

Lesson 4: Medical Imaging Revolution

The Power & Potential of MRI



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MRI Marvels

Your Journey into Biomedical Engineering

Lesson Objective

Together, we'll learn how MRI is used to find diseases early and create treatment plans just for you. By the end of this lesson, you'll see how important MRI is in healthcare today and how it might change the world tomorrow!

By the end of this lesson you will:

- Learn about advancements in MRI technology
- Develop your own ideas for future use of MRI technology



Review

Magnetic Resonance Imaging L1-3

- **MRI, or Magnetic Resonance Imaging**, allow doctors to see inside your body without surgery, making it a revolutionary tool in modern healthcare.
- This technology creates a **powerful magnetic field** that aligns the atomic nuclei within the body, along with radio waves, to **produce detailed images** of internal structures in our bodies.
- Unlike other medical imaging methods that may use radiation, **MRI's non-invasive technology allows for safer examinations**, which is essential for ongoing monitoring and diagnosis.
- MRI technology is improving with new ideas and tools, like **stronger magnets** and **quicker ways to take pictures**. This leads to clearer images and faster appointments, so doctors can better see what's happening inside the body.

Scientist Spotlight

Dr. Elizabeth Hillman is a Professor of Biomedical Engineering and Radiology at Columbia University. Her research focuses on the development and application of innovative imaging techniques, including MRI and other optical imaging methods. She is dedicated to exploring how imaging can be applied to study the brain, diagnose diseases, and advance medicine.

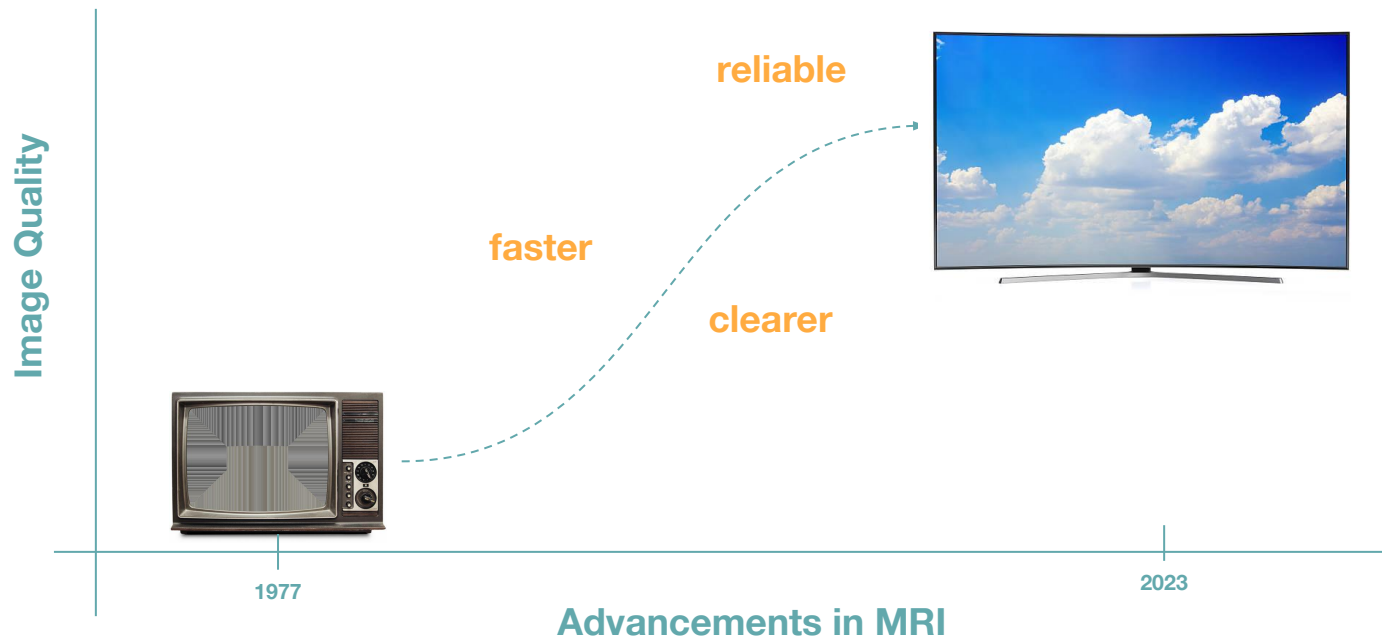
Her research on brain imaging contributes to understanding neurological conditions and paves the way for more targeted treatments.



