TOPICS THAT INTERESTED US (WILL STAR TOPICS TO COMBINE)

- How plants get through seasons/tough times
- Roots stay alive underground in cold, leaves reduce size in dry desert
- High-pressure area under the sea
- Ones lack oxygen in a given area
- Way of stay alive, produce energy
- Why is the human body temperature 36-37 degrees? What makes it important? Why do we need to feel cold?
- Northern light, people witness it in Beijing, so much more south, why?
- Sunrise sunset, colours, so short
- Chinook wind in Calgary
- The sky is yellow and blue but not green, why?
- The bottom of the clouds is flat, why?
- Scents, why do some smell nice, some awful?
- What is the science behind lying?
- Which is better: hand soap or hand sanitizer?
- How does adaptation work?
- *DNA vs. Cells
- *How do stem cells work?
- *Transcription factors and how they can change a cell

–NOTE–: We both did some independent research that was not mentioned in this logbook as during that point, we did not fully understand what we needed to add to the logbook.

FINAL PROJECT IDEA/NAME: Can Cellular Reprogramming Design a Stem Cell for Transplantation

Jan 17 - Finished Ethics and Due Care, Basic Project Info. From now until Jan 24, research about transcription factors in cells and cellular/genetic reprogramming

Jan 24 - we completely solidified our basic information and ethics and due care. From now until Feb 1, come up with ideas for our big “problem”.

Problems:

- Each year tens of millions of people are diagnosed with cancer and more than half of them eventually DIE (leukemia is a type of cancer)
- Although the survival rate of leukemia is 65%, this has only happened because of the remarkable discoveries of cell reprogramming. People use stem cell transplants to try to cure this.
- Some sort of cancer-related problem (as cancer is a huge issue in the medical field)

RANDOM RESEARCH SOURCE:

- https://sitn.hms.harvard.edu/flash/2014/do-it-yourself-stem-cells-the-story-of-induced-pluripotency/

Jan 31 - We had some doubts about our project but decided to keep going with it. We did a bit of research about leukemia and need to finish our problem.

Feb. 14th - Worked more on research, and layout of the project, and brainstormed an equitable problem. Formulated a problem/testable question “Can we use a reprogrammed stem cell to enhance the effects of cell transplants for leukemia” and researched further into the in-depth process of how a cell is reprogrammed.

Feb. 21st - We continued researching the process of reprogramming a cell, and inserted our hypothesis/thesis (*If* a directly reprogrammed stem cell that is based on existing stem cell properties is used, *then* it will provide better rates of success in leukemia treatments, *because* of the potential that stem cells and cellular reprogramming have in this field) in the CYSF website, and properly cited all of the sources we have used up to this date.

Feb 23rd - We researched transcription factors like Oct4 and Sox2 that are inside of stem cells (both embryonic and induced pluripotent) We should try to lengthen our research to make sure it is detailed and informative.

Feb. 28th - We finished research on the transcription factors of stem cells, normal cells, cancer (leukemia) cells, etc. For next week, add this research to CYSF and finish up any loose-ended research. Maybe start working on the conclusion (the conclusion should be finished by March 3-7).

March 3rd - Finished research on methods of reprogramming and transcription factors. Need to make a slideshow of information to put on the trifold, and also prepare a presentation. Will meet on Wednesday, Saturday, and Sunday this week to do so.

March 4th - Continued our Conclusion and began working on our presentation. We felt the need to add a little bit more research so we added that to the CYSF as well.

March 5th - Continued working on our presentation and only one paragraph is left for our Conclusion.

Continued March 5th - finished conclusion, added our problem, method, and hypothesis to the presentation. Filled up a couple of gaps in the research and conclusion, and put those into CYSF. We will meet up at Mia’s house tomorrow to finish adding everything to CYSF, hopefully, finish the presentation, and start working on our tri-fold.

March 6th - made our tri-fold background all white and got some feedback from our parents. Applied the feedback and put everything into CYSF again to ensure we didn't forget anything. Finished all the research and background research part of the presentation (in summarized form). Tomorrow Eden will come to Mia's house again to finish the presentation, start speech, and continue the tri-fold.

March 7th - Unfortunately Eden was too sick to come over to Mia's house so we Zoom called instead. Added pictures/diagrams related to our presentation and printed it out so we can put it on the tri-fold. Outlined what each of us will be saying for our speeches and worked on our script.

March 8th - Met on Zoom again and finished our loose scripts. Eden will come to Mia's house tomorrow to finish trifold and practice speeches to parents (and get feedback)

March 9th - Finished the trifold at Mia's house and printed out our speeches. We also practiced a bit. Eden will come to Mia's house again tomorrow and practice, practice, PRACTICE!

March 10th - Eden was back at Mia's house to practice the loose script. We need to practice making eye contact with the judges and not reading off our papers. Presented to our parents and received helpful feedback. Are almost prepared to the best of our abilities

March 13th - Mia is at Eden's house this time. We thought that our title wasn't catchy enough, so we changed it to "Transforming Stem Cells for Transplant Success". Then, we practiced our script and did a practice presentation to Eden's parents. Made a video to put on CYSF.

