- Stem cell research

SCIENCE

STEM CELLS UNCOVERED

Long billed as the next big thing in medical treatment, a change in approach may unlock stem cells' limitless potential

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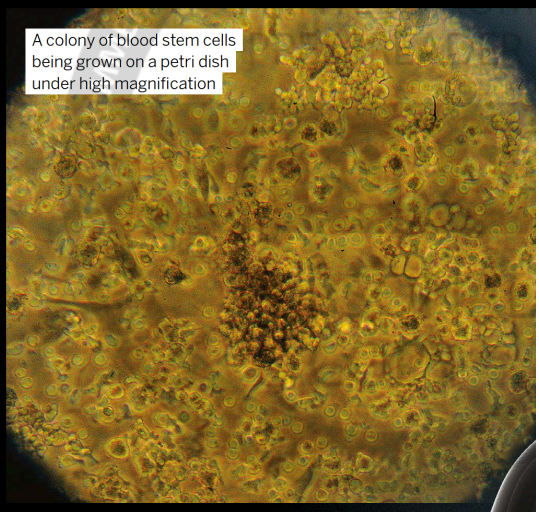


A colony of blood stem cells being grown on a petri dish under high magnification

Stem cells are the 'parent' cells from which all other cells in our bodies arise. They are nature's building blocks, with the potential to become any type of cell – from the skin on the soles of our feet to photoreceptors in our eyes. While scientists suggested their existence as far back as 1908, it wasn't until 1978 that they were finally discovered in umbilical cord blood. Stem cells quickly became the focus of a scientific and media frenzy. There was much speculation about their potential to solve all sorts of medical issues – from curing diseases such as Alzheimer's to creating whole new organs – thanks to their ability to change into any cell type and therefore replace those that have been damaged or lost.

But this excitement was swiftly followed by debate and controversy, most of which has centred on the source of the stem cells. Most controversial are embryonic stem cells. They are harvested five to seven days after the fertilisation of a human embryo, while it's still a tiny ball of cells. Embryonic stem cell research is only permitted in certain US states and is allowed, subject to tight controls, in the UK. But researchers have also turned their attention to adult stem cell research.

Stem cells found in adults are left over from foetal development. They remain in specific tissues, such as bone marrow and fat tissue, and replace old, dying cells. While they are not able to turn into as many cell types as embryonic stem cells, they still hold a lot of therapeutic potential and are at the cutting edge of stem cell research. In 2006, scientists found they could reprogram normal adult cells, such as skin cells, to a stem-like state. Skin cells have already reached their end goal, but they can be 'rewound' to become stem-like by being treated with specific proteins. These cells were named induced pluripotent stem cells, or iPS cells. IPS cells are not without their problems, however. Their genes are regulated in a different way to those of naturally derived stem cells, and researchers are not yet sure how this might affect their behaviour. Nonetheless, iPS cell research has rocketed in the past two decades.

One advantage of this change in approach, aside from avoiding the ethical issues of using embryonic cells, is the potential adult stem cells and iPS cells have for autologous therapy. This is where cells are removed from and given back to the same person. The reimplanted cells don't cause the immune system to respond in the same way that 'foreign' cells would. Adult stem cells and iPS cells are offering new, accessible and varied approaches to regenerative medicine. And while research into embryonic stem cells continues, these newer methods also provide hope for curing diseases such as Huntington's and cancer.

> "Stem cells found in adults are left over from foetal development"