Elizabeth Hillman

Advancements in MRI

In recent years there have been many advancements in technology that have made MRI images much clearer, faster, and reliable. This has allowed us to explore new ways to use these images



Advancements in MRI

Let's take a look at some of the latest science using advanced MRI technology!



Personalized Medicine



Early Disease Detection



Precision Interventions

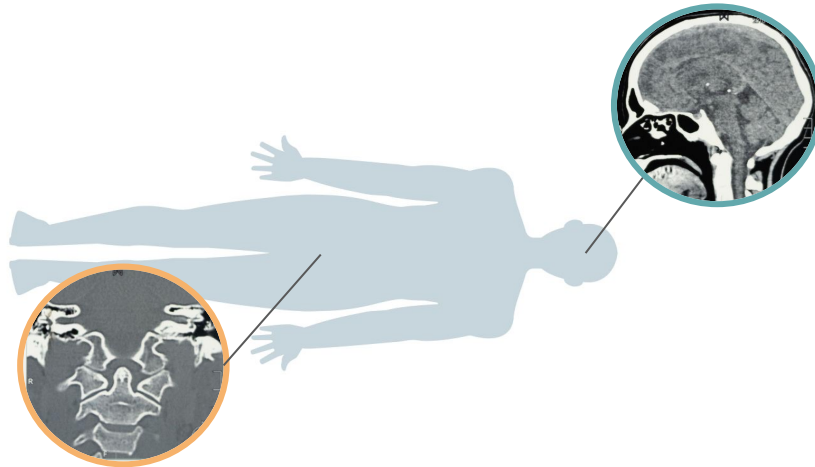
What is Personalized Medicine?

Personalized medicine is like having a **tailor-made suit**; instead of one-size-fits-all treatment, doctors can use MRI and other tools to create treatments that **fit each patient's unique body and health condition**.



Personalized Medicine

MR technology can create **clear** and **accurate** images of the internal structures of the body, including bones, organs, and blood vessels. This **helps doctors to choose the best treatment** for that **specific person**, whether it's surgery, radiation, or something else.



Key idea 💡

Personalized medicine is more than a scientific innovation; it's a vision of healthcare that recognizes the uniqueness of each individual.

How could your unique perspective help shape the future of health?

What is Early Disease Detection?

Think of early disease detection as spotting a storm on the horizon before it reaches your town. The sooner you know it's coming, the more you can prepare. In healthcare, **finding a disease early is like that warning**; it gives doctors more **options** and **time** to treat it, which can **lead to better outcomes**.



Early Disease Detection

Using MRI doctors can detect diseases much earlier providing the opportunity to adjust treatment plans and incorporate preventative measures.

One example of this early detection is in **Multiple Sclerosis** a chronic neurological disorder that affects the central nervous system



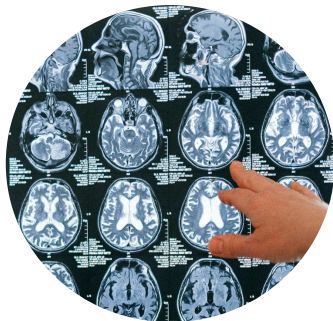
Other Examples!

In the case of breast cancer, MRIs have been able to improve the detection rate of early stage tumors by nearly 23% compared to conventional methods.

Gao Y, Reig B, Heacock L, Bennett DL, Heller SL, Moy L. Magnetic Resonance Imaging in Screening of Breast Cancer. Radiol Clin North Am. 2021 Jan;59(1):85-98. doi: 10.1016/j.rcl.2020.09.004. Epub 2020 Oct 29. PMID: 33223002; PMCID: PMC8178936

Early Disease Detection

Multiple Sclerosis



Lesion Detection

Treatment Guidance



Early Symptoms

In the beginning stages of MS, patients might have mild neurological symptoms like numbness, tingling, weakness, or vision issues that don't clearly indicate MS. MRI can detect hidden neurological problems before obvious symptoms appear.

Lesion Detection

In MS, abnormal areas called lesions form in the brain and spinal cord. MRI can easily spot these lesions, which have unusual signals. MRI can find and measure these lesions, helping diagnose MS early.

