AN ADVANCEMENT OF STEM CELLS

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ABSTRACT
Around 37 trillion cells make up the entire human body; all of which come from a very specific group of undifferentiated cells capable of curing nerve disorders and cardiovascular diseases as well as turning into 200 different types of specialist cells. In this paper I will explain the evolution of major stem cell research in the past, as well look into current progression and advancements in projects showing the potential in stem cell technology. I will also be exploring how ethics has had a large impact on the development of stem cell research. I will decide whether the involvement of ethics in stem cell research has been beneficial or if it has essentially slowed down the progression of modern medicine.

INTRODUCTION
For decades, scientists and researchers have been studying the anatomy of stem cells in order to use them to treat or cure certain diseases. The term ‘stem cell’ was first established in 1908 and research has developed dramatically over the past few decades. In 1908, there was strong evidence for neurogenesis, where neurons are made from stem cells. In as early as 1968, the world’s first successful bone marrow transplant was performed which cured two children with an immunodeficiency disease. Sheep were successfully cloned in 1996 using adult somatic cells. This was famously shown by Dolly the Sheep as demonstrated by the work of Ian Wilmut (1997), ‘Viable offspring derived from foetal and adult mammalian cells’. In as recent as 2001, human embryos were cloned for the first time which was a large step forward into stem cell research. However this was one of the many experiments that sparked outrage throughout religious communities, calling the research highly unethical and immoral. In 2005, rats who had suffered major spinal injuries were able to walk again after an experiment transferring embryonic stem cells from aborted foetuses.
There are at least two main sources of stem cells in the human body. Other sources have been discovered such as perinatal stem cells however more research is needed to fully understand their potential in medicine. The first main source of stem cells are embryonic stem cells. When an embryo develops, it contains a group of around 150 pluripotent stem cells which can specialise into different organs and limbs. Before they differentiate, these stem cells be removed from the embryo, and then specialised to regenerate certain cells (as shown in Figure 1), tissues and organs or to treat medical conditions. In October 2014, researchers in America were able to use embryonic stem cells to treat macular degeneration and macular dystrophy which are both conditions that cause blindness. This is shown in the work by Dr. Robert Lanza (2014), Human embryonic stem cell-derived retinal pigment epithelium in patients with age-related macular degeneration and Stargardt's macular dystrophy. The other main group of stem cells are adult stem cells with are found in places such as bone marrow and body fat. However adult stem cells cannot specialise into as many different cells as embryonic stem cells can. Current research shows adult stem cells have the capability to grow into bone cells or into heart muscle cells but research is still in its early stages. Scientists are also able to convert ordinary adult cells into adult stem cells by altering their DNA, yet the side effects on humans are unknown.
DISCUSSION
Stem cell research is one of the most ... alongside cancer research and Alzheimer’s research. There are now hundreds of institutes set up across the world dedicated to stem cell research.
Every year in the United States a recorded 610,000 people died from heart disease. This accounted for 1 in every 4 deaths in the US. Cardiac stem cells were only discovered at the beginning of the century. This opened a new wave of possibilities for cardiac therapy using cardiac stem cells. Originally scientists thought that it could not be possible to amend a heart that has been damaged by myocardial infarction or chronic diseases such as coronary heart disease. Early tests had shown that even though doctors could moderately repair some hearts using stem cells, it did not produce new heart cells altogether. Scientists have then been researching whether bone marrow stem cells could be used to treat patients who have suffered from heart disease which is the main focus of using stem cells in cardiovascular medicine. Patients are currently given special transplants where patients are given specially prepared stem cells which improve heart functions after a heart attack. Though the treatment was safe, it did not improve heart conditions enough that it could replace current treatments at the time.
