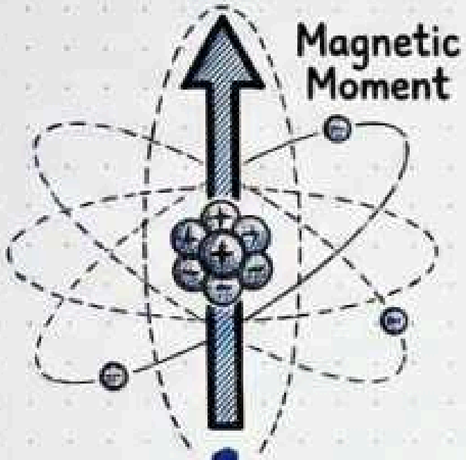
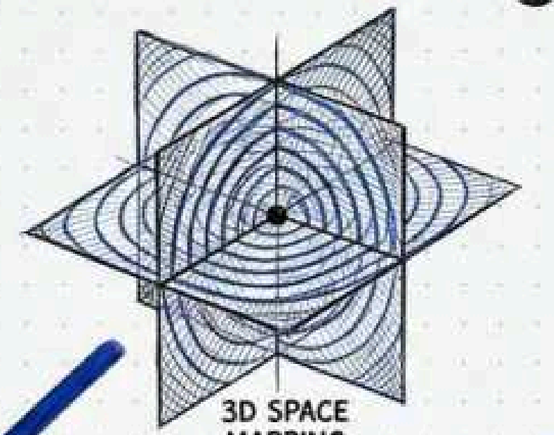
The Origins of Magnetic Resonance Imaging

¶ 4.1







1940s
Discovery of NMR.

1970s
Paul Lauterbur & Peter Mansfield develop spatial mapping.

Late 1970s
First images of patients produced.

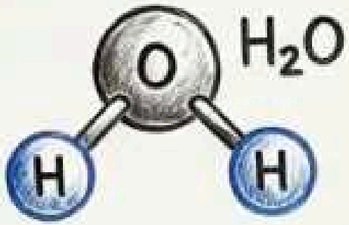
2003
Nobel Prize in Medicine.

CORE PRINCIPLE: Produces highly detailed images of soft tissues entirely without ionising radiation.

