

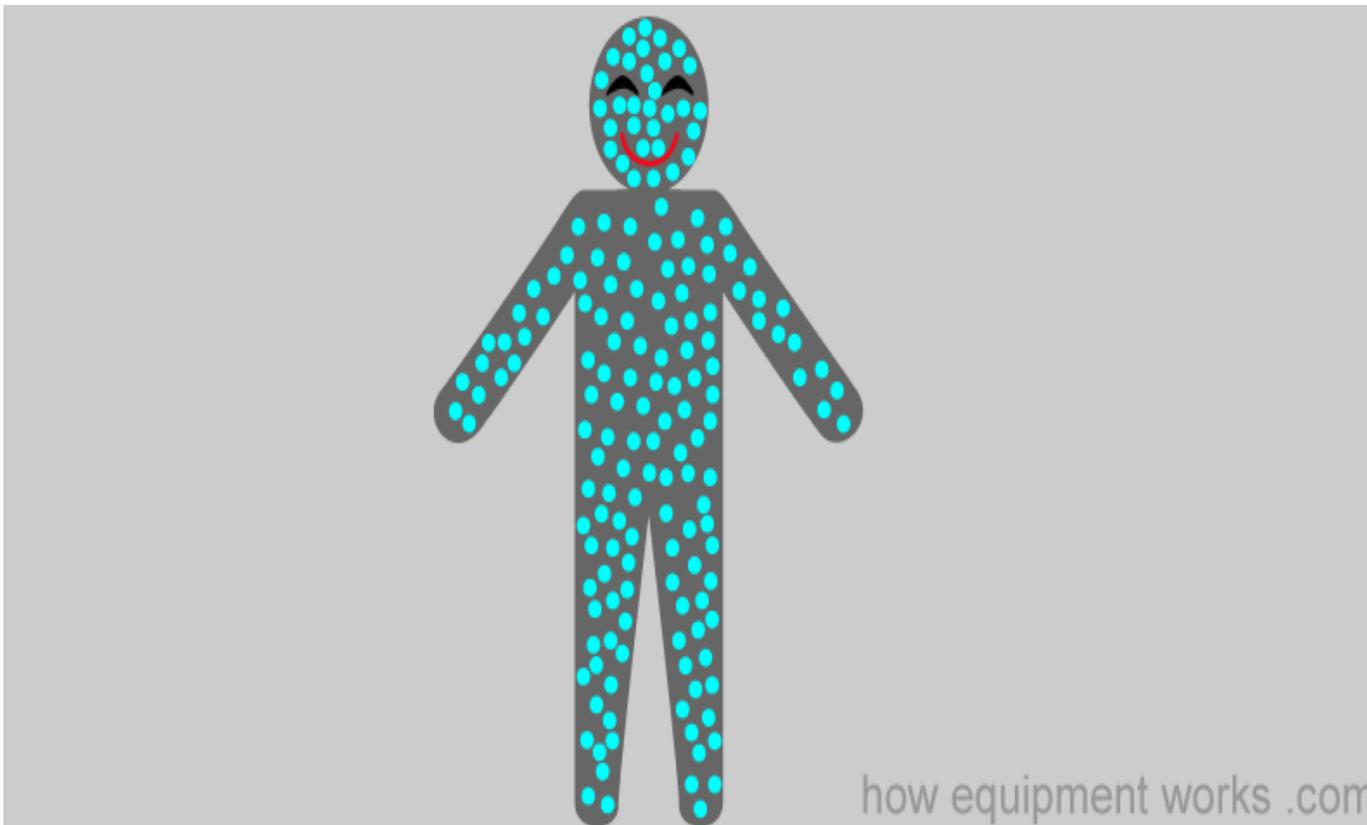
## What is an MRI?

This is a shortened version of the explanation of how an MRI works found on [howequipmentworks.com](http://howequipmentworks.com).

Magnetic resonance imaging (MRI) is a test that uses powerful magnets, radio waves, and a computer to make detailed pictures inside your body.

It is all about water (the hydrogen nuclei) !

The MRI machine is able to “see” water and this makes it a very useful tool as we humans are mostly made out of water (about 70 %). Water is distributed throughout our body in different ways and the MRI machine is able to see these differences and construct an image for us.

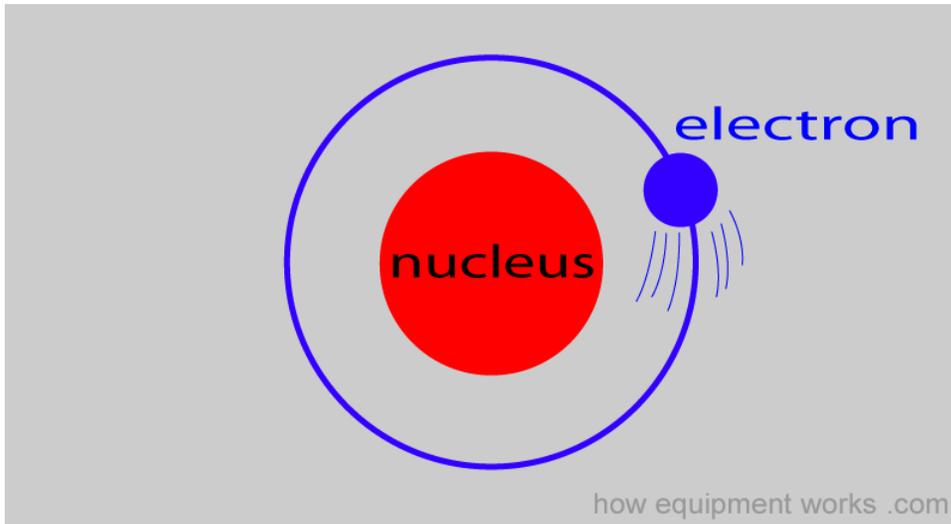


As you probably know, water consists of water molecules. A water molecule is made up of two hydrogen atoms and one oxygen atom.