STEM CELLS' HEALING POWERS WILL WORK ACROSS THE BODY

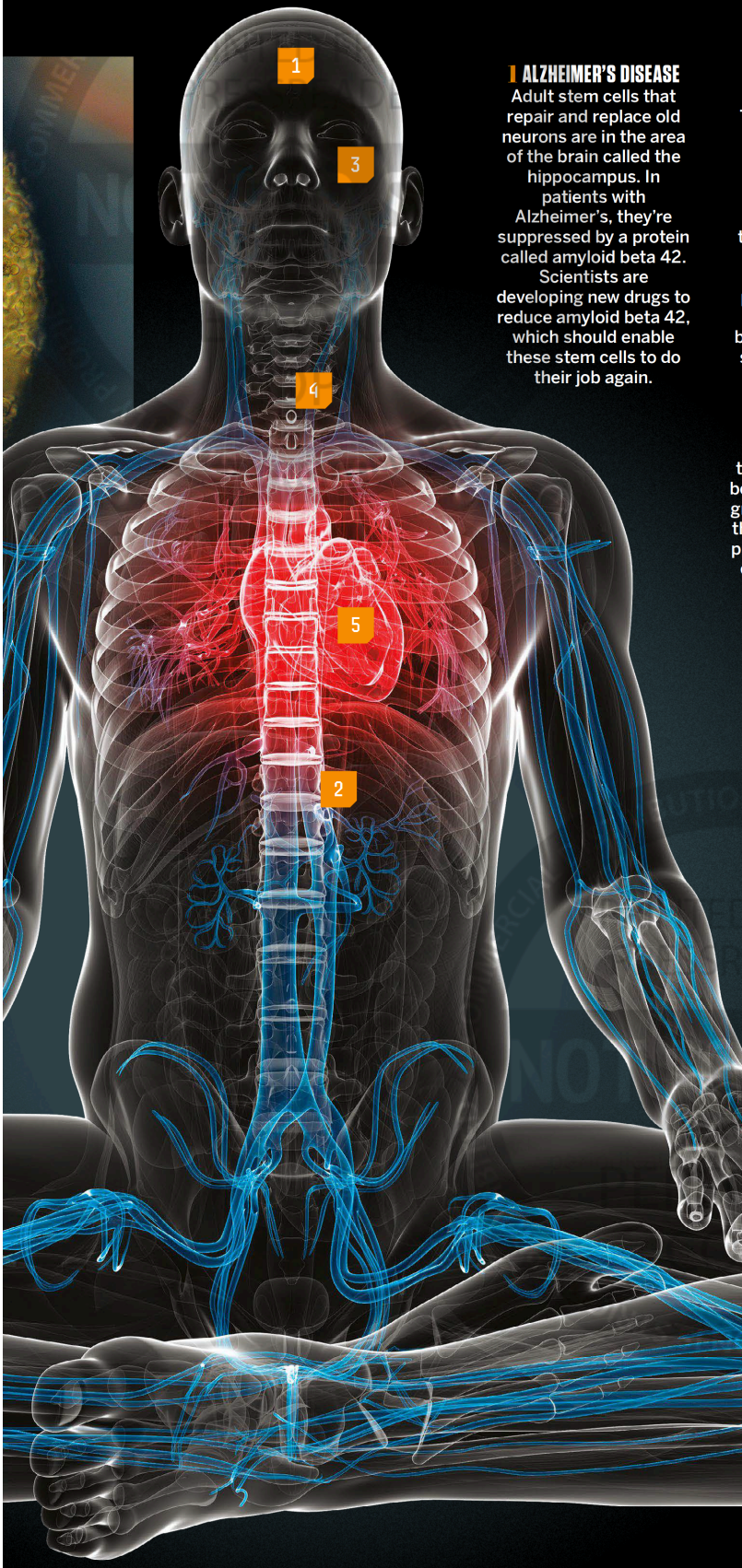
Stem cell therapies are under development for a wide range of diseases

Did you know?

Females have fewer cells in their bodies than males



DID YOU KNOW? Stem cell therapy started in 1959, when five Yugoslavian nuclear workers had bone marrow transplants



1 ALZHEIMER'S DISEASE

Adult stem cells that repair and replace old neurons are in the area of the brain called the hippocampus. In patients with Alzheimer's, they're suppressed by a protein called amyloid beta 42. Scientists are developing new drugs to reduce amyloid beta 42, which should enable these stem cells to do their job again.

2 TYPE 1 DIABETES (PANCREAS)

Type 1 diabetes is caused by the loss of cells in the pancreas that produce insulin, islet cells. Adult stem cells from bone marrow have been transplanted into diabetic rats, where they are integrated into the pancreas and turned into islet cells. This has also been performed with adult stem cells from fat tissue with even better results.

