

Are stem cells the future of healthcare?

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Abstract

Stem cell technology holds a key, although arguably not an exclusive position, in the future of healthcare. Alongside two other candidates worthy of this mantle – personalized cancer medicine and vaccine development – all three healthcare innovations are explored primarily from a scientific and also an ethics perspective. This insightful and informative essay secured its 12-year old author a place on Newcastle Upon Tyne's city universities' 'Leading Edge' science programme in January 2012. The programme forges links between local academics and enthusiastic youngsters aged 12–14 years, selected from 13 participating schools. The aim is to motivate and inspire children to consider careers in science. Supported by their science teacher Jonny Instone, Gosforth Central Middle School's team of six, including the author, worked with Dr Ben Horrocks from the University of Newcastle Upon Tyne's Chemical Nanosciences Laboratories in the School of Chemistry. Their four-month nanotechnology project focused on the quantum dot and insights into its clinical applications. Project presentations took place at the city's 'Centre for Life' in July 2012.

Keywords: Stem cell research, Individualized medicine, Vaccination

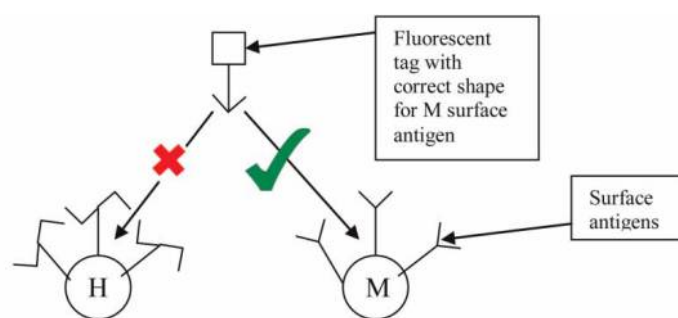
Stem cells are pluripotent (function in more than one way) cells that under the right conditions develop into any specialized cell in the human anatomy. This is a massive scientific breakthrough because if a patient has a dysfunctional liver they need not wait for a donor. An injection of stem cells into the failing liver will make new specialized liver cells. This is the theory. Many factors such as rejection and incorrect vascularization (production of new blood vessels from other blood vessels to feed a new tissue) can be fatal.

So, are stem cells the future of healthcare? There are other new treatments such as personalized

cancer medicine and large-scale vaccination in developing countries that serve different purposes but are also a big part of the future of healthcare.

When a sperm successfully fertilizes an egg, it divides into eight different embryonic stem cells, each one being identical to the other. These can then become different specialized cells, e.g. red or white blood cells because stem cells contain different genes needed to become any cell. These genes can be turned on or off by factors in the surrounding environment. The specialized cells then multiply to form a tissue or organ. Huge concentrations of stem cells are found in the umbilical cord because the growing embryo needs to develop tissues and organs.¹

Early experiments in 2005 looked at patients with a muscle disorder. Scientists took a donor's umbilical cord, collected the stem cells and placed them under the right conditions to create muscle cells. The steps were: removing the nucleus from the donor's stem cell and adding the patient's nucleus instead, successfully turning the stem cell into a mesenchymal precursor (this intermediate stem cell can be made into either a muscle, fat, cartilage, or bone cell) then adding appropriate tissue-specific stimulation to produce a muscle cell. To successfully make the muscle cell the scientist cocultured the cells with mouse feeder cells but could not give a mix of cells to a human because the human would not recognize the mouse cells and would reject them. So they had to remove the mouse cells. To make sure the scientist had successfully made a muscle cell from a stem cell they made a fluorescent tag which only connected with the muscle cell due to its unique surface antigens (each surface antigen has a different shape like a jigsaw piece that needs the other correct shape for it to fit into). Any cells that were not muscle cells were not tagged. When the cells were washed, only muscle cells kept the fluorescent tags. It was then possible to see the fluorescently tagged muscle cells using a special microscope (Fig. 1).



H, haemopoietic precursor cells – the intermediate stem cell for blood cell types; M, mesenchymal cells.

Figure 1: Diagrammatic representation of selective fluorescent tagging of mesenchymal cells.

It was important that all stem cells were converted to mesenchymal precursors and this was also checked using fluorescent tagging. Unconverted cells could start to proliferate (grow) and form a tumour/cancer cell. If injected into a patient they could become cancerous.² The scientists had made muscle cells to use in humans but these early experiments needed more work to make the cells safe by stopping rejection. Also, a way to make the new cells become a part of the patient's main tissue was needed.

Nowadays biomaterials science is used in stem cell technology to minimize problems with rejection and to make the new cells vascularize. Angiogenesis is the process that starts vascularization by producing the first blood vessels which helps make the 'scaffolding' needed to keep the cells working as one with the body. Also, materials science can help stop the rejection of the newly implanted cells by encasing them in a synthetic semi-permeable membrane through which the cells can secrete their products. The membrane does not allow the body's immune cells to attack the new cell inside it.^{3,4}

In 2006, it was discovered in a mouse that cells – almost identical to stem cells – could be made from normal specialized cells. These stem cells are called induced pluripotent stem cells or iPSCs. These cells are created by a virus that causes the specialized cells to have almost the same characteristics as a stem cell but this virus can also cause a tumour which can lead to cancer. iPSCs are currently in their preclinical stage (tested on animals) but slowly progressing to clinical testing on humans.⁵

Stem cell research today is mostly at the pre-clinical stage with bone, blood vessels, and ligament engineering. So far, there have been no treatments able to cure a patient with no dangerous side effects. However, progress and discoveries continue.