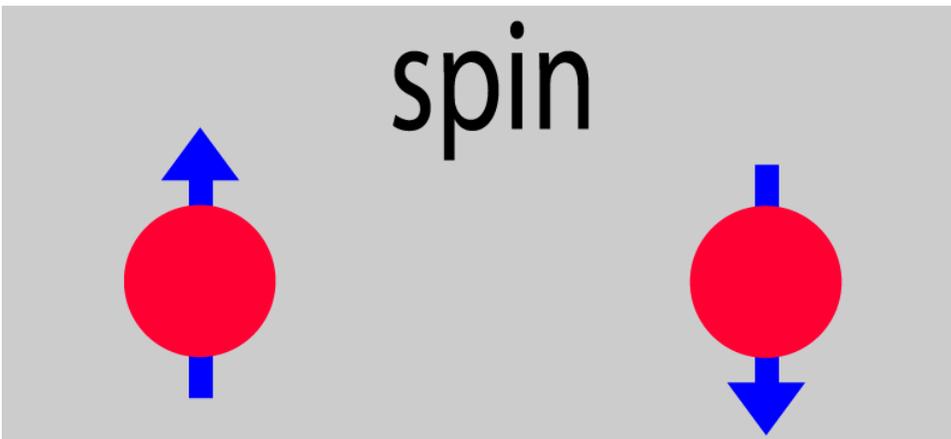
The MRI machine does not “see” all parts of the water molecules. Instead, it sees only specific parts of each water molecule.

The MRI machine can only see the hydrogen atoms shown in red below.

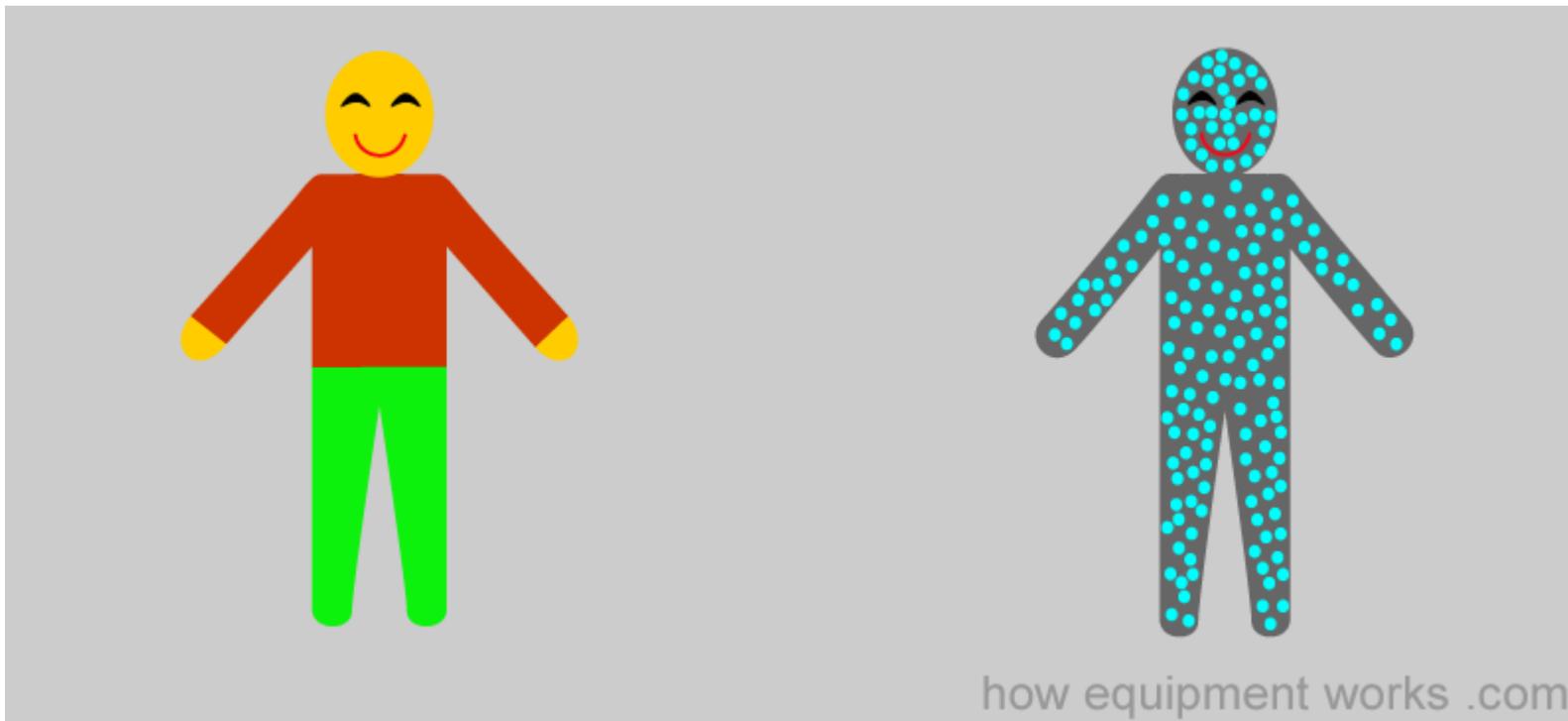
Each hydrogen atom consists of a nucleus with one electron going around it. The MRI machine doesn’t “see” these electrons either.



All it sees is the hydrogen nucleus.



Hydrogen nuclei have a quantum physics property called "spin".