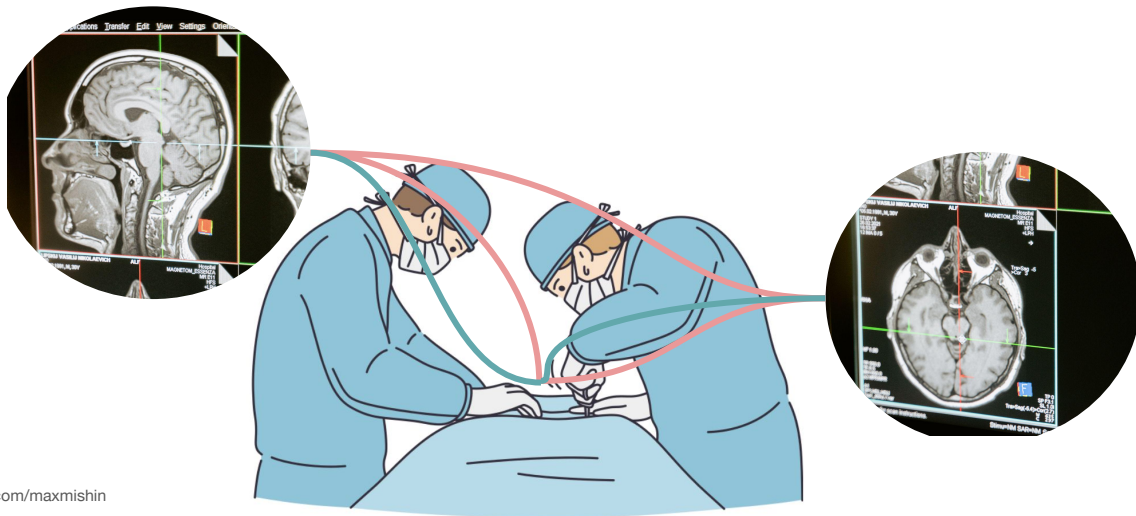
What are Minimally Invasive Interventions?

Minimally invasive procedures are like fixing a watch with precise tools rather than breaking it open. These techniques lead to **less pain**, **quicker recovery**, and **minimal scars**.



Minimally Invasive Interventions

MRI helps in performing procedures that are so exact they can be compared to hitting the bullseye in archery. The **MRI images** can be used to provide **real-time guidance** to doctors during procedures.



What are the advantages?

Quicker recovery times, reduced risk of infection, and less discomfort. These advantages make minimally invasive interventions an important part of modern healthcare.