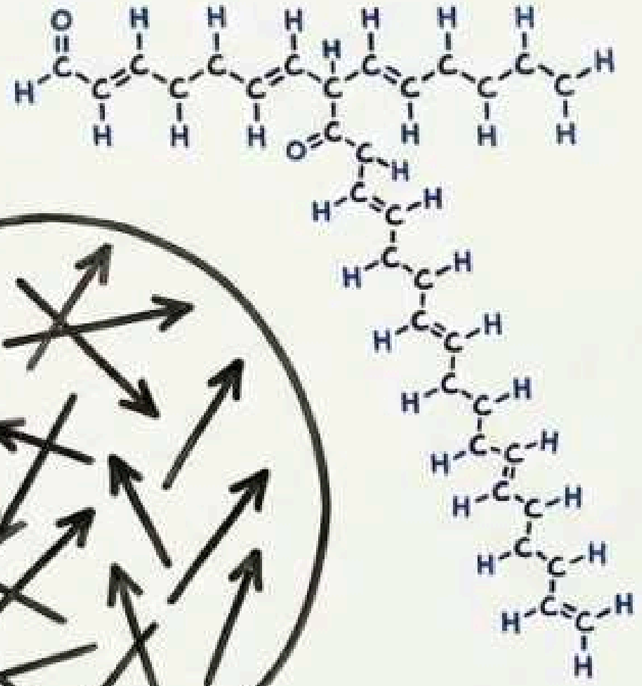
The Physics of Hydrogen Alignment

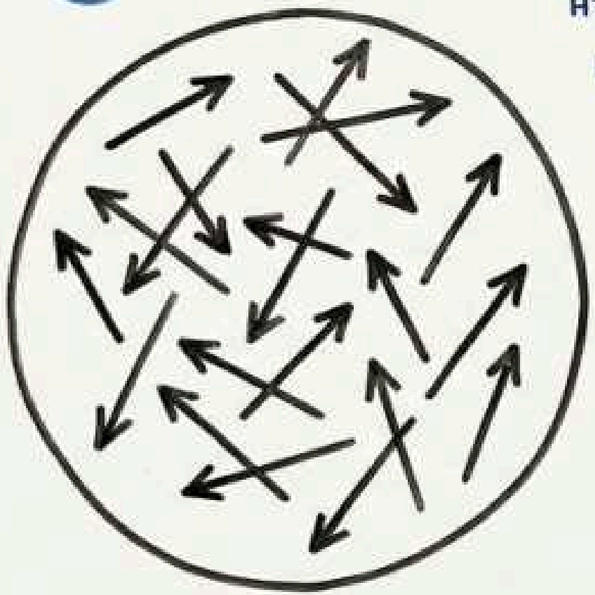
¶ 4.2

The Human Baseline



H_2O





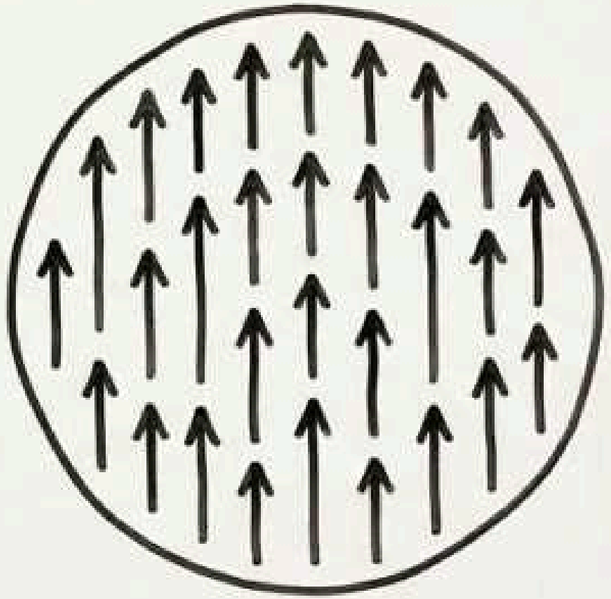
Protons act as tiny magnets (Randomly aligned in the body).

Inside the Scanner



1.5 to 3.0 Teslas

$\approx 10^4$ x stronger than Earth's magnetic field.



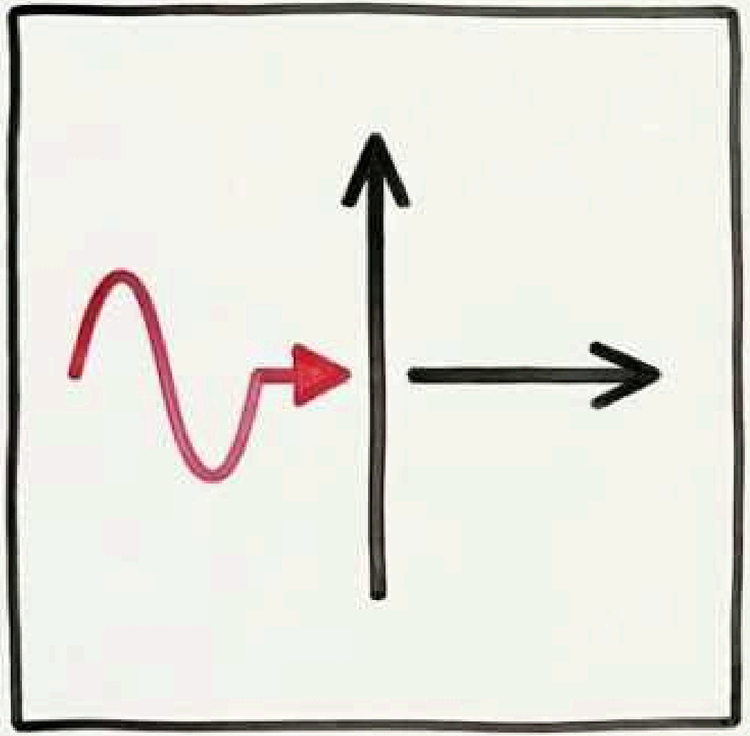
A small excess of hydrogen protons line up with the strong external field.

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Resonance, Signal, and Gradients