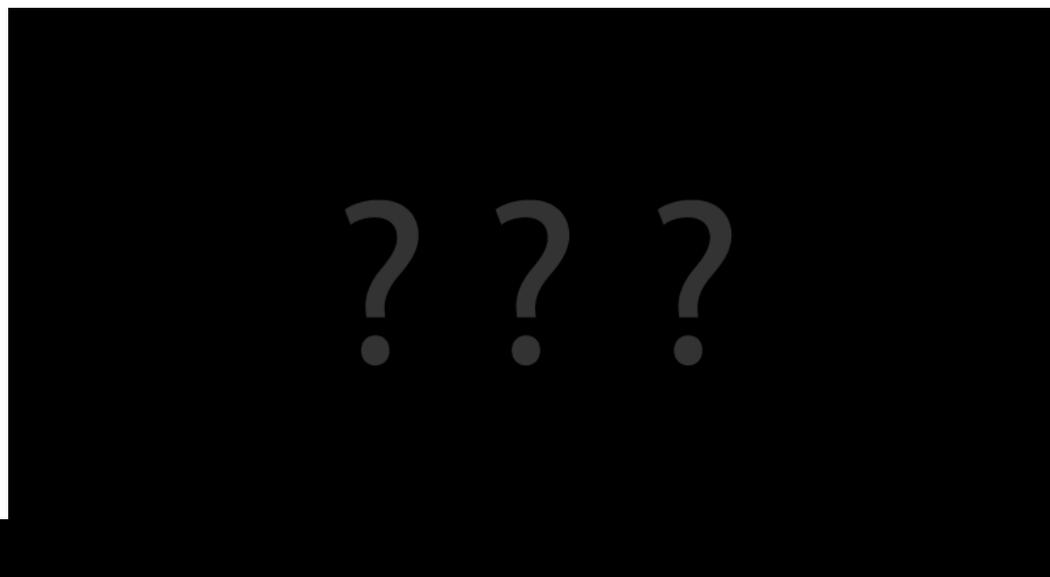


The MRI machine cannot just simply “see the hydrogen nuclei which lie “hidden” in the water molecules distributed in the patient.

It needs to do ‘something’ to the hydrogen nuclei to detect their presence. It is a bit like the scenario I will describe to you. Just imagine that we have three grumpy men.

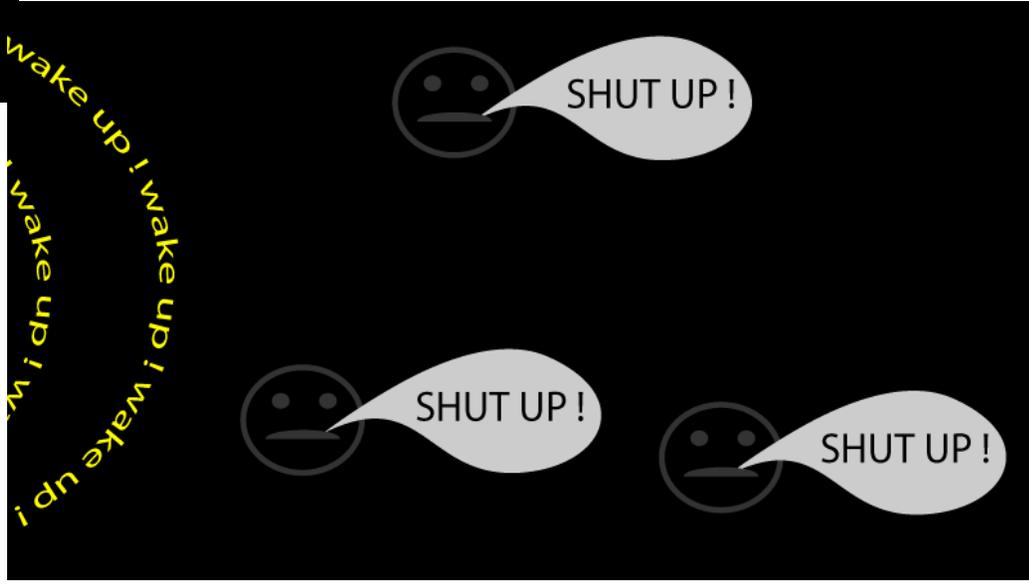


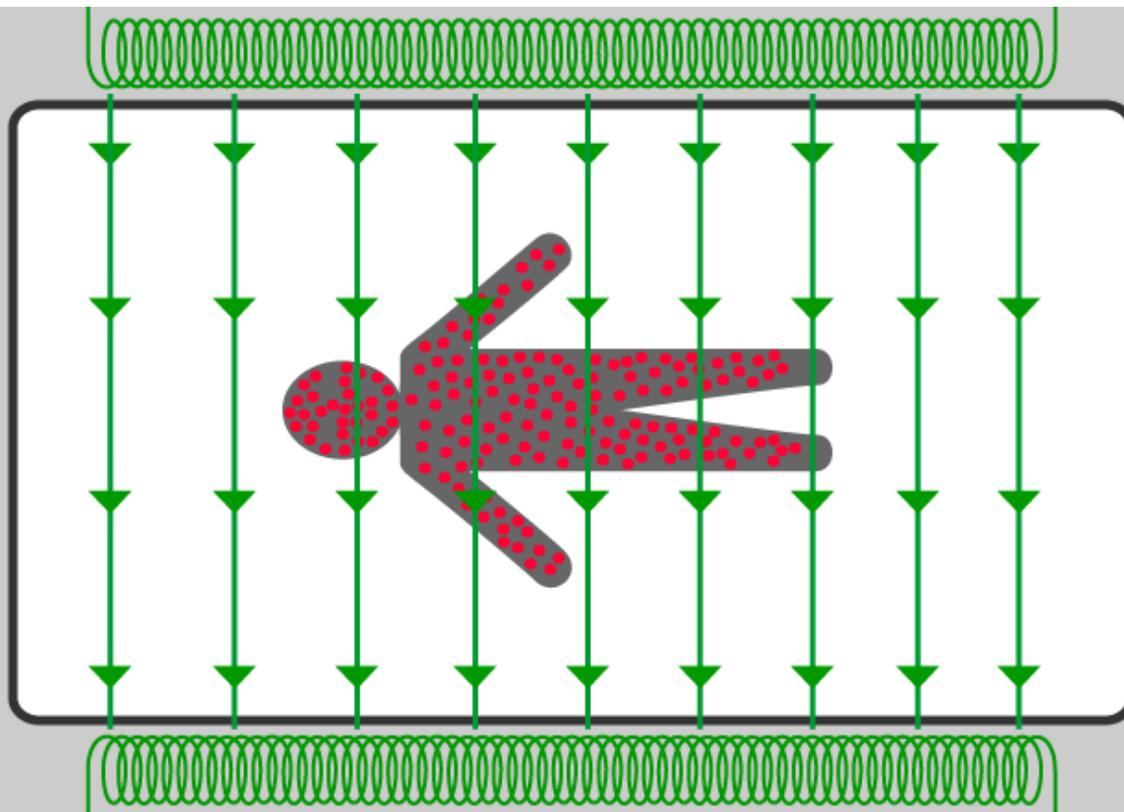
The three grumpy men are now sleeping in this black room. Let us imagine that you have work out where each of the three men are. But looking at the room, you really can't make out where they are since it is completely dark.



