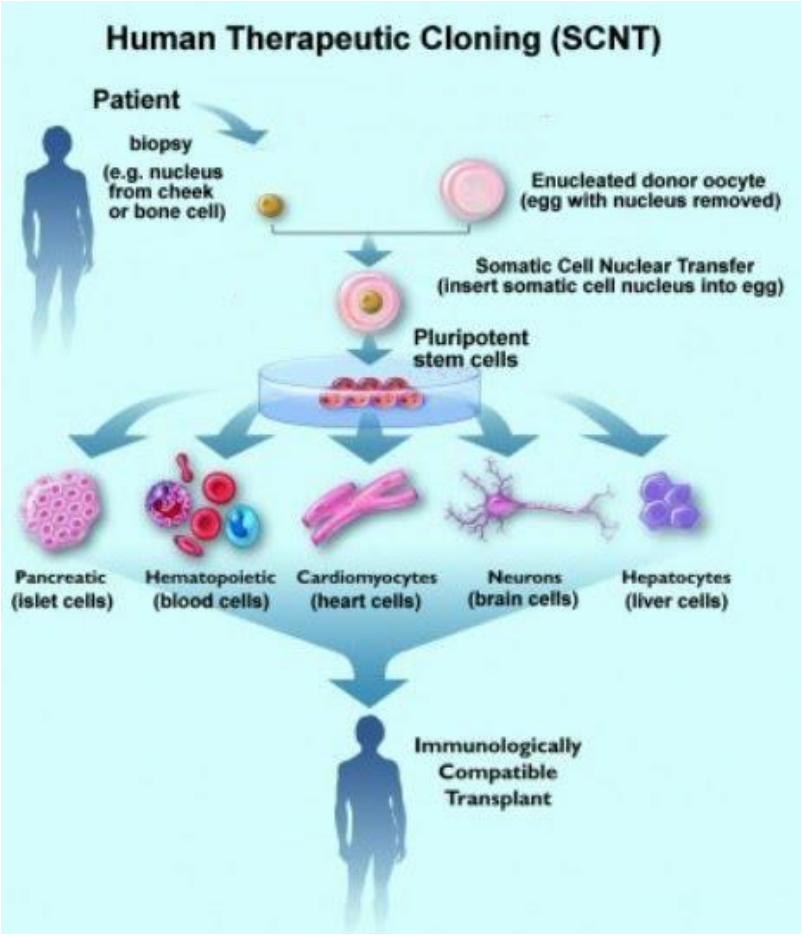
The Future of Medicine

The Answers to 15 commonly asked questions about therapeutic cloning

Imagine it's the year 2050 and the diseases that currently effect the lives of thousands of people no longer exist. People with diseases such as sickle cell anemia, diabetes, and multiple sclerosis are now able to "cure themselves" in a sense, thanks to scientific advancements that allow for an individual to produce the healthy cells they need.