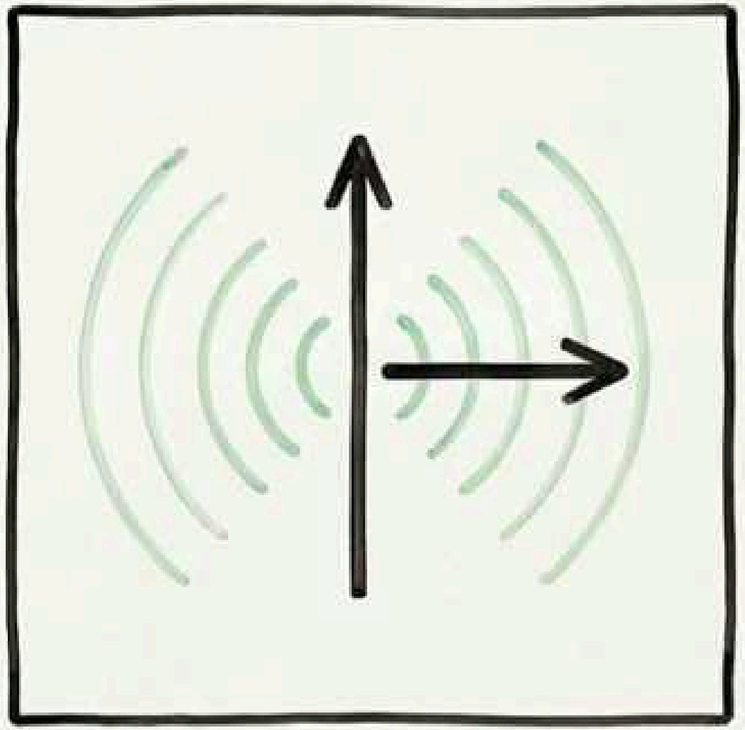
¶4.3

The RF Pulse



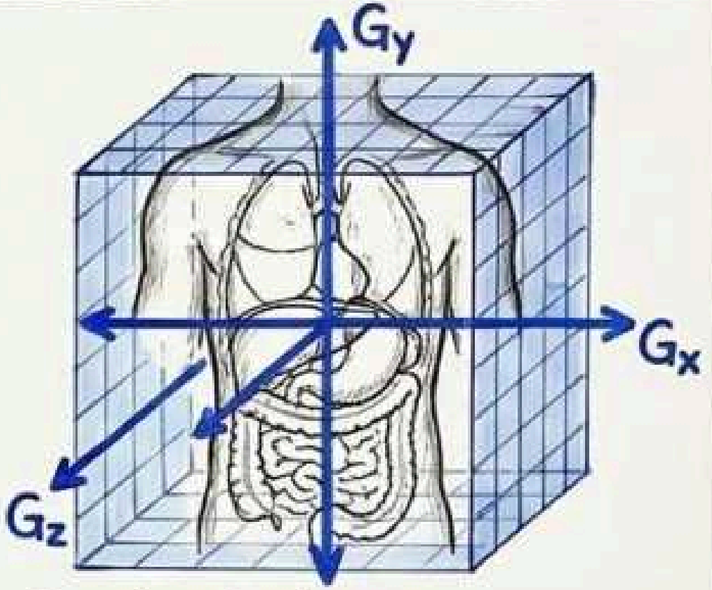
Radio waves at resonant frequency tip protons.

The Echo



Protons return to alignment, emitting a faint radio signal.

Spatial Mapping



Gradients (weaker, varying magnetic fields) make the signal frequency depend on physical position.

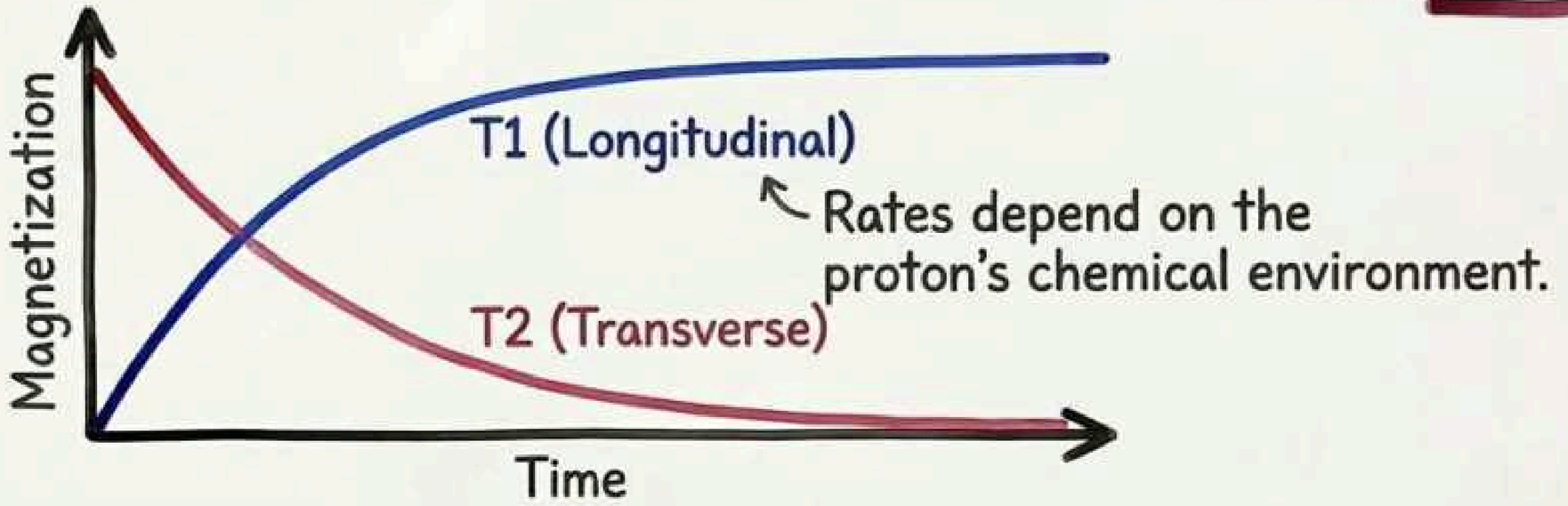


Switching gradients = Loud knocking noise.