One way to work out where the three men are is to "irritate them". You send some "energy" across the room in the form of you shouting "wake up" repeatedly.

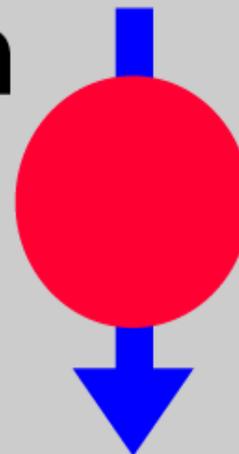
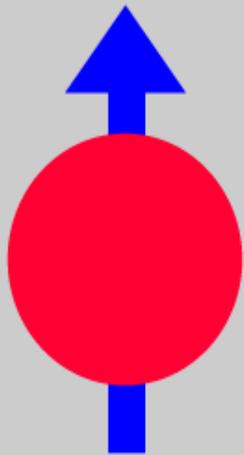
This will agitate the men and they will shout back at you. By working out from where their voices are coming, you can identify where the three men are.





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## spin orientation



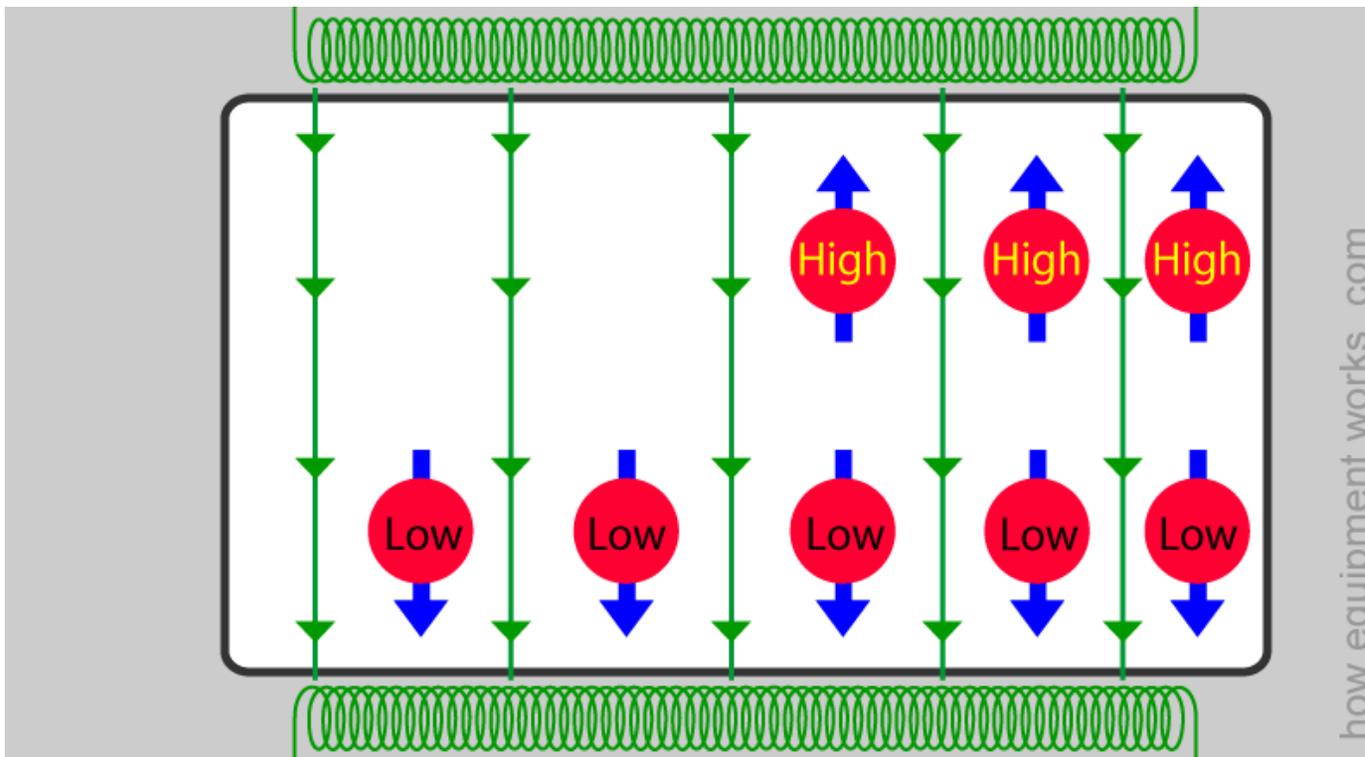
We now put the patient into the magnetic field of the MRI machine.

The patient, like all of us, has water molecules distributed all over. As described before, the water molecules have hydrogen nuclei, and this is what is of interest to the MRI machine.

You will recall that hydrogen nuclei have a property called 'spin'. The spin can be 'oriented' in certain ways.

The magnetic field makes the "spins" line up along the magnetic field.

