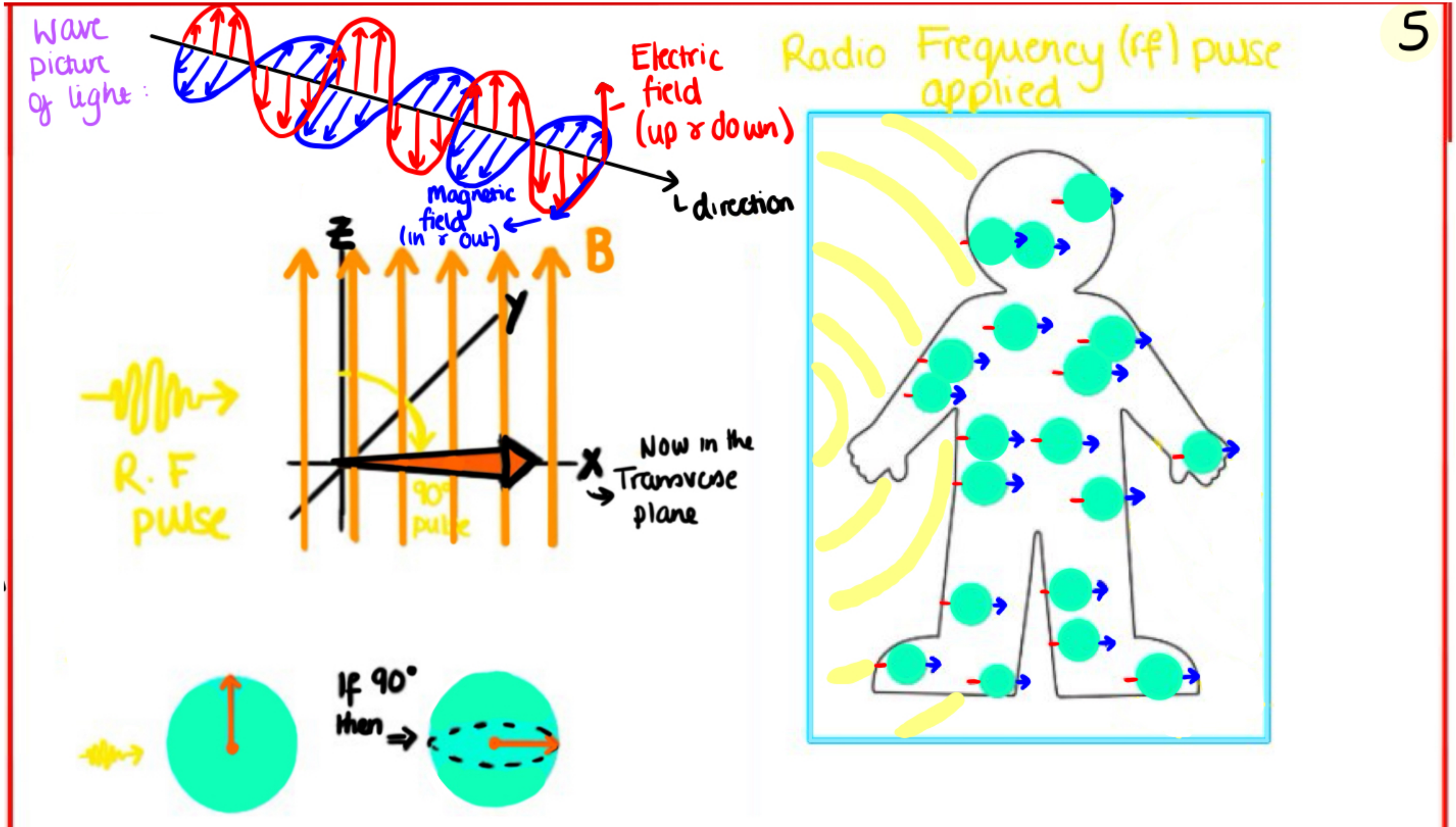


The human body is partially composed of water, sugars and fat, all of which include hydrogen. Like other atoms, hydrogen has a nucleus with electrons orbiting it. This nucleus has a charge, mass and a property called spin, meaning it can act like a mini magnet. Therefore it can interact with magnetic fields. Typically, the magnetic part of hydrogen atoms, called their magnetic moment, are not aligned.

