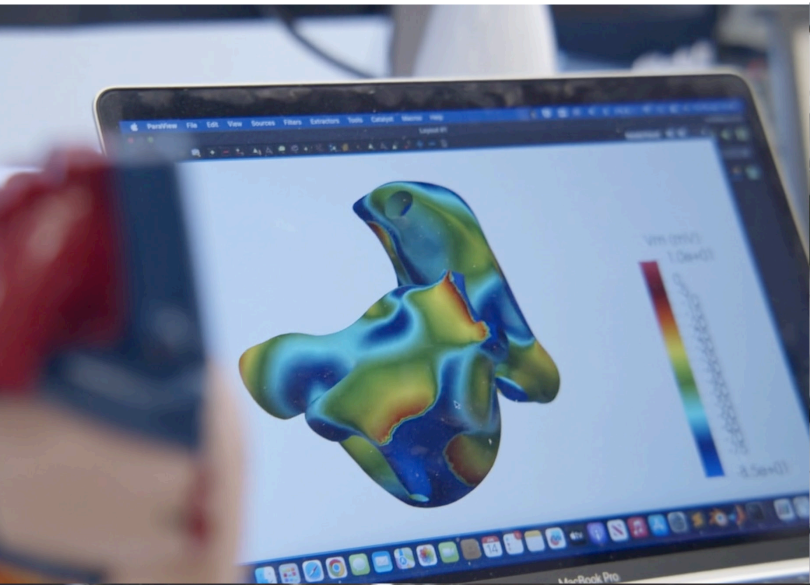
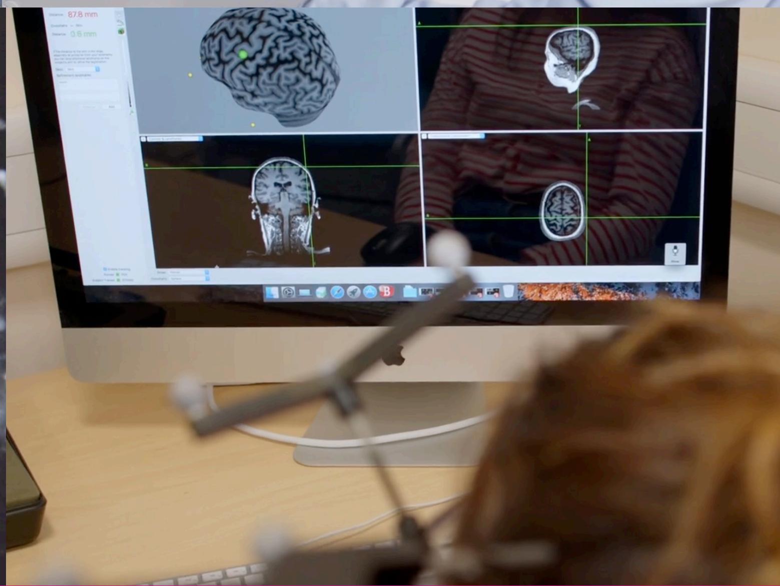
THE FUTURE OF SCIENCE

Many people believe that animal experiments are not only cruel but also produce results that are unreliable and misleading when applied to people. This factsheet describes some of the human-relevant research methods that are replacing animal experiments and helping to improve medicine.





ANIMAL AID

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www.animalaid.org.uk

HUMAN STEM CELLS

Stem cells can divide and become many different types of cell. They have great potential for use in medicine.

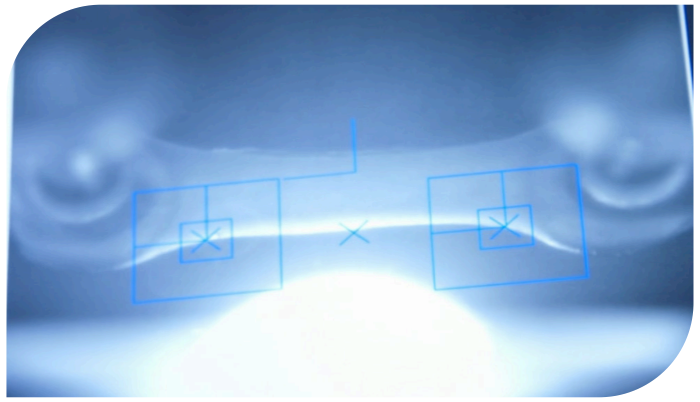
Embryonic stem cells (ESC) are pluripotent, meaning they can differentiate into any type of cell. They are already used to treat diabetes by replacing cells in the pancreas. However, some people believe it is unethical to use ESCs because the embryos are destroyed.

Adult stem cells (ASC) are less controversial, but they can only differentiate into a small number of cell types. For example cells taken from the bone marrow can only become blood cells.

Technological breakthough

In 2007, a team in Japan discovered a technique to 'reprogramme' ASCs back into their pluripotent form - similar to ESCs.

Induced Pluripotent Stem Cells (iPSCs) solve many of the problems associated with ESCs and ASCs. This is a huge breakthrough with enormous potential to improve disease research and the drug development process.



iPSCs can be grown into organoids which are simplified *in vitro* versions of organs, capable of modelling some functions of an organ in the lab.

Mini human heart organoids (pictured above) are used to research heart disease and to test the safety and efficacy of new drugs. Mini human brain organoids have been used in the study of Alzheimer's and Parkinson's disease.