Some align with the field and some align opposite the field

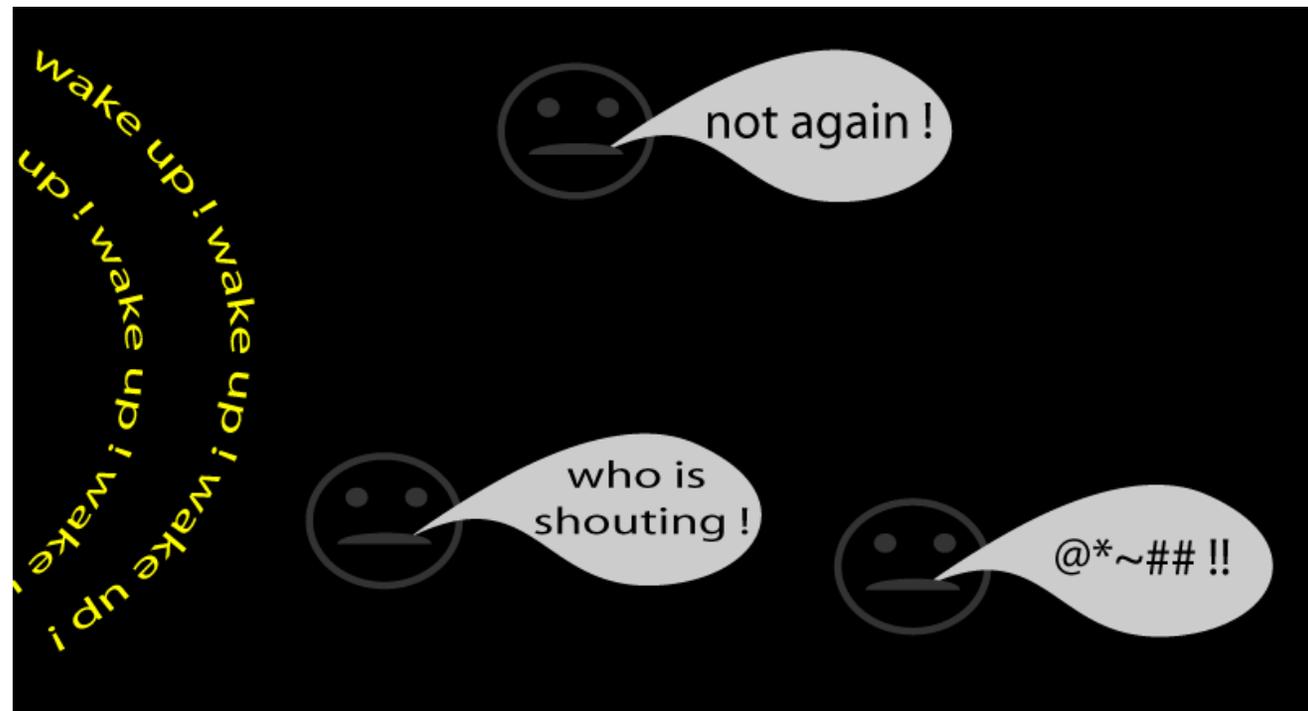


High energy hydrogen nuclei are opposite the magnetic field.

Low (lazy) energy are with the magnetic field.

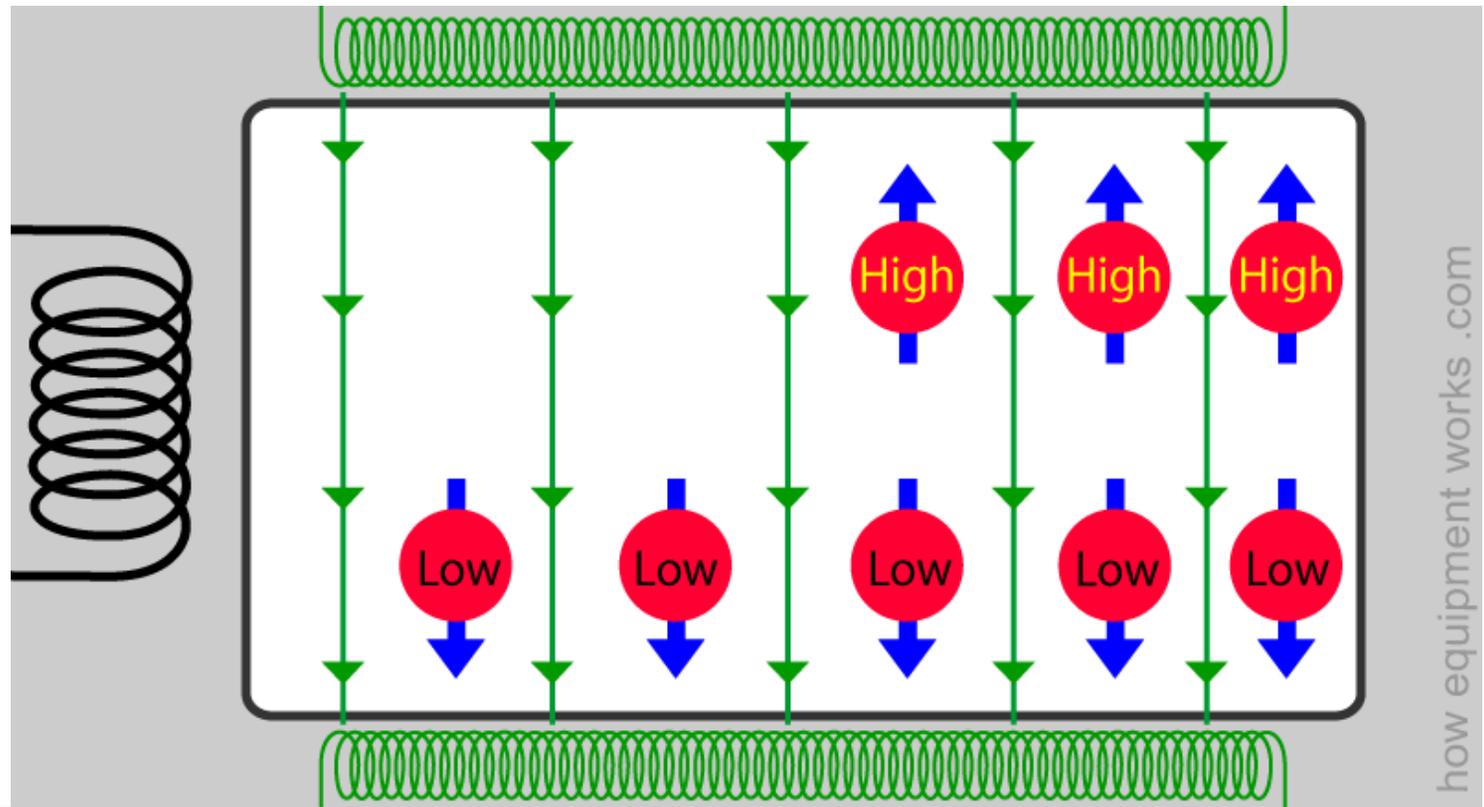
Do you remember our story about finding the three grumpy men by irritating them ?