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T1 and T2 Relaxation Times

¶4.4



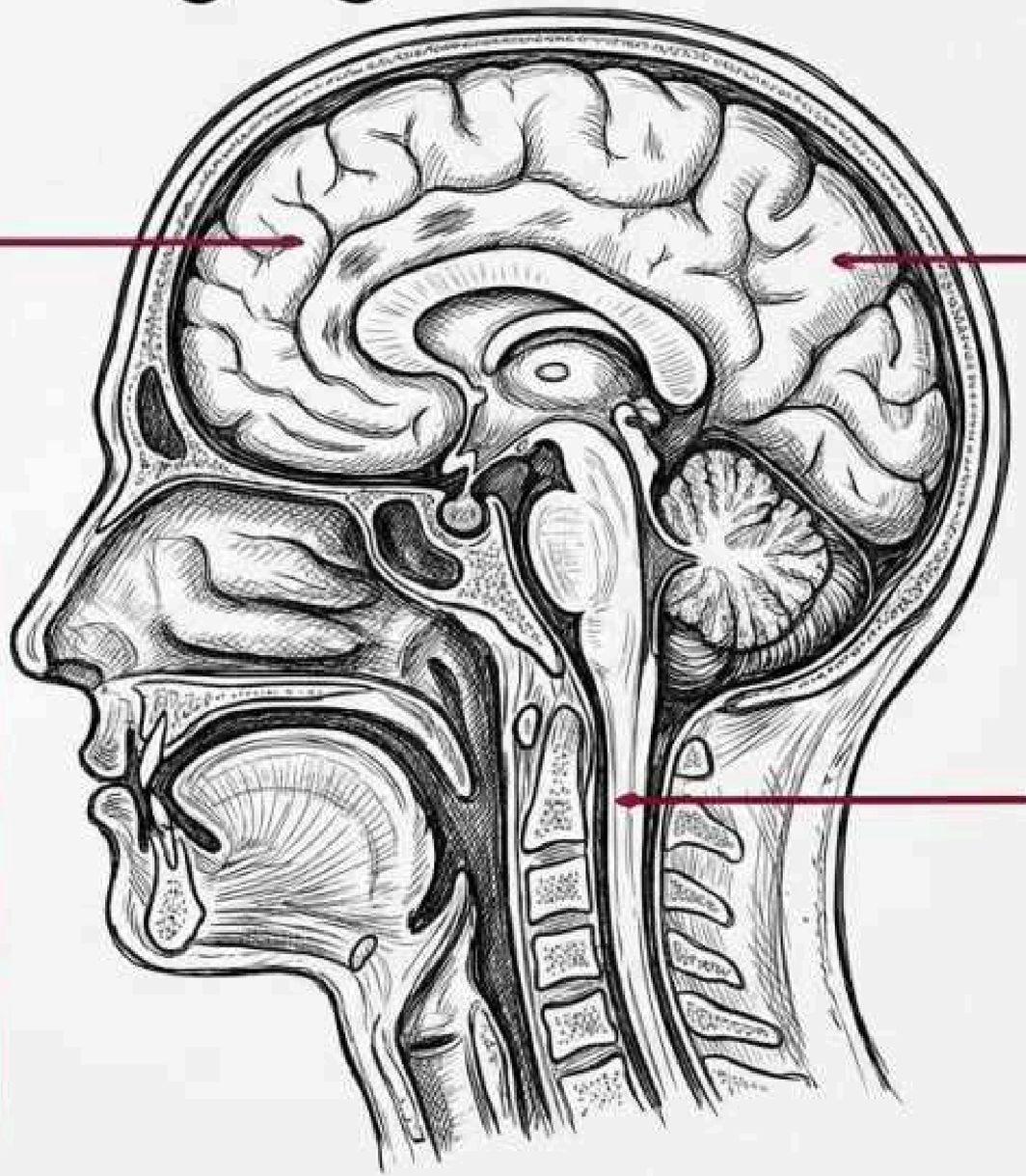
T1-Weighted	T2-Weighted
Fat = Bright Water = Dark Primary Use: Anatomy mapping	Water = Bright Fat = Dark Primary Use: Pathology (Inflammation, swelling, tumours)

Because most diseases increase water content, T2-weighted images are critical for detecting pathology.

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Neuroimaging Excellence

¶ 4.5

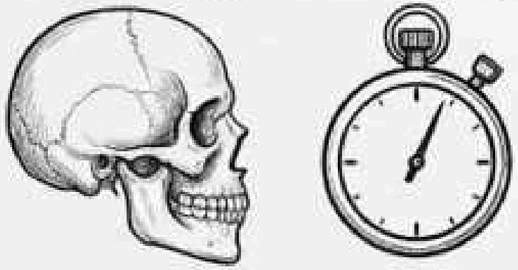


Multiple Sclerosis plaques

Tumours & Stroke effects

Disc prolapse pressing on nerves

Diffusion-Weighted Imaging (DWI)



Measures how freely water moves.
Can detect a stroke within minutes of onset (when a CT scan may still appear normal).