1. What is therapeutic cloning?

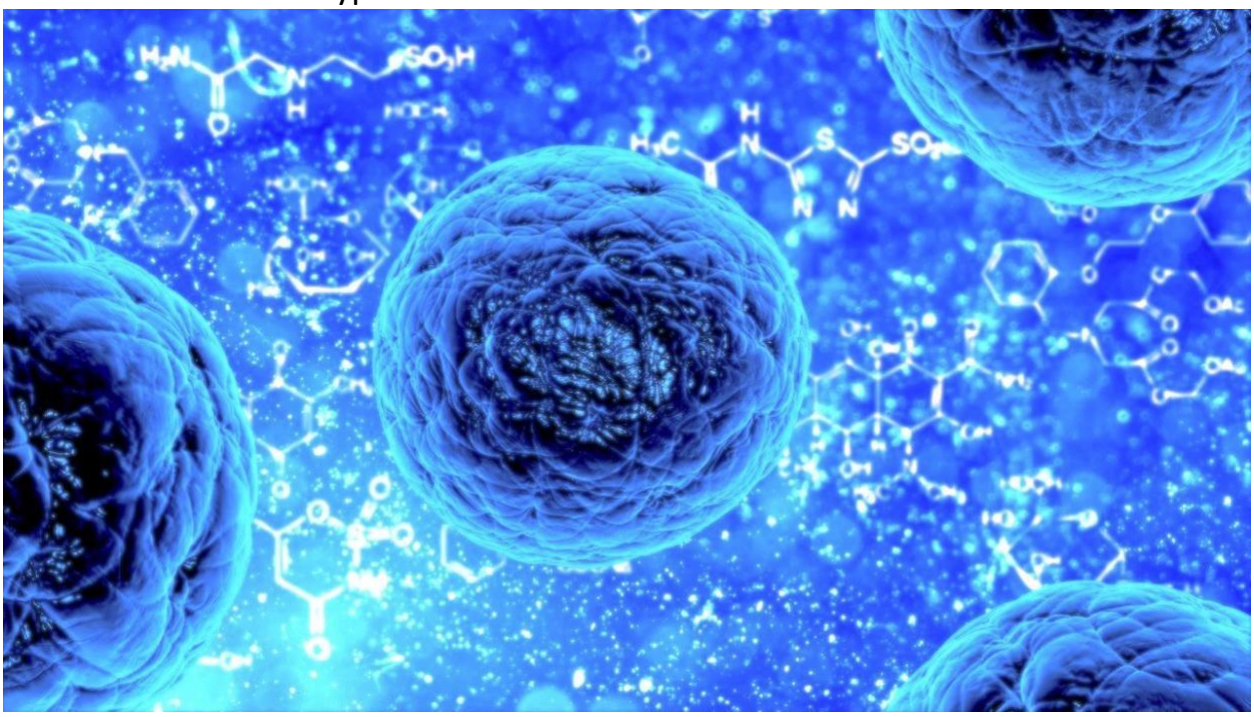
Therapeutic cloning involves a process called Somatic Cell Nuclear Transfer or SCNT for short. SCNT refers to the procedure where a donor egg cell is *enucleated* meaning, the nucleus is removed. The nucleus of a specific somatic cell is then transferred into the enucleated egg cell. The egg cell houses the nucleus of the somatic cell. The somatic cell nucleus used will depend on the needs of the patient. The cell is then incubated under specific *in vitro* conditions, meaning that, an artificial environment is created in order to induce cell division and begin embryonic development. (merrium-webster.com) After an incubation period of 4-5 days, epithelial stem cells are harvested from the inner cell mass of the blastocyst (mayoclinic.org). These stem cells are then placed another in vitro environment that guides the stem cells into becoming the desired cell type. These new specialized cells now have the exact same DNA as the patient and can be used for therapeutic medicine with no risk of rejection from the patient (sceintificamerican.com).



2. What are stem cells?

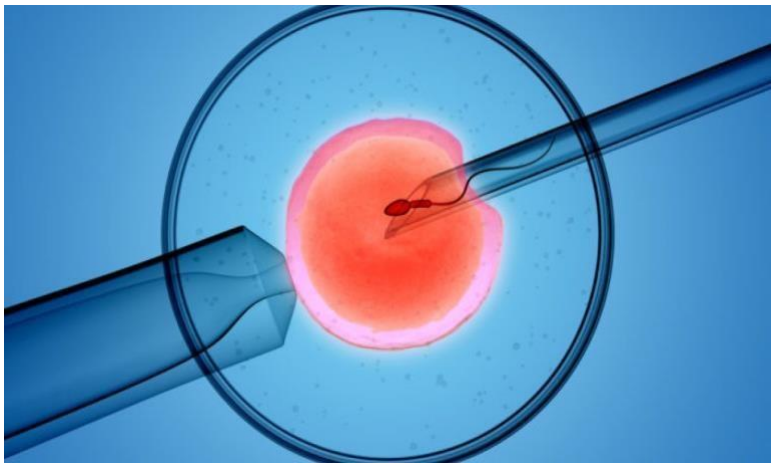
Stem cells are truly the “jack of all trades” of our bodies. Stem cells have the unique ability to transform into other cell types *as needed* by the body. There are two main types of stem cells:

1. **Embryonic stem cells:** Embryonic stem cells can only be found within the embryo of an organism. More specifically, embryonic stem cells are located within the inner cell mass of the blastula (mayoclinic.org). These stem cells are used in therapeutic cloning techniques because of their ability to become *any* cell type. This characteristic is referred to as *pluripotency.*
2. **Adult stem cells:** Adult stem cells are saved by the body in various regions (ex. Bone marrow, blood, brain, etc.) and can transform or *dedifferentiate* into *related* cell types as needed by the body (cryocell.com). Adult stem cells are different from embryonic stem cells because they are *multipotent*, meaning they can only dedifferentiate into related cell types.