As mentioned, the MRI machine does something similar. However, instead of 'shouting' things, it uses 'energy' to 'irritate' the low energy hydrogen nuclei.

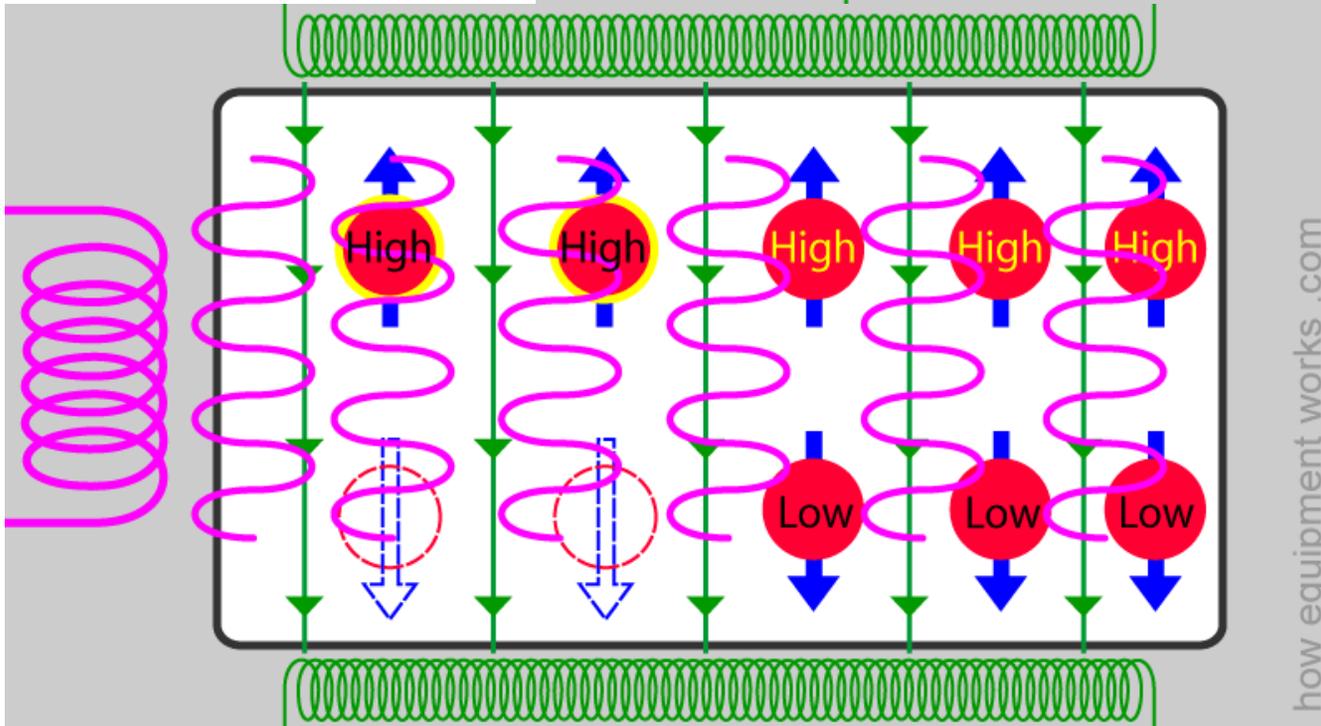


The MRI machine has a special coil of wire that is there to produce the needed energy to 'irritate' the low energy hydrogen nuclei. In this diagram, this coil is shown in black, on the left side.

The MRI machine applies a current to this energy-producing coil for a short period. During this period, the coil produces energy in the form of a rapidly changing magnetic field (this energy is often called "radio frequency" energy (RF energy) and the coil is often called an radio frequency coil ( RF coil).