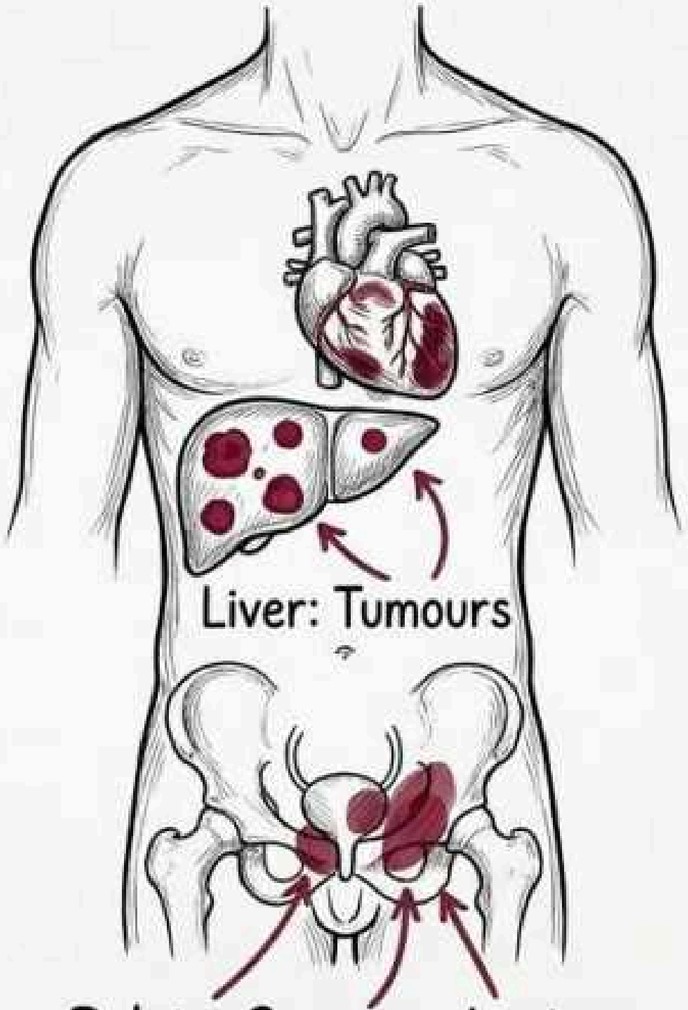
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Joints, Oncology, and Soft Tissues

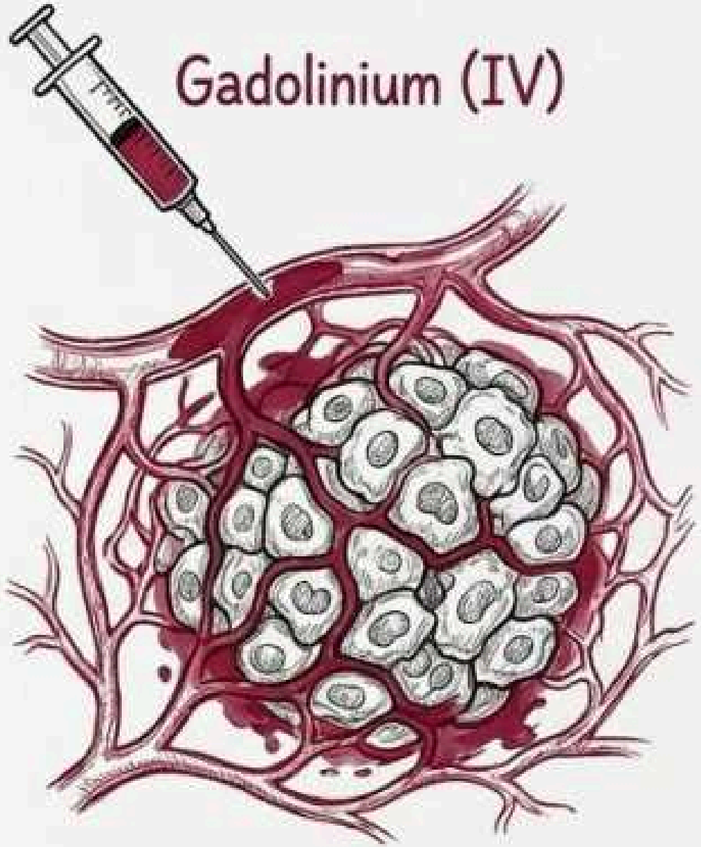
¶ 4.6



Orthopedics: Torn ligaments, cartilage, and tendons.



Pelvis: Cancer staging (Prostate, rectum, cervix)