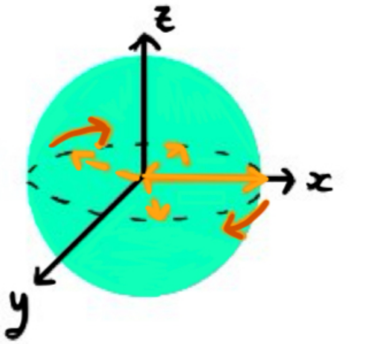


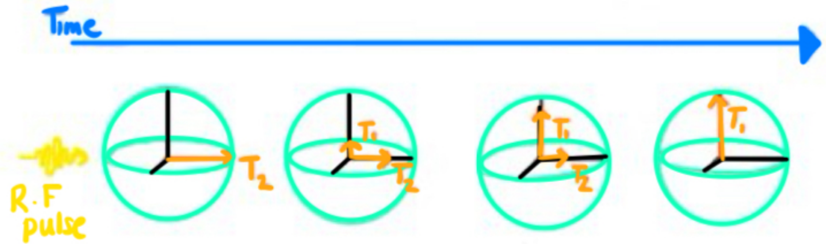


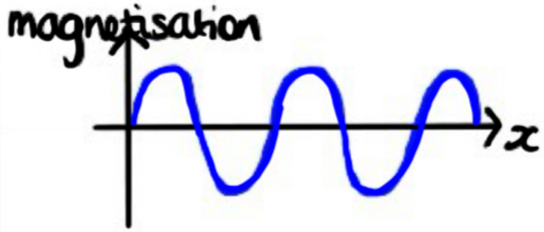
The MRI scanner's magnet creates an external magnetic field. When placed into the scanner, the magnetic moments of the hydrogen atoms align with the direction of this magnetic field. As the hydrogen atom's magnetic moments line up together they add up, creating a net magnetisation in one direction.

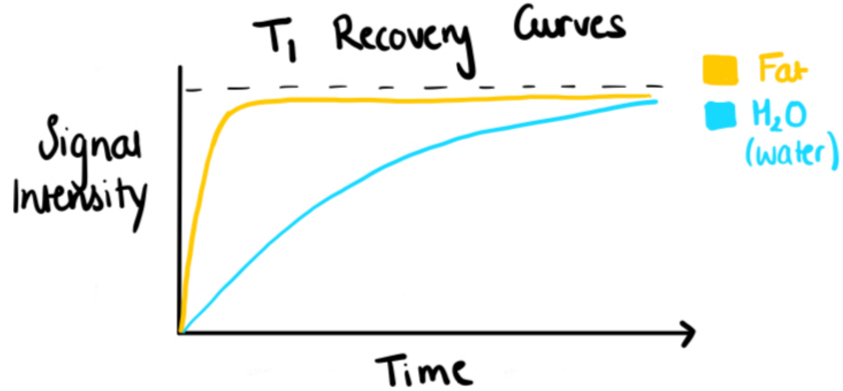


Light contains both electric and magnetic fields: it is able to interact with the magnetic moment of the hydrogen atom. For MRI this light is in the radio frequency (RF) region of the electromagnetic spectrum. So when a radio frequency pulse is applied it causes the atoms to be ‘knocked’ 90 degrees into the transverse (horizontal) plane. Resulting in a transverse magnetisation.