3 EYE DAMAGE

Embryonic stem cells can be turned into early, or 'precursor', photoreceptor cells in the lab. The idea is that they can then be implanted into the retina to restore sight. So far the technique has only been tested in rodents, and scientists are still developing the tools and protocols to translate this research to humans. This is costly, but early results in mice are promising.

4 TRACHEA

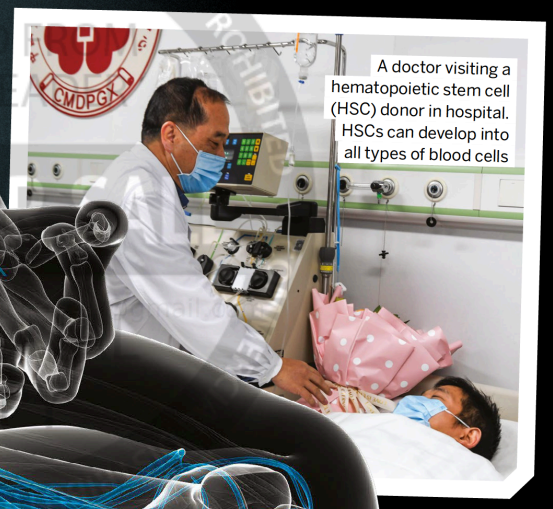
To create a replacement trachea, the patient's own bone marrow stem cells are grown into cartilage cells in the lab and then put onto a protein scaffold made from either a donor trachea or synthetic material. The first trachea engineered in the lab was implanted into a patient in 2008, and more have followed.

5 HEART

After a heart attack, the heart muscle that has been deprived of oxygen dies, and currently there is little that can be done to repair it. Ongoing clinical trials are extracting stem cells, which have the potential to become heart cells, from patients' bone marrow. These cells are then injected back into the patient's heart to help repair the damaged tissue.

6 KNEE

Adult stem cells from the patient's own bone marrow or fat tissue have been used to repair arthritis in the knee joint. The cells are harvested, grown or 'expanded' in the lab and then re-injected back into the patient's damaged knee. Several studies have reported reduced pain, increased mobility and an improvement in the quality of the cartilage.



A doctor visiting a hematopoietic stem cell (HSC) donor in hospital. HSCs can develop into all types of blood cells