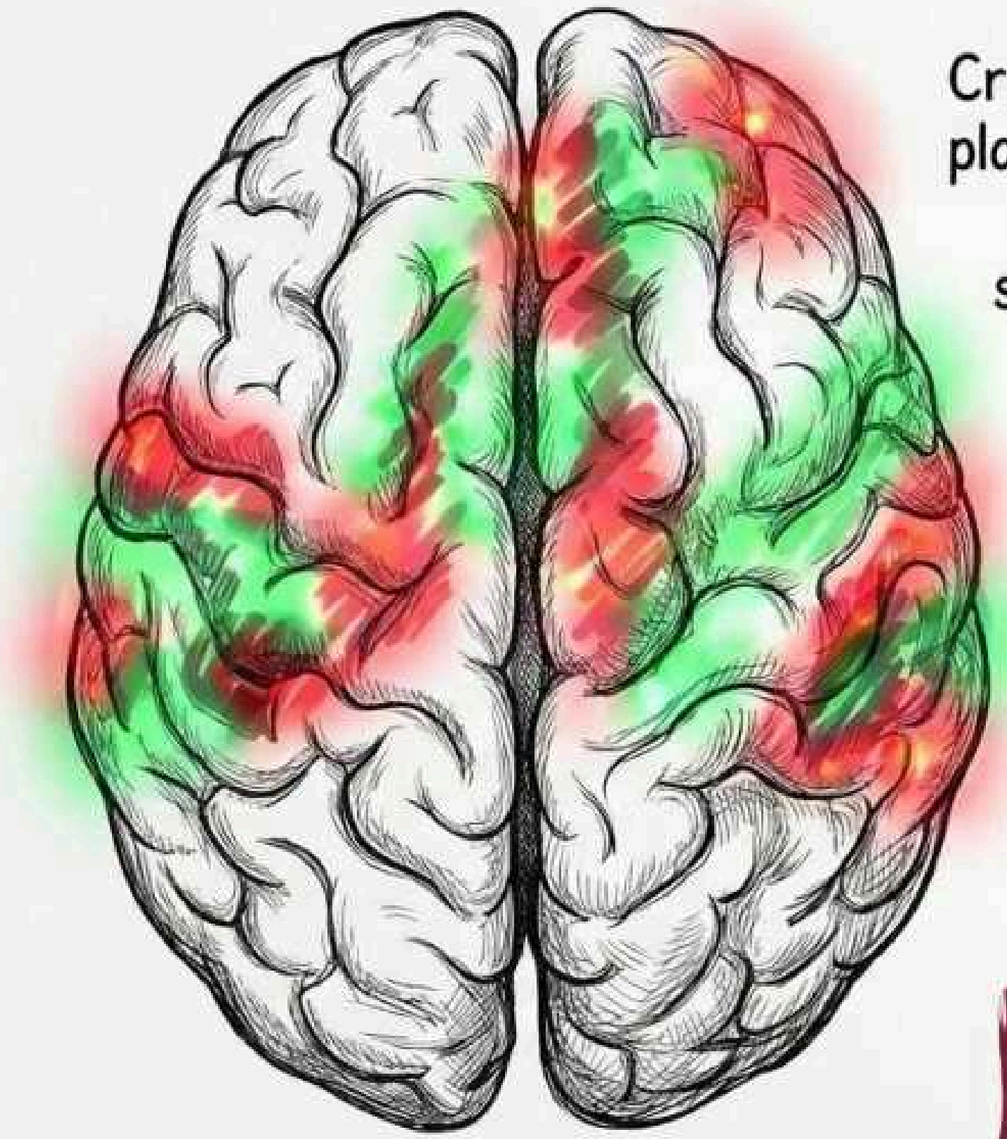
Gadolinium highlights areas with leaky blood vessels (tumours and inflammation).

Shows blood vessels even without

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Mapping Brain Activity (fMRI)

¶ 4.7



Crucial tool for surgeons planning operations near areas controlling speech or movement.