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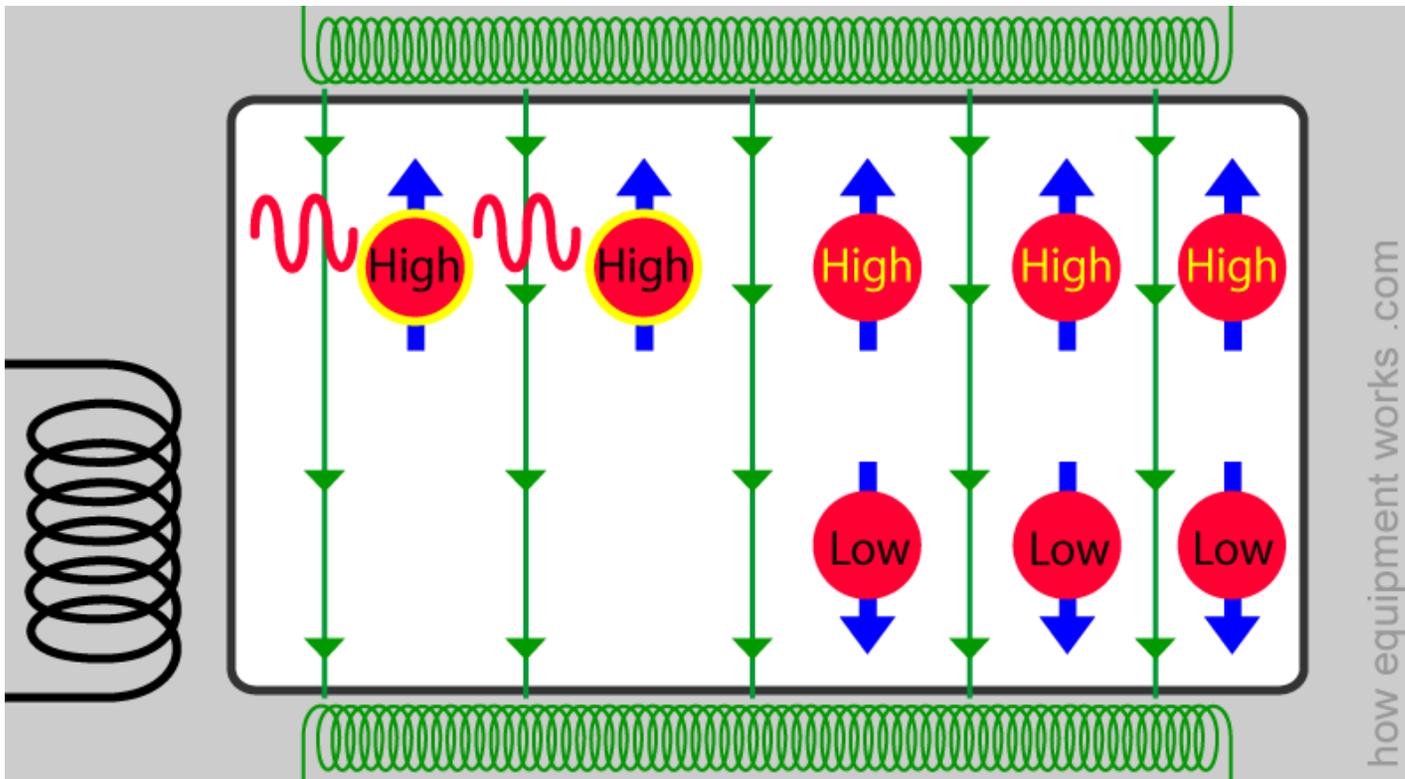


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The hydrogen nuclei with low energy absorb the energy sent from the coil.

The absorption of RF energy changes the energy state of the low energy hydrogen nuclei. Once the low energy nuclei absorb the energy, they change their spin direction and become high energy nuclei.

After a short period, the RF energy is stopped.



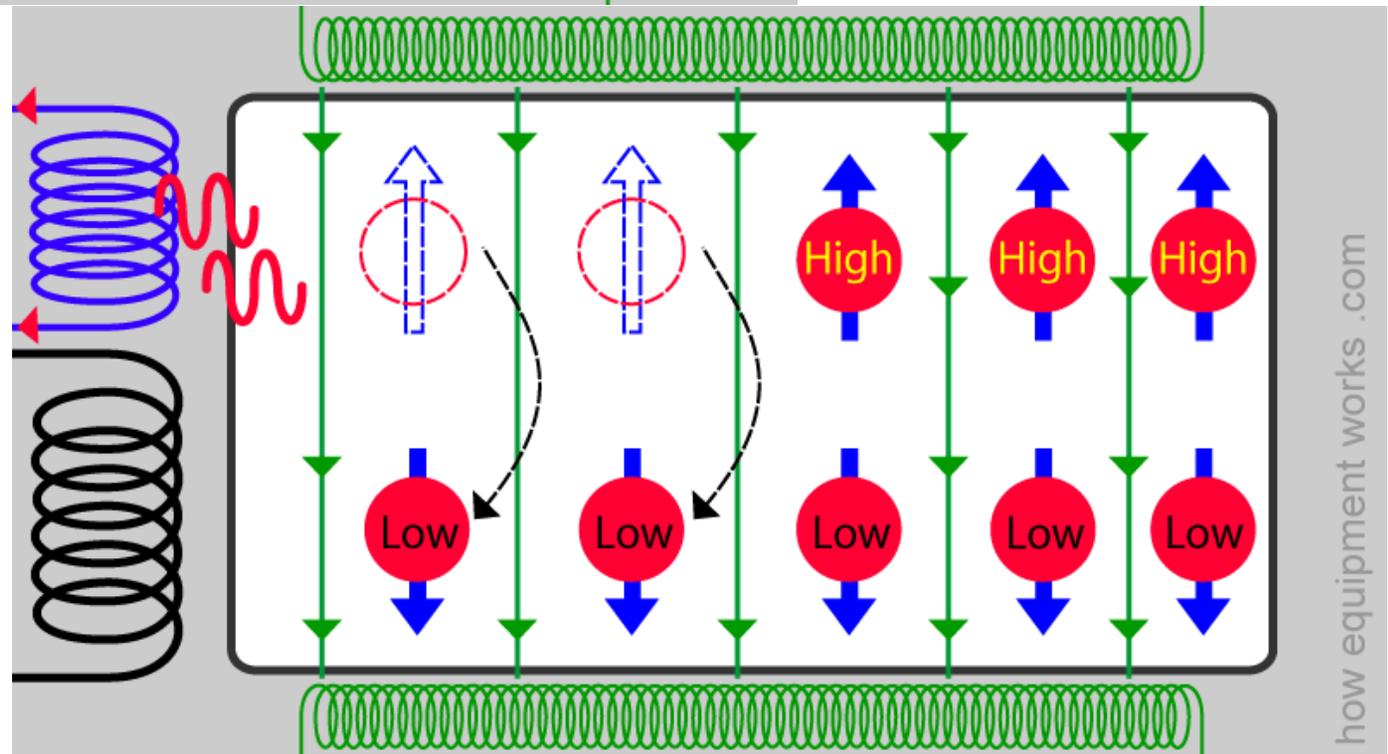
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The hydrogen nuclei that recently became 'high energy' prefer to go back to their previous, 'low energy' state and they start releasing the energy that was given to them (i.e. the previously lazy nuclei want to be lazy again !).