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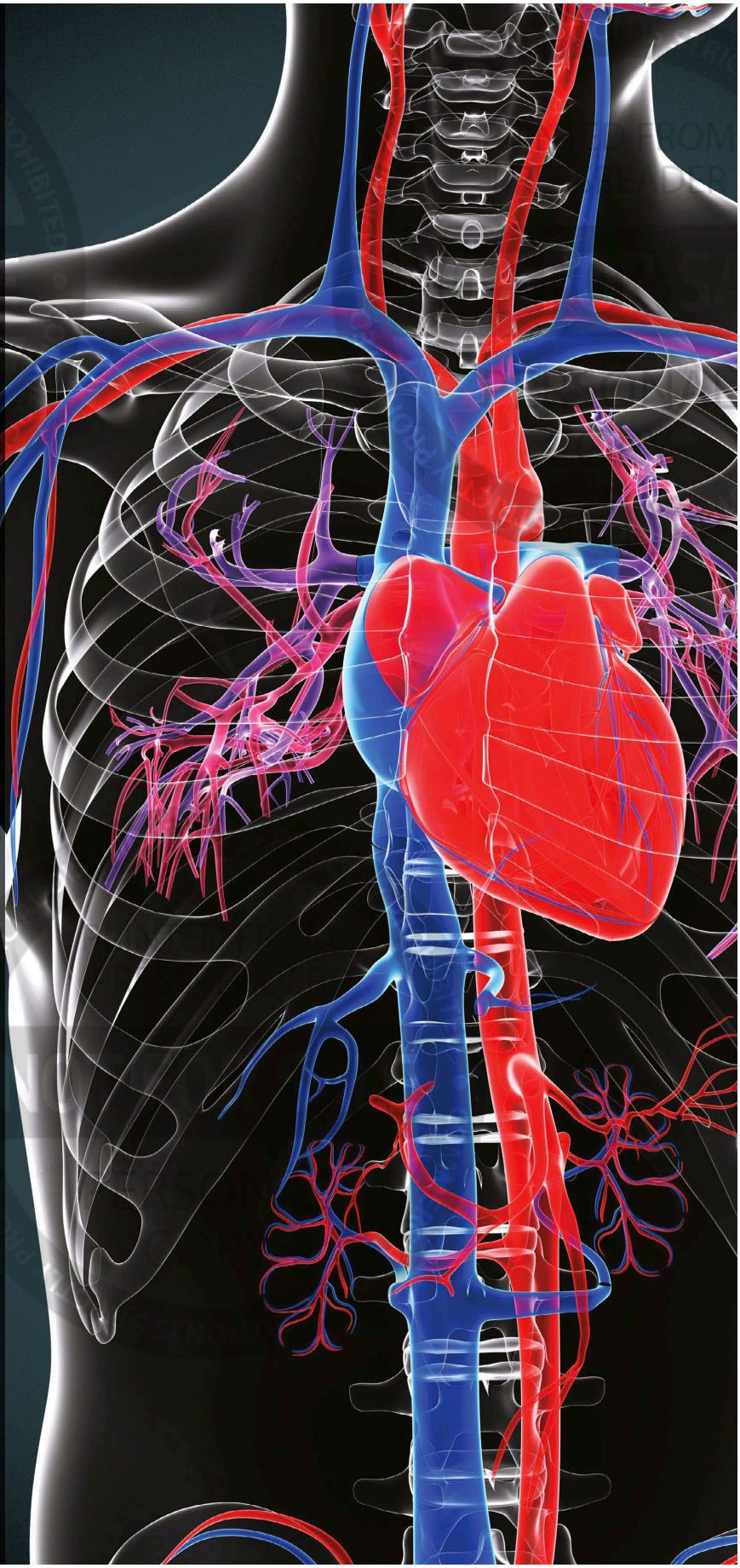
SCIENCE

REPAIRING THE HEART WITH STEM CELLS

Blocked or damaged blood vessels around the heart can cause heart disease, and must be replaced during heart surgery. Stem cells cultivated from your own body can be used to repair the damage



1

GATHERING

Stem cells are isolated and treated with proteins to induce them to become the types of cells needed to form blood vessels. Stem cells from the patients themselves are less likely to trigger the immune system.

2

INCUBATING

The appropriate scaffold material on which to grow the cells is selected. It must be able to withstand high blood pressures, be elastic so it can stretch and contract with variations in blood flow and have the potential to degrade over time.

3

GROWING

The cells are grown on the cylindrical scaffold inside a bioreactor – a specially designed incubator. The bioreactor also allows scientists to grow one type of cell on the inside of the scaffold and another on the outside.

4

IMPLANTING

Once the scaffold is coated with cells, it is implanted into the patient to replace the damaged blood vessel. If the cells are from the patient's own body, it's unlikely that the graft will be rejected.

5

HEALING

As the patient heals, the engineered vessel is assimilated into the body. The cells break down the scaffold and lay down their own, leaving a totally biological vessel.

DID YOU KNOW? Embryonic stem cells can be used to treat spinal cord injuries



STEM CELLS by numbers

200
The estimated number of specialised cells in the human body

40%
of unrelated stem cell transplants are international – the donor is living in a country different to that of the recipient

ONE MILLION
haematopoietic (bone marrow or blood) stem cell transplants had been carried out worldwide by December 2012

1 MILLION
Americans were treated with their own stem cells in the mid-1980s

Did you know?
The EU has banned patents on embryonic stem cell research

96 MILLION
cells are created by an adult male per minute

96 MILLION
cells are lost by an adult male in a minute

3.72×10^{13}
cells make up an average male human body

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