Task Performed

↓

Changes in Blood Oxygen

↓

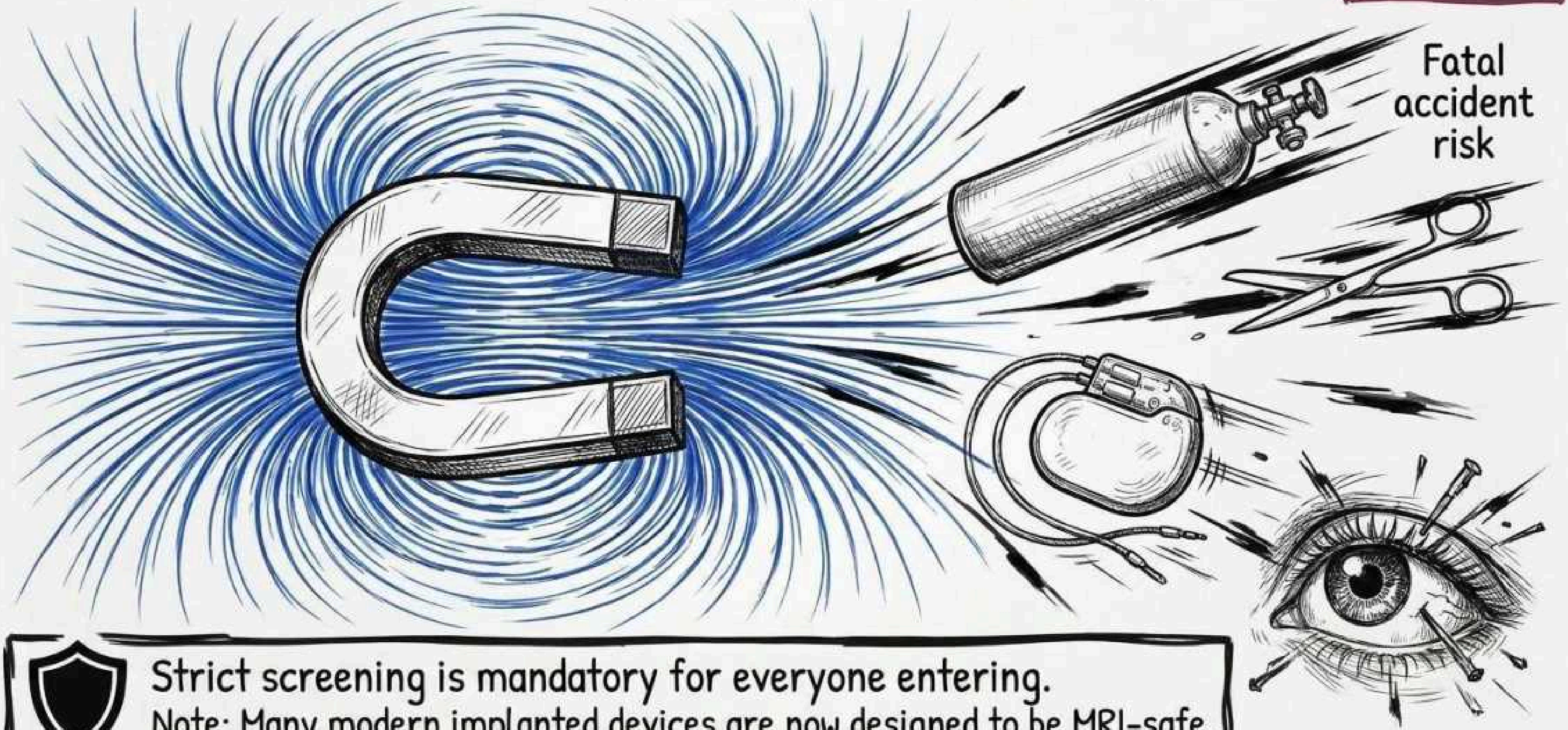
fMRI Detection

Mainly a research tool. Findings are powerful but frequently overinterpreted in popular media accounts.

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The Primary Danger: The Magnet

¶ 4.8



Strict screening is mandatory for everyone entering.

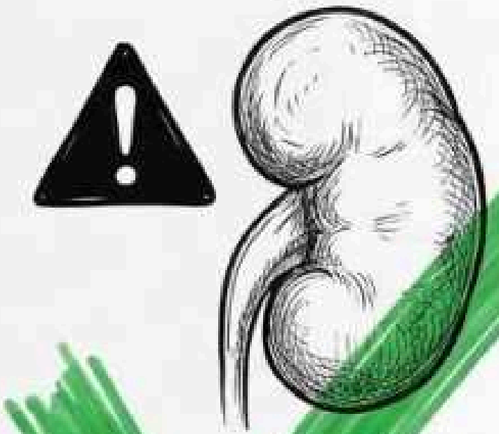
Note: Many modern implanted devices are now designed to be MRI-safe.

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Gadolinium Safety Profile

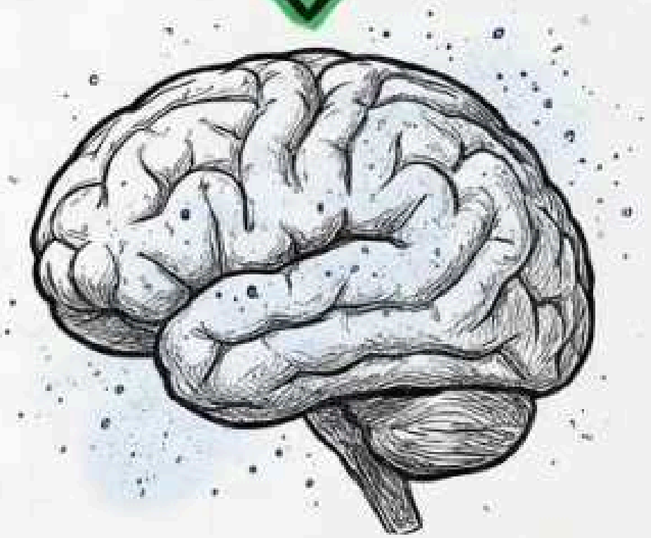
¶ 4.9

Gadolinium Contrast
(Generally Safe)



In severe kidney failure (2000s data)
→ Nephrogenic Systemic Fibrosis (NSF)
causing severe skin/organ thickening.

Changes in protocols have made
this very rare today.



Repeated doses → Small amounts
retained in the brain.

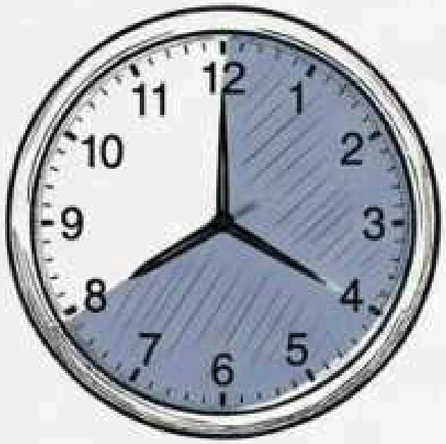
No proven harm so far.