Recently however, researchers were able to use human stem cells in order to regenerate damaged hearts of monkeys. Studies in Australia showed that embryonic stem cells from humans were able to encourage regeneration of the heart in macaques and larger primates. Initially, experiments on animals using human stem cells were only used on mice and other rodents. However, since humans share over 98% of DNA with primates this shows that similar treatments could possibly be used safely on humans as well. Scientists at the University of Sydney caused a heart attack in a number of macaque monkeys which eventually damaged the monkey’s heart. A fortnight later stem cells were injected into their heart and up to 40% of dead heart tissue was regenerated successfully. Figure 2 shows the results of human stem cells repairing damaged monkey heart tissue. This is shown by the recent work of Dr. James Chong (2014), Human embryonic-stem-cell-derived cardiomyocytes regenerate non-human primate hearts. It is hoped that from this research, the possibility of using stem cells to repair damaged human hearts has increased. As of now, the only possible major treatment for damaged hearts is a heart transplant which is both expensive and risky.
Cancer Research
Cancer accounts for the highest number of premature deaths in the UK which, arguably, is caused by stem cells themselves. Radiotherapy is a commonly used treatment which can kill some of the cancer cells in a patient's body. Unfortunately however this can also lead to normal cells and some stem cells in the bone marrow being destroyed as well. One way to overcome this problem is by giving the patient a stem cell transplant where more stem cells are injected into the body so that the patient can receive stronger radiation from radiotherapy for a longer time. This increases the chance of killing all of the cancer cells whilst damaging less of the body's normal cells.
Recently, attention has been turned to see what other treatments stem cells could create in terms of beating cancer. In late 2014 Dr Khalid Salah, along with a group of researchers from Harvard Medical School in the United States were able to engineer stem cells so that they could target and destroy tumours in the brain and leave normal cells untouched. Tests on mice with brain tumours have produced positive results, as shown by D.Stuckey (2015), Engineering Toxin-Resistant Therapeutic Stem Cells to Treat Brain Tumours. Figure 3 shows how toxins released from these new stem cells (in blue) attack the tumorous cells (in green). It is hoped that soon, similar treatments could be used on humans in around five years time. Should this become a new treatment then future research would eventually be focused on engineering stem cells so that they could destroy all types of cancer.
Regenerative Medicine
The *Ambystoma mexicanum*, more commonly referred to as the Mexican axolotl, is one of a very small group of unique animals which has the ability to regrow whole limbs, major organs and even their CNS should they become cut off or destroyed. These salamanders depend entirely on their white blood cells to regenerate lost parts of their body. Unfortunately, humans do not possess a similar ability to regrow lost limbs or destroyed organs. At most, humans are able to regrow toenails and fingernails if they have been cut off. Adults can also regrow their liver if it has not been too heavily damaged but most other organs or tissues won’t regenerate similarly. Instead, lost limbs are replaced by prosthetic versions and damaged organs are replaced by organ transplants via donations.
Recently however, research on mice in Spain has shown that certain totipotent stem cells could be grown in animals which can lead to possible regrowth of organs and limbs. Professors and researchers were able to develop stem cells in a mouse’s intestines and kidneys along with other organs, as demonstrated by M. Abad (2013) Reprogramming in vivo produces teratomas and iPS cells with totipotency features. Maria Abad added that not only could these produced stem cells ‘survive in a culture’ but that they could also be ‘manipulated in laboratories’. At the time this was regarded as a massive breakthrough in regenerative medicine, even though the same mice developed cancerous tumours soon after the stem cells were harvested.
On average mice and humans share over eighty percent of genes with each other. So theoretically, if this research further advances and improves then similar research could eventually be used on humans. Undeniably however, regenerative medicine is very far behind from becoming a reality.
Ethical Issues

