BRIEFING NOTES ON HUMAN STEM CELLS

What are stem cells?

- Stem cells are cells which can generate new copies of themselves, and can turn into the more specialised cells (e.g. red blood cells) that perform functions in the body.
- There are different types of stem cells, some of which can turn into any cell in the body (**pluripotent**) and some of which can only turn into certain cells in one type of tissue (**tissue specific**).
- **Adult** and **foetal stem cells** are tissue specific: they only turn into certain types of specialised cells.
  - We all have adult stem cells in many of our tissues which repair and replenish damaged cells.
- **Embryonic stem cells** exist only briefly after fertilisation, well before the embryo becomes a foetus, and can turn into any cells in the body. This is why they are so important scientifically.
  - Scientists can create **induced pluripotent stem cells** (iPS cells) which act like embryonic cells.

How do we get stem cells?

- Human **embryonic stem cells** are obtained from very early stage embryos, within 5-6 days of fertilisation.
  - Most embryos used in stem cell research were initially created for use in IVF and are donated by parents.
  - The cells isolated from the embryo give rise to one **cell line** which can produce an infinite number of cells
- **iPS cells** do not occur naturally, but any adult cell could potentially be manipulated to become an iPS cell.
  - There are various different techniques for 'reprogramming' adult cells into iPS cells, though it is not yet known whether any iPS cells can exactly mimic embryonic cells.
- **Adult** and **foetal stem cells** can be isolated from specific tissues, where they are naturally small in number.

What are stem cells used for?

- Stem cell research does not just focus on medical treatments that put cells into patients: all types of stem cell are used in basic research to understand how our bodies work and develop, and to understand disease.
  - Studying disease at the cellular level provides an alternative to animal based models of drug discovery
- Two distinct approaches exist for using stem cells in medical treatments, both the subject of research
  1. **Cell replacement therapies** where cells are transplanted to integrate with the body's existing tissue
     - Not all cell replacement therapies use stem cells, some use specialised cells
  2. Using stem cells for the substances they release which encourage the body to repair itself

What stem cell-based treatments exist?

- There are only a **few widely available** stem cell-based treatments all of which use adult stem cells; there are no current stem cell-based treatments that use embryonic or iPS stem cells.
  - Blood stem cells have a long history of use in treating blood disorders
  - Stem cells can be used to grow sheets of skin for use in skin grafts and wound healing
- Cell replacement therapies for various conditions, including eye diseases, spinal cord injuries and stroke are in clinical trials, but are not yet available outside trials.
- Stem cell treatments that encourage natural repair, making use of substances that stem cells release, are in early development for a range of neurological conditions as well as heart disease and diabetes.

Where does the scientific community stand?

- The majority of scientists think research on all stem cell types, including embryonic stem cells, is necessary because of their obvious potential for the effective treatment of all sorts of conditions.
- There is not enough evidence to say whether iPS cells can completely replace embryonic stem cells, though there is a minority of scientists who have ethical reservations about embryonic stem cells.

What are the issues around stem cells?

Ethics

Some religious groups like the Catholic Church object to using human embryonic stem cells since they view the destruction of very early stage embryos as the destruction of a human life; likewise they object to research on human embryos and IVF treatment. There is an argument that iPS cells could, in theory, produce human life so they do not answer these objections. Ethical and legal debates rest on when an embryo gains 'personhood', though this is a not a question the science alone can answer.

> ***Patenting life:*** Some groups, including Greenpeace, have objected to the patenting of stem cells on the basis that application of intellectual property rights to anything that represents a life should not be allowed. One possible alternative is the patenting of technologies used to carry out stem cell research.

Stem cell tourism

Dramatic claims about the potential of stem cells to provide a 'cure for everything' have prompted people to travel to countries with unregulated clinics offering stem cell treatments for a huge range of conditions. Primarily advertised on the web, such treatments tend to use stem cells for the beneficial substances they produce, though patients may be wilfully deceived into believing they are receiving cell replacement therapies. Even though there are numerous legitimate clinical trials taking place for treatments which use stem cells for their beneficial products, most advertised treatments are not properly tested.

Why have we not seen more treatments?

Regenerative medicine is a very new field compared to traditional medicine, and to some extent the science is running ahead of the regulatory system. Testing regenerative treatments is a challenge and our ability to develop new treatments is limited by the fact that stem cell behaviour is not yet fully understood.

> ***Clinical trials:*** The usual model for a clinical trial is hard to apply to regenerative medicine and benefits of cell therapies are more likely to be seen at safety testing. However, benefits seen in safety trials should not be interpreted as 'breakthrough cures' as the experiments are designed to assess safety, not to look at how effective the treatments are.

Safety and side-effects

Concerns exist over the safety of using cells that can reproduce indefinitely in medical treatments. These concerns are addressed when treatments go through proper clinical trials, but this is not the case for unregulated treatments (see '*Stem cell tourism*').

> ***Rejection:*** Treatments that transplant stem cells have a risk of rejection as the body recognises differences in the DNA of transplanted cells. Therapies have been developed that use patient-derived adult stem cells which avoid this problem, though we are far from making these commercially viable.

Cord blood and stem cell banking

Blood from the umbilical cord, which is rich in stem cells, can be stored indefinitely for use in later life. Cord blood can be donated to public banks, or private companies offer storage for use by the baby or his/her relatives in later life. Storage of fat tissue (adipose cells) and dental tissue is also possible. There is some controversy over the logic of private stem cell banking since the likelihood of the donor needing their own cells is small, and future scientific developments may make the stored tissue obsolete.

Links/Further Information

EuroStemCell is a Europe-wide collaboration of research centres aimed at public engagement. Great resource for information including fact sheets and FAQs spanning all topics

www.eurostemcell.org/

Wellcome Trust resources on stem cell, including succinct information on research and medical potential

http://www.wellcome.ac.uk/About-us/Policy/Spotlight-issues/Human-Fertilisation-and-Embryology-Act/Stem-cell-basics/index.htm

"Stem cell science - Hope not hype" publication by Biotechnology and Biological Sciences Research Council

http://www.bbsrc.ac.uk/web/FILES/Publications/hope_not_hype.pdf

BioNews provides timely news and comment on embryo/stem cell research and related topics

www.bionews.org.uk

The UK Stem Cell Bank provides a repository of human embryonic, foetal and adult stem cell lines as part of the UK governance for the use of human embryos for research

http://www.ukstemcellbank.org.uk/

Scientific Opinion Paper on Umbilical Cord Blood Banking from the Royal College of Obstetricians and Gynaecologists

www.rcog.org.uk/womens-health/clinical-guidance/umbilical-cord-blood-banking

The International Society for Stem Cell Research (ISSCR) has become the voice of the stem cell research community

www.isscr.org/

These Briefing Notes have been written by the Science Media Centre in consultation with a number of scientists, science press officers and broadcast journalists. They are not intended as a comprehensive summary on a subject, but rather a snapshot of the basics, of points of controversy and a pointer towards sources of more detailed information. They are subject to change and will be updated as and when the science moves on.

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