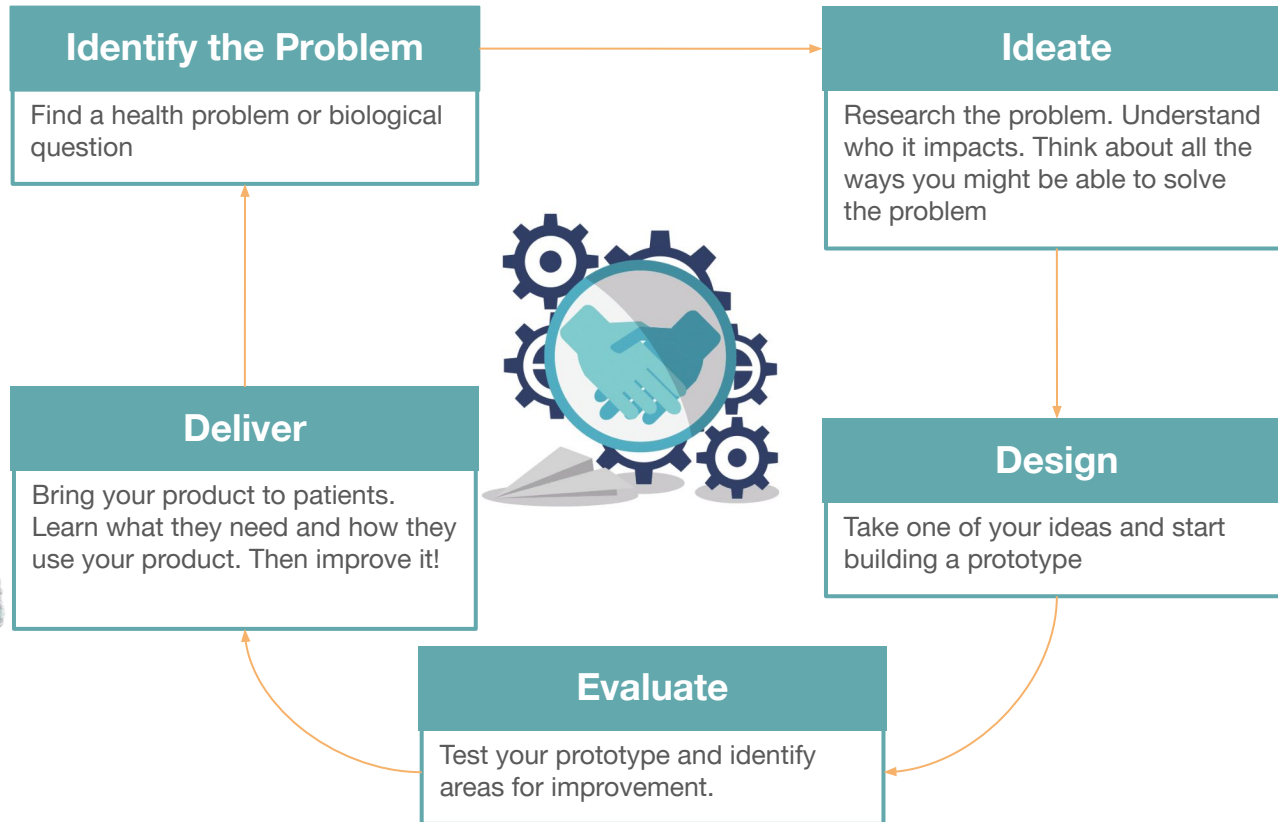


Designing Like A Biomedical Engineer

In this lesson, we talked about how MRI machines can help doctors find out what's going on inside our bodies. We also saw how MRI technology enables new ways to solve complex health problems.

Now, let's get creative and think about how we can use this amazing technology to solve problems and make people healthier!

Design Process



The Design Process

Whenever you approach a new problem you want to follow a design process.

One project may take several cycles through the design process. With each iteration you will make improvements that will help your idea to address the problem.

Case Study

Head-Only MRI System

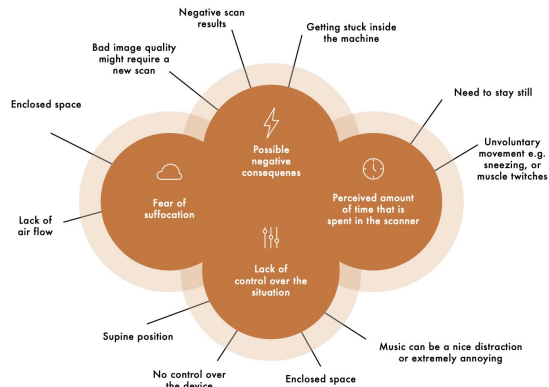
This incredible invention was developed by a team of researchers at the Victoria University of Wellington in New Zealand. This system is designed to improve the patient experience in an MRI by creating a comfortable head only imaging system.

Let's look at their **design** process!

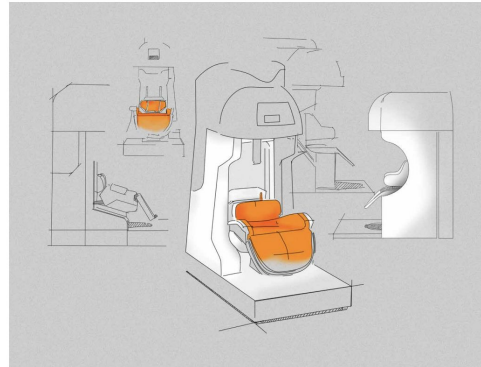


Case Study

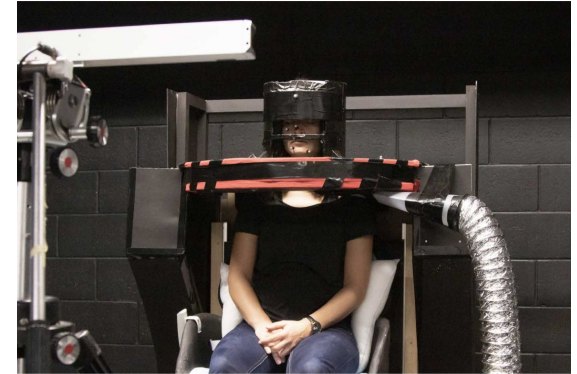
Head-Only MRI System



Identify the Problem



Ideate



Design

Case Study

Head-Only MRI System

It felt harder to keep my head still when performing the hand movements. But apart from that, when I was just remaining still it was fine.

Participant 04
User testing of the inflatable head support prototype
July 2019

Evaluate



Deliver

The Design Process

The developers of this device carefully followed each step of the design process to develop a solution to make MRI more comfortable for patients.

Reflect

Can you think of ways you could use the design process to develop new biomedical tools?

Design Challenge!

Group Exploration: Divide the class into groups and assign each a challenge or application area, such as early disease detection, precision intervention, or personalized medicine.

Brainstorming and Discussion: Each group should brainstorm and discuss potential ways that MR technology could be used to address their assigned challenge. Consider this a puzzle where each idea is a piece that helps complete the picture.

Each group must present their ideas as if they are unveiling a new invention. You can make drawings, charts, or other visual aids to make your innovative ideas come alive!