3. Is the egg fertilized?

One of the most common misconceptions about therapeutic cloning is that the egg is fertilized in the SCNT process. This confusion is partly due to the way we use and think of the term “embryo”. In the usual sense, a human embryo refers to the first stages of development that occur after the sperm inserts its genetic material into the mother egg cell to create a genetically unique organism. In the case of therapeutic cloning, cytoplasmic factors within the egg cell (when placed in an in vitro environment) signal the cell to begin mitosis resulting in an embryo that is genetically identical to the original cell (abc.net.au).

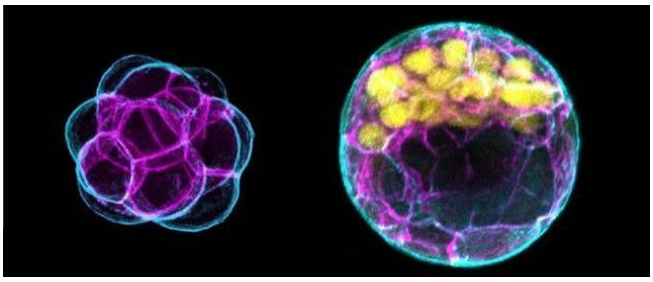


4. How is therapeutic cloning different from adult stem cell therapy?

Adult stem cell therapy involves collecting stem cells from the patient before they undergo chemotherapy in order to replace the cells that were destroyed by the radiation (uchicagomedicine.org). The patient will typically be instructed to take a medication to stimulate stem cell production in a target area before extraction. This process is different from therapeutic cloning because it does not involve the SCNT process. The types of procedures that can be done using stem cell therapy are much more limited than the outreach of therapeutic cloning due to the fact that adult stem cells are used as opposed to embryonic stem cells.

5. How is therapeutic cloning different from embryonic stem cell therapy?

Embryonic stem cell therapy is much more versatile than adult stem cell therapy because of the embryonic stem cell's ability to dedifferentiate in any cell type. In addition to their versatility, embryonic stem cells are much more durable than adult stem cells. The embryos used for embryonic stem cell therapy are embryos that were fertilized in IVF clinics but were never implanted in the mother, as well as from aborted fetuses (ncbi.nlm.nih.gov). This process is what distinguishes embryonic stem cell therapy from therapeutic cloning: because the process of SCNT is absent, the embryo used in embryonic stem cell therapy has been fertilized



(mayoclinic.com). In addition, because the DNA in the stem cells used in embryonic stem cell transplants do not match the DNA in the patient, the body will often reject the cells, marking the procedure ineffective.

6. What are the ethical advantages of therapeutic cloning?

If therapeutic cloning could be successfully and safely implemented into everyday medical practice, the need for embryonic stem cell therapy would diminish. With therapeutic cloning, a human being could never be potentially made at any point of the SCNT process, thus a "human life" could never be destroyed for the sake of a medical procedure. Statistically speaking, less than 1% of cloned embryos have the capacity to form into a complete human being, making it virtually impossible to create life by using a therapeutic cloning technique (abc.ner.au).

7. What are the medical advantages of therapeutic cloning?

Perhaps the biggest medical advantage of therapeutic cloning is that the stem cells have exact dame DNA as the patient. This advancement allows for the integration of the stem cells into the patient with no risk of rejection (Eurostemcell.org). In turn, if therapeutic cloning were to become available to the general public, it would ensure that every patient could be treated successfully.

8. So, what are the roadblocks?

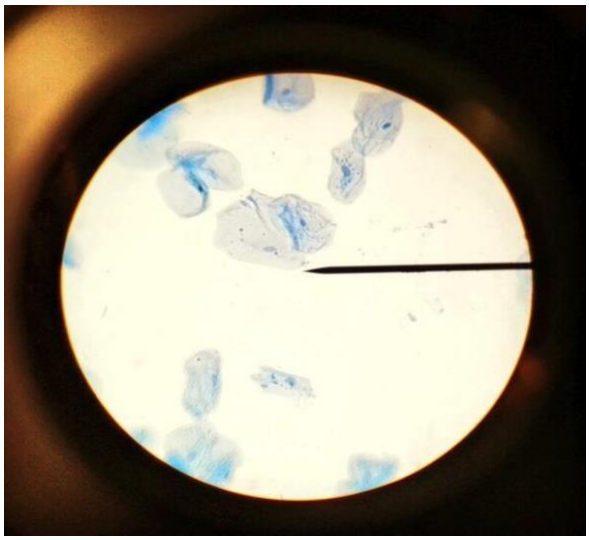
One of the biggest issues related to therapeutic cloning testing and research is the low availability of egg cells (oocytes). As of now, it is illegal to offer financial compensation for oocyte donation in many areas

of the world. The implementation of a financial incentive for oocyte donation would greatly increase the availability of oocytes for research purposes (ncbi.nlm.nih.gov). However, even areas where financial compensation for oocytes is legal, the medical procedures involved in egg cell donation are quite intensive, involving a multiple month course of hormone therapy and daily clinical observation. In addition, the

increasing demand for IVF fertilization procedures means that the majority of donated oocytes are used in IVF clinics.