In 2010, over one million litres of blood was collected in the UK from donors for blood transfusions. This is very expensive as every needle costs £1.50. Overall, this costs millions when added to the cost of paying the staff who take the blood. However, in 2011 scientists experimented up in Edinburgh and successfully grew red blood cells from stem cells on a small scale, *in vitro* (in the laboratory).⁶ If this can be done on a larger scale in future, blood could be made to order.

Scientists of today predict that stem cells could influence treatments of conditions like: Parkinson's disease, Alzheimer's disease, diabetes, heart disease, stroke, cancer, and burns.⁷

There are many ethical issues with such complicated new technologies. Non-religious views state that an embryo is a living organism and therefore is entitled to some protection. This means that the cells taken out are entitled to their own protection and cannot be taken from that embryo for someone else to use. There are strict rules and regulations governing cloning of a human being using stem cells as any resulting cloned person may become confused and distressed due to his or her method of creation. Stem cells also have religious perspectives about how taking cells from another being is theft. Many Jewish followers believe that the world is incomplete and needs human interference for the world to 'work'. They believe one of the commandments was to heal in any way possible. This means they believe that using stem cells is right. Many Catholics in the 1960s strongly believed taking organs and transplanting them is a mutilation of the human body and thought this went against one of their beliefs, 'First do no harm.' Now they believe that it is charity and goodwill for someone to give up a precious organ for another human being.⁸ This may mean that in future they may agree with the usage of embryonic stem cells, but as of now they are undecided.

Islamic law states that since the embryo is not a person, the extraction of embryonic stem cells does not violate any rules of the Holy Qur'an. However, the only humans who can use these cells are the couple who created them as the parents have the only rights to use them. On the other hand, the embryos can be cloned for therapeutic uses and the Islamic Institute allows embryos to be taken for research purposes. This means that stem cells can be taken from an embryo and used for research purposes but they cannot be transplanted into other patients.⁹

Personalized cancer medicine is an alternative to stem cells without as many ethical issues. Unfortunately, this medication is more expensive than stem cells and can only be afforded in modernized countries. Many types of the cancers respond differently when treated, so for example not all breast cancers can be treated with the same medicine. Surface antigens (or markers) on some types of cancerous cells allow scientists to create the 'missing jigsaw piece' or drug that fits into the marker and kills the cancerous cell. As surface antigens differ from person to person, the treatment is tailored to suit that person's cancer, hence the name personalized cancer medicine. Scientists can therefore identify the type of cancer a patient has before the doctor treats them. Drug companies developing new cancer medicines by law now have to develop a test kit for the cancer type at the same time as they develop the drug.

WIN consortium are a group of cancer experts trying to encourage cancer patients to participate in clinical trials for personalized cancer medicine. They have made a massive breakthrough with non-small cell lung cancer – a vicious killer – and have found that 5% of patients have a translocation – a point mutation (a point where the sequence in a gene has changed) – in the ALK gene that occurs in the cancer cell. This makes these patients good targets for the new drug. The drug has been tailored to find the patient's ALK gene and kill the cancer cell. This trial showed that 50% of patients with the gene translocation given the drug survived the cancer.¹⁰

Every year there are 14 million cancer sufferers worldwide so we need to tackle this. Personalized cancer medicine is at the same level of development as stem cell technology¹⁰ and in the future they are both worthy contenders for the future of healthcare.

Another possibility for the future of healthcare is vaccine development.

Vaccines are much cheaper than both other technologies and are cheap enough for undeveloped countries. However, pharmaceutical companies

making these vaccines cannot afford to make them in sufficient quantities. Luckily, Bill Gates has enough money to develop vaccines and distribute them among developing countries. He has developed a malaria and typhoid vaccine, both killers in Africa, Asia, and Far Eastern countries.¹¹ These new vaccines are further developed than personalized cancer medicine and stem cell technologies. So is this the way forward?

For vaccines, scientists make a weakened microorganism which causes the disease they want the immune system to fight. Once injected into the body, the immune system creates antibodies that fight the microorganism. The immune system then remembers the microorganism in its 'immune memory' so when the vaccinated person comes into contact with the disease for real, their immune system remembers and fights off the disease.¹²

The Bill and Melissa Gates Foundation has funded the development of vaccinations for use in African children and babies. Currently, they are in clinical trials and 15,460 children and babies aged 6-12 weeks or 5-17 months of age were tested. The results show that after the first year of vaccinations, severe malaria went down by 50%. These are amazing results that the Gates Foundation is working hard to improve.¹¹

With stem cells, personalized cancer medicine and vaccines, we can tackle three of the major causes of morbidity (illness) and mortality (death) in the world. All of these types of medicine are worthy contenders for the future of healthcare. Although vaccinations inhibit (stop) the patient having the disease in the first place if the patient did get cancer then they would require personalized cancer medicine. However, if the patient survived the cancer and lacked a particular specialized cell/cells, say a limb after a car accident, then stem cell technology would be required. All these technologies serve different purposes and therefore they all deserve a place in the future of healthcare.

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Cameron Hamilton attends Gosforth Central Middle School, Newcastle Upon Tyne, UK, as a Year 8 pupil. He has a keen interest in science that he looks forward to developing next year when he embarks on his high school career at Gosforth Academy.