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Operational Logistics and Limitations

¶ 4.10

Time



20 to 40 minutes per scan. Significantly longer than CT imaging.

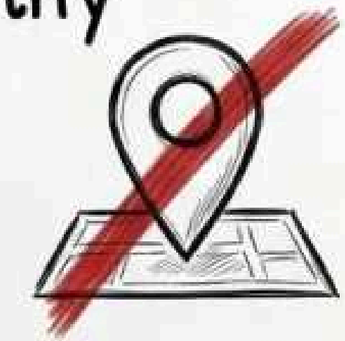
Patient Experience



Requires lying completely still in a confined space. High risk of claustrophobia.

Accessibility

$$$



Highly expensive equipment. Less widely available than CT or X-ray.

Pediatrics

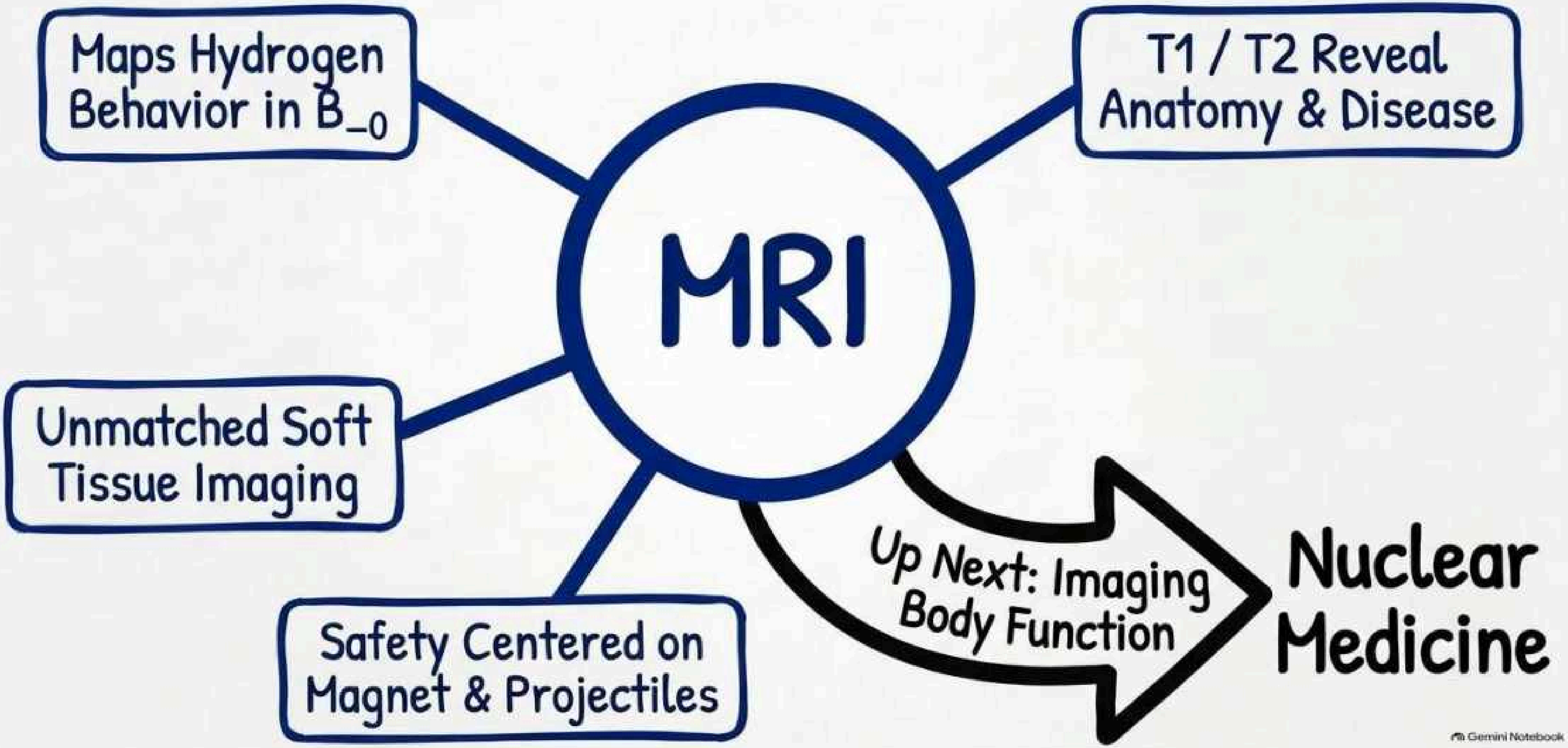


Young children frequently require sedation to remain still for the duration.

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MRI Synthesis and Next Steps

¶ 4.11



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