9. What is haploidization?

Haploidization is a SCNT process that uses a human cumulus cell as opposed to an oocyte as the enucleated donor cell (Tesarik et.all). Research on this process is ongoing. The article: *Human Artificial Oocytes from Patient's Somatic Cells: Past, Present, and Future* by: Jan Tesarik, Carmen Mendoza, et all, encompasses the details of their successful attempt to generate functional artificial human oocytes. Tesarik and his team observed a 50% success rate, and 3 of the oocytes were successfully fertilized



(ncbi.nlm.nih.gov). The biggest issue observed with this model is the failure of the cell to reprogram the somatic cell nuclei correctly.

10. Has therapeutic cloning ever been successfully done in humans?

Unfortunately, therapeutic cloning has never been successfully done in humans. However, it has been done in some animal species (mayoclinic.org). The research suggests that we are still a while aways from being able to use therapeutic cloning to treat disease in humans, despite its recent success in small rodents.

11. How was therapeutic cloning used in the Parkinson's mouse disease model?

In March of 2008, Viviane Tabar, Mark Tomishima, and their team of scientists successfully used therapeutic cloning to transform cells from a mouses tail into cells that treat Parkinson's disease. Although the process of SCNT is in its infantile phases, the results from experiments such as this show promise that it one day may be used as a practical medical procedure (nature.com).

12. How is therapeutic cloning different from reproductive cloning?

The main difference between therapeutic cloning and reproductive cloning is the purpose of the procedure. With reproductive cloning, the purpose of the procedure is to create a fully formed organism that is an exact genetic match to the original organism. Reproductive cloning requires the implementation of the cloned embryo into a uterus. The embryo is then allowed to develop for the normal gestation and birth period (ncbi.nlm.nih.gov).

13. Who is Dolly the sheep?

July 5th, 1996, at the Roslin Institute in Scotland, the first ever cloned mammal was born, and her name was Dolly. Dolly was originally cloned from a white Dorset sheep. The nucleus of a mammary cell taken from the Dorset sheep was implanted into an enucleated egg cell from the surrogate mother (a Scottish Blackface sheep) using electrical current. The cells were then incubated until they entered the embryonic stage of development, when they were implanted into the surrogate mother until the time of birth (dolly.roslin.ed.ac.uk).

14. What are the ethical issues that surround therapeutic cloning?

The major ethical issues that surround therapeutic cloning is the need for embryonic stem cells for further stem cell research in the future (sciencedirect.com). Many people feel that utilizing aborted fetuses and unused IVF embryos for stem cell research is unethical because it encourages abortion and devalues the nature of human life.

15. Where do we go from here?

Undoubtedly, the medical benefits that could be obtained through use of therapeutic cloning procedures are vast, and much is yet to be discovered about the potential uses of stem cell therapies to treat disease. The outreach of therapeutic cloning goes as far as procedures such as treating severe burns to correcting the damage caused by a stroke (ncbi.nlm.nih.gov). Although humanity is a way away from being able to clone their cells at a local family practice, the scientific community remains optimistic about *the future of medicine.*

Image sources:

0. https://images.pexels.com/photos/4173248/pexels-photo-4173248.jpeg?auto=compress&cs=tinysrgb&fit=crop&h=627&w=1200

1. https://thealevelbiologist.co.uk/images/therapeutic_cloning.jpg

2. https://cdn-images-1.medium.com/max/1600/1*-FvScjJZsrMPsBjAvj6lTA.jpeg

3. https://1.bp.blogspot.com/-iFiTcaB3nBo/Xrb-RbHzTdI/AAAAAAACkic/FsfCbyVL5iI_Jom3N2ilJB6YfR5TPwnfwCLcBGAsYHQ/s1600/fertilizacao-in-vitro.jpg