Ethics has always had a significant impact on decisions in medicine, ranging from the abortion issue to the more recent three parent vote in the House of Lords. The use of embryonic stem cells is no different because if scientists want to use stem cells from an embryo then they need to destroy something that has the potential to become a fully grown human. However by doing so, doctors and scientists are improving the standard of life of someone who has already become a developed human. When doctors make these decisions, they have to choose between one of two main ethical principles, both of which seem very similar but become completely different when talking about embryonic stem cells. The first of which is that it is the doctor's duty to limit the amount or prevent pain in patients. The second principle is that doctors must respect the value of a human’s life.

This argument is very similar to the abortion issue which involves the destruction of an embryo with the potential to become a human being. Two main questions are asked when considering the use of embryonic stem cells. Firstly, do the positives outweigh the negatives? Would it be worth the destruction of a potential life if it’s only use is to restore parts of a damaged hand? On the other hand some may argue that it may be more beneficial to destroy an embryo, with no current value, in order to save or drastically improve the life of an already living person who holds much more value than an undeveloped foetus. This would respect the first moral principle. Second, has any wrong been done by using stem cells in this way? Many religious representatives say that the destruction of embryonic stem cells is the equivalent to murder, yet others see no wrong doing in improving the quality of life by using these specialist cells.

In order to address these questions scientists, doctors and politicians first need to consider the value of life for a developing embryo. There are two extreme ways at looking at this. The first is that an embryo, no matter what stage in development it is in, have the same rights and hold the same value to any other human being. This is referred to as the ‘full status’ position. People who believe this (mostly religious followers) agree that destroying embryos for research is, morally, just as wrong as murder and research on embryos is nothing less than human experimentation without consent. They believe that doctors destroying embryos fail to respect the value of human life. On the contrary, the other extreme view is that an embryo holds no value or status at all until it can survive independently from its’ mother. This particular view is referred to as the ‘no status’ position where an embryo is nothing more than simply ‘a bunch of cells’. People who stand in this position believe that there is no wrongdoing in exterminating an embryo. They believe destroying an embryo is the same, morally, as cutting off your own fingernails. Between the two extremes is the most popular view of an embryo’s value. This is called the ‘limited status’ position where the value of the embryo is proportional to its stage in development. So a 16 week old foetus holds more value than a 1 week old embryo.

Many different important figures have different views on what value an embryo has which leads to postponements and possible discontinuation of research. Arguably speaking ethics have delayed many possible advancements in science because a majority vote is needed for certain research to be accepted and proceeded. This becomes very time consuming and one can’t help but think where the position of medicine would be today without such mass intervention from ethical or religious groups. On the other hand however, medicine could be in a much worse position if no ethics were involved at all. Euthanasia would be allowed at any
given time without consideration and human cloning would become more of a reality than just a possibility. Ethics and morals are essential for making sure medicine is practised in a proper manner, and genetic research does not create an abominable horror which could threaten our very existence. In this extreme case, intervention of ethics is crucial and it is most necessary to have in research. But thinking that if ethics had less influence of developments and research, we could be in a much more advanced position today than what we already are in. It’s hard not to think whether we could find a cure for cancer sooner if animal rights activists never existed. Many people believe that a cure for HIV or AIDS would have already been found if human rights activists did not have such a large influence on human testing.

CONCLUSION
Stem cells have an unparalleled potential in medical research and scientists are only beginning to fully understand how stem cells can be used to change the face of medicine entirely. Increased funding and further research means that the use of beneficial stem cells is now becoming more of a reality than just a possibility. Should advancements in research continue to improve at an increasing rate, then we may have a possible cure for certain types of cancer or even heart diseases. Cures and treatments could be easier to find and may even be cheaper as well. Even though this may seem like the clearest direction that research needs to follow, this all hangs in the balance of medical ethics, moral principles and the law. There are many topics in medicine which have greatly divided the opinions and viewpoints of politicians, doctors and the general public and stem cells is no different. Whilst many find that stem cell research is undoubtedly the way forward for medicine, there is an equal, if not greater, number who believe that stem cell research is a step backwards for humanity. And even if major experiments were to happen in stem cell technology, we would first need the approval from major representatives for the experiments to proceed. This would consume a large, invaluable amount of time in which cures and treatments could be found. This is indeed a disadvantage to the involvement of ethics but it is crucial that it is involved in every form of scientific research so that experiments can be carried out safely, humanely and is ultimately beneficial. Though there are many positives that can come out of stem cell research, there are still a greater number of negatives that can come out as well. Therefore it is vital that the time is taken for everyone to approve the reasons why stem cell experiments are carried out and the usefulness of them.

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