They release the energy in the form of waves, which in the diagram is shown in red.

The MRI machine has "receiver coils" (blue coil) that receive the energy waves sent out by the nuclei.

Having given up their energy, the nuclei change their spin direction and return to the low energy (lazy) state that they were in before.

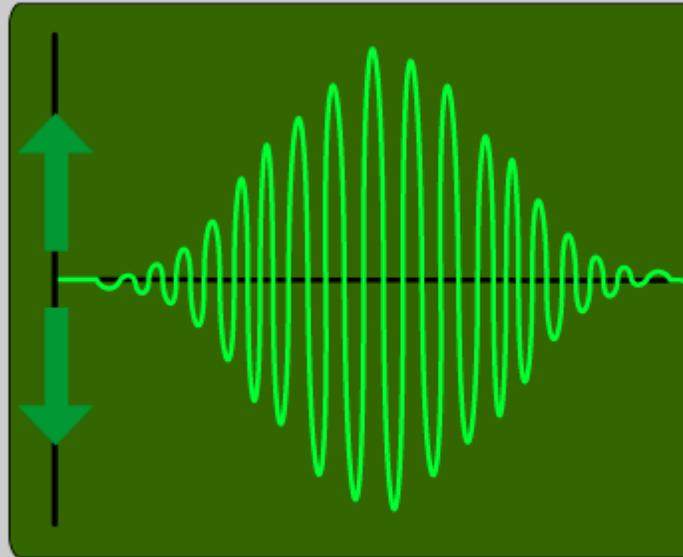


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The receiver coil converts the energy waves received from the nuclei into an electrical current signal.

In this way, the MRI machine is able to detect hydrogen nuclei in the body.

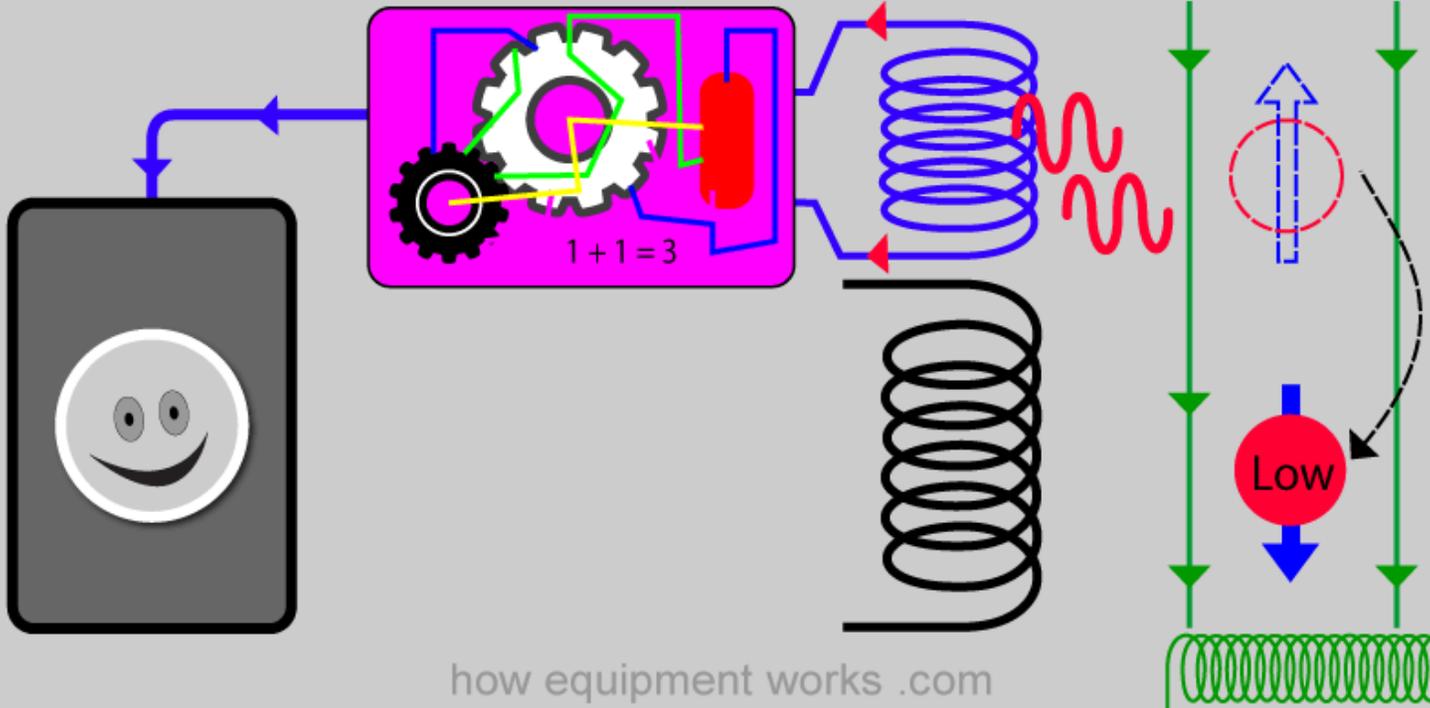
signal induced  
in receiver coil



time →

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computer



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The computer processes all the information gathered to construct the high quality images.

Of course, this is a super simplified version of how actually things happen.