It is extremely challenging to keep these mini organs alive in a laboratory environment outside a human body. Scientists are gradually refining and improving these techniques so that they can one day completely replace animal

ORGAN ON A CHIP

Small devices which models human organs or groups of organs (called organ systems). They can be used for disease research and drug development.

These chips have tiny chambers, each containing different types of cells or tissues. A blood-like substance moves from chamber to chamber through channels, like how blood flows through capillaries in a human body. The test substance circulates around the device, modelling what happens in the organ or organ system on a microscopic scale.

Sensors in the chip detect how the different types of cells react to substances such as drugs and send the data to a computer for analysis.

Chips that model the workings of various human organs include skin-on-a-chip, lung-on-a-chip, heart-on-a-chip, liver-on-a-chip and brain-on-a-chip. Researchers are working towards building a human-on-a-chip which is a device that mimics several key organs in the body.

ELECTRICAL STIMULATION

All activities in the brain - our thoughts, behaviour and perceptions – are caused by electrical impulses. Electrical stimulation involves safely and reversibly activating regions of a human brain and observing the response. This can help us discover more about how the brain coordinates our behaviour, how it goes wrong and how we can treat disease.

One such technique is TMS (Transcranial Magnetic Stimulation) which sends a magnetic field into a specific part of the brain, stimulating electrical activity in that area. Stimulating different areas will result in the person responding differently. For example, stimulating the motor cortex will cause an involuntary movement in the body.

Learning what different parts of the brain do and how they communicate with each other means we can look for other parts of the brain which could potentially carry out the same function. TMS research at Durham University has trained people with damage in the visual area of their brain to look differently at the world and restore their vision. It is hoped that this technique could lead to treatments for neurodegenerative diseases.

IMAGING TECHNOLOGIES

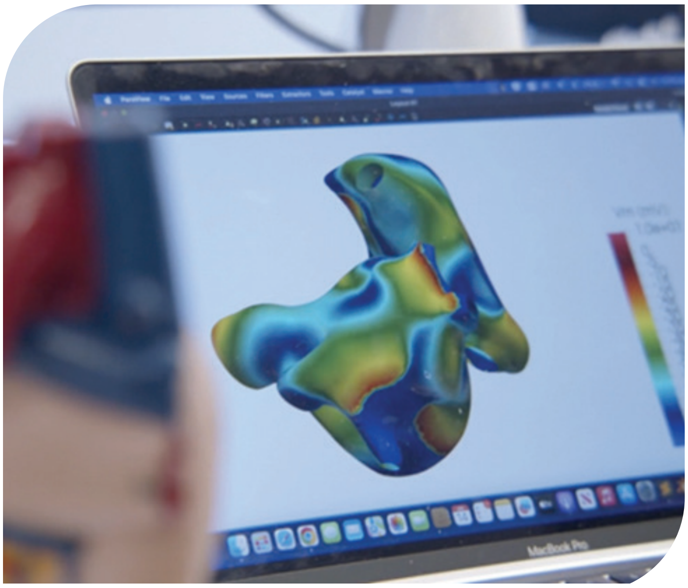
Imaging techniques such as MRI (Magnetic Resonance Imaging) use magnetic fields and radio waves to show what is happening inside the human body, particularly the brain.

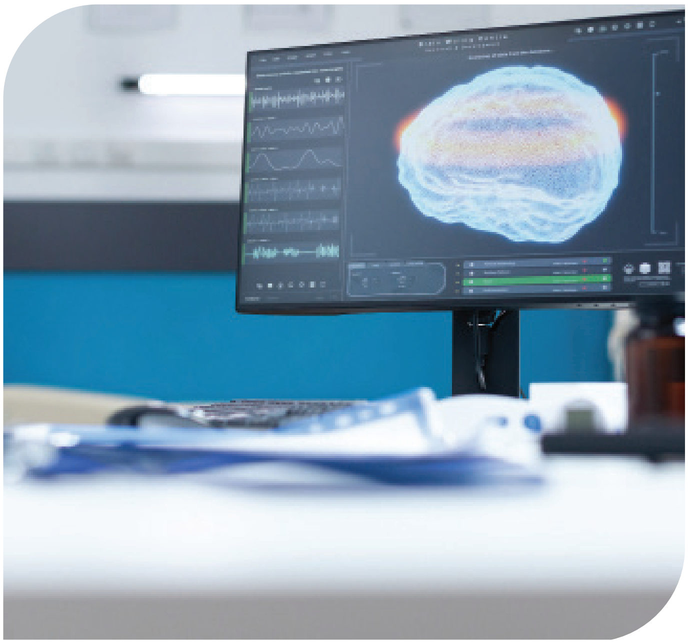
COMPUTER MODELLING

In silico research involves collaboration between experts in different fields such as computer science and medicine. The result is a powerful tool which is rapidly improving our understanding of disease and provides a reliable way to test new treatments.

Human data is turned into mathematical models which can be used to create simulations of organs and organ systems. Because these models are based on human physiology, the results are more easily translatable to humans than experiments on animals.

One study at the University of Oxford's Department of Computer Science found that a computer model representing human heart cells predicted the safety of new drugs with greater accuracy than animal studies.





These sophisticated computer models allow us to delve into the complexity of the human body and study how variables such as sex or ethnicity might affect the diagnosis and treatment of disease. Work is also ongoing in a European project to co-ordinate the development of a 'virtual physiological human' as a single complex system.

It is hoped that one day this research will pave the way for personalised medicine in the form of an AI-generated digital twin. This is a digital representation of a person which could accurately and precisely predict a patient's health outcomes if given different treatments.

Watch the Future of Science film:

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