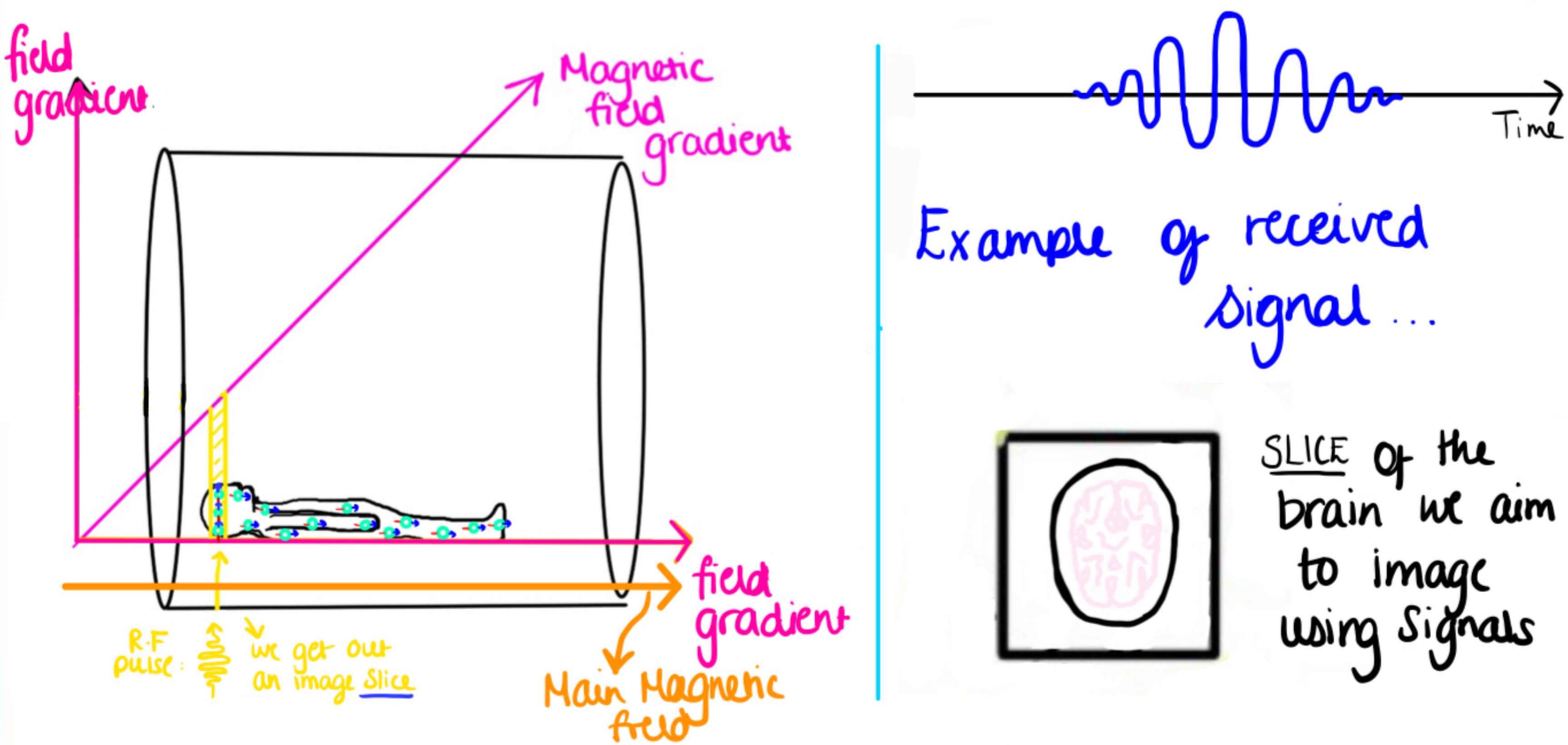






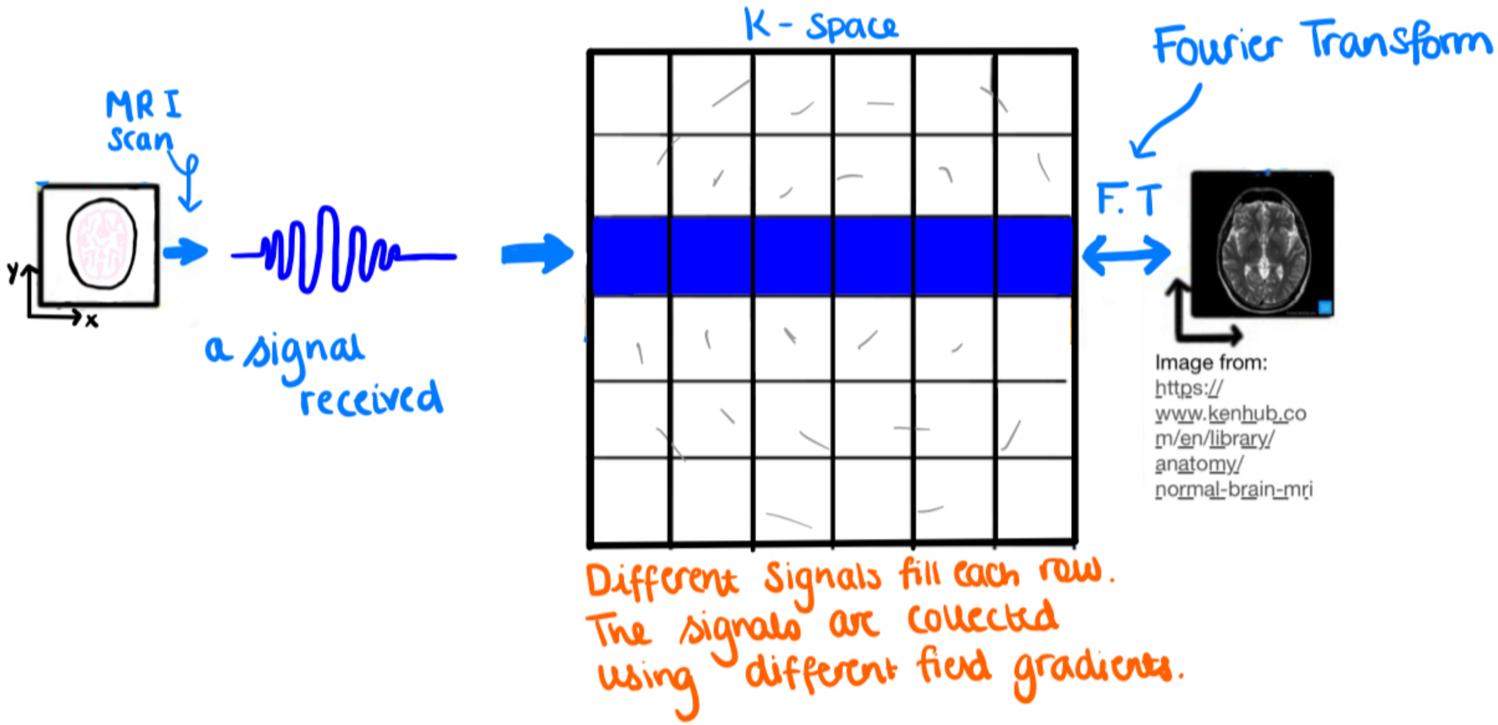
When the RF field is turned off, the magnetisation in the transverse plane rotates. The rotating magnetisation produces a current in the MRI detector. The magnetisation will now relax to align in only the direction of the external magnetic field. There are two important times: the time for transverse decay (T_2), and the time for recovery of alignment with the external magnetic field (T_1). These times depend on the environment of the hydrogen. For example, if the hydrogen is part of water or fat. The different environments will show up on the MRI image with different brightnesses, this is called *contrast*.

Inside the MRI Machine:



Here we see a perspective of what happens inside the MRI scanner. We use the magnetic field gradient caused by the gradient coils, and transmit specific RF pulses. A combination of field gradients and pulses leads to an image slice being selected and then a signal. Many signals must be detected to give the complete slice.

FROM DATA TO IMAGE:



The data we receive from the signals is in what physicists call k-space which is related to real space by a mathematical technique called Fourier Transformation. A Fourier Transform (FT) of the MRI data for the slice produces the desired image.

different types of MRI image

Tissue Type	T1 image	T2 image
Water / fluid	Dark	Bright
Fat	Bright	Bright
Solid / Some bones (typically very little hydrogen)	Dark	Dark

See a contrast on the image

Better view of soft tissue

Better view of bones

Adapted from: https://www.healthline.com/health/mri-vs-xray#gallery-open

MRI X-RAY

Due to the amount of hydrogen and the different relaxation properties of hydrogen in the different biological substances, the MRI image has darker and lighter areas, this is the contrast. Utilising different types of MRI measurements produces specific contrast images that allow specific areas of interest to be seen. Above you can see a comparison of an MRI image and and X-Ray image.