4. https://pressbooks.bccampus.ca/clinicalproceduresforsaferpatientcaretrubscn/wpcontent/uploads/sites/472/2015/05/Sept-22-2015-083-300x199.jpg

5. https://iiif.elifesciences.org/digests/42298/digest-42298.jpg/full/full/0/default.jpg

6. https://researchleap.com/wp-content/uploads/2019/08/photo_2019-08-01_12-16-34-e1564643911888.jpg

7. https://img.rawpixel.com/s3fs-private/rawpixel_images/website_content/227a-eye0098.jpg?h=370&dpr=1.5&fit=default&crop=default&auto=format&fm=jpg&q=50&v ib=3&con=3&usm=15&ixlib=js-1.1.1&s=d4b96e9d4f275e0d3a90ef9718beb8b6

8. https://media.sketchfab.com/models/cf4cc4280ebb4ab6979f2dac248a436d/thumbnails/aaa197cf0e534f8d810e88e617b2968f/2d5dbb1a08bc40659de6605d194c72b9.jpeg

9. https://www.biologycorner.com/resources/cheek_cells_nihells_2013.jpg

10. https://knowledge.insead.edu/sites/www.insead.edu/files/images/2020/06/three_essentials_of_b2b_digital_transformation.jpg

11. https://c2.staticflickr.com/6/5707/30569177913_3377715bf1_b.jpg
12. https://saudbukhari.commons.gc.cuny.edu/files/2018/12/human-clones.jpg

13. https://live.staticflickr.com/8283/7717672726_0facc18473_b.jpg

14. https://bioethics.com/wp-content/uploads/2014/03/human-dignity.jpg

15. https://researchoutreach.org/wpcontent/uploads/2020/07/Depositphotos_383680730_xl-2015.jpg

Works Cited:

"Definition of *in vitro*" *Dictionary, Merriam- Webster,* *https://www.merriamwebster.com/dictionary/in%20vitro*

"Stem Cells: What They Are and What They Do" *Mayo Clinic,* Mayo Foundation for Medical Education and Research, March 19, 2022, https://www.mayoclinic.org/testsprocedures/bone-marrow-transplant/in-depth/stem-cells/art-20048117

"Therapeutic Cloning: How it's Done" *Scientific American,* A Division of Springer Nature America, Inc., November 4, 2001, https://www.scientificamerican.com/article/therapeutic-cloning-how-i/

"Where Do They Find Stem Cells, and Why Does That Matter?" *Cryo-cell international,* Last Updated on May 13, 2019 by Benjamin Greene, https://www.cryo-cell.com/blog/july2017/differences-where-stem-cells-found

"Ask an Expert: Therapeutic Cloning" *ABC,* *https://www.abc.net.au/science/expert/realexpert/cloning/01.htm*

"The Stem Cell Transplant Process", *Uchicago Medicine: Comprehensive Cancer Center,* The University of Chicago Medicine, https://www.uchicagomedicine.org/cancer/typestreatments/stem-cell-transplant/process

Kfoury, Charlotte. "Therapeutic Cloning: Promises and Issues", *McGill Journal of Medicine,* July 2007, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2323472/

"What is Cloning, and What Does It Have To Do With Stem Cell Research?", *EuroStemCell,* *https://www.eurostemcell.org/what-cloning-and-what-does-it-have-do-stem-cellresearch#:~:text=In%20therapeutic%20cloning%2C%20the%20blastocyst,promise%20for %20studying%20genetic%20disease*.

Tesarik, Jan, Mendoza, Carmen, et al. “Human Artificial Oocytes from Patient’s Somatic Cells: Past, Present, and Future” *PubMed,* National Library of Medicine, January 5, 2021, https://pubmed.ncbi.nlm.nih.gov/35128436/

Ledford, Heidi. “Therapeutic Cloning Create Perfect Match: Animal- Spefific Stem Cells Treat Parkinson’s Symptoms In Mice” *Nature,* Springer Nature, March 21, 2008, https://www.nature.com/articles/news.2008.686

“The Life Of Dolly” *The University of Edenborough, https://dolly.roslin.ed.ac.uk/facts/the-life-ofdolly/index.html*

Lisker, Rubén. “Ethical and Legal Issues in Therapeutic Cloning and the Study of Stem Cells” *ScienceDirect,* Archives of Medical Research: Volume 36, Issue 6, November 2003, https://www.sciencedirect.com/science/article/abs/pii/S0188440903001024