PROBLEM/TESTABLE QUESTION:

How can cellular reprogramming be used to design a stem cell for transplantation?
**How can we use a reprogrammed stem cell to enhance the effects of cell transplants for leukemia?*

HYPOTHESIS/THESIS:

If a directly reprogrammed stem cell that is based on existing stem cell properties is used, *then* it will provide better rates of success in leukemia treatments, *because* of the potential that stem cells and cellular reprogramming have in this field.

Each year there are about 62,770 new cases of leukemia and about 23,670 deaths occur. It fatigues the body, affects the bone marrow and the blood, and can cause the white blood cells to perform weakly against disease. Often, cell transplants are used to treat this cancer but donors for cells of the right type are not always available and thirteen in twenty people will die from this sickness. Sometimes it is possible to treat a patient with leukemia but there is no guarantee that the cancer won't come back. Data has revealed that half of patients receiving the transplant often

have a relapse; or a recurrence of the cancer. By investigating our problem/testable question, we may get one step closer to understanding how to treat the 62 770 people diagnosed each year by analyzing currently existing stem cells, finding their flaws, and researching how to improve the cells and the topic in great detail.

BACKGROUND RESEARCH:

WHAT IS A CELL:
A cell is the root source of all living organisms. They are essential components of all living beings by carrying out special functions. For example, a blood cell's specialized function is to transmit oxygen obtained from our lungs and distribute it to the rest of the body.

WHAT IS A STEM CELL (SOMATIC/ADULT, EMBRYONIC/PLURIPOTENT, AND INDUCED PLURIPOTENT STEM CELLS):
Somatic/adult stem cells are undifferentiated, meaning they are not yet specialized and don't have specific structures of functions. They are most commonly found in tissues throughout the body of nearly all living organisms. They are categorized as multipotent (unlike the embryonic/pluripotent stem cells which can become any cell) which simply means that they are restricted to becoming any cells in the tissue or organ such as the brain, skin, liver, heart, and bone marrow.

Embryonic/pluripotent stem cells are found in the inner cell mass of the blastocyst (the early developing stage of an embryo). These stem cells can become any type of cell in the body and are the type of cells that give rise to multipotent stem cells such as the somatic/adult stem cell. They are slightly more versatile than somatic/adult stem cells. Their use in stem cell research and cell medicine is controversial as it involves the extraction of the embryonic cell, destroying the human embryos.

Induced pluripotent stem cells (iPSC) are derived from adult/somatic stem cells that have been cellularly reprogrammed back to an embryonic/pluripotent state that grants them the ability to develop into an unlimited number of human cell types. An example would be an iPSC being specially designed to become a stem cell used to fight off leukemia which is related to the hypothesis/thesis that we have.

WHAT IS CELLULAR REPROGRAMMING:
Cellular reprogramming is when a cell is converted into another type of cell, most often done by creating Induced Pluripotent Stem Cells which are also known as iPSC or just stem cells.

https://iscrm.uw.edu/what-is-cell-reprogramming/#:~:text=What%20is%20Cell%20Reprogramming%3F,of%20cell%20in%20the%20body

https://youtu.be/Ea-8EMbkUHs?si=TjSp i9I9 gq8

WHAT IS A TRANSCRIPTION FACTOR:
Transcription factors regulate the process of transcription, occurring when an RNA copy is made of a gene's DNA. These also make up parts of a cell, including stem cells. The transcription factors involved with stem cells are Oct4, Nanog, and Sox2. These are what allow the stem cells to be pluripotent, or transformable, and may be used to create and reprogram a stem cell.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7221782/

WHAT IS A CELL/STEM CELL TRANSPLANTATION:
Cell transplantation is a method used to insert new cells into the body. Samples of cells are taken from a donor and moved into the patient's blood. This is frequently used in an attempt to treat leukemia. However, using cells from donors won't always work because the cells need to be of certain types, and not everyone wants to donate. Stem cell transplants, however, may be a better solution because the stem cells can become any type of desired cell.
https://www.cancer.net/navigating-cancer-care/how-cancer-treated/bone-marrowstem-cell-transplantation/what-bone-marrow-transplant-stem-cell-transplant#:~:text=A%20bone%20marrow%20transplant%20is%20also%20called%20a%20stem%20cell,that%20affect%20the%20bone%20marrow.

WHAT ARE THE PROPERTIES OF LEUKEMIA:
There are 4 main variations of leukemia, the cancerous disease. Acute Lymphocytic Leukemia or acute lymphoblastic leukemia which is the most common form of leukemia and is typically found in young children (but can also occur in adults), starts in the lymphoid cells of the bone marrow. Acute Myeloid Leukemia is the most common aggressive leukemia found in adults (but can also affect children) and starts in the myeloid cells of the bone marrow. Chronic Lymphocytic Leukemia is the most common slow-progressing leukemia, usually affecting older individuals and also starts in the lymphoid cells of the bone marrow. Chronic Myeloid Leukemia usually affects adults and starts in the myeloid cells of the bone marrow, growing slowly so symptoms are not noticeable for several months or years. When a person is diagnosed with leukemia, most of the effects are fairly similar and the only different aspect would be the age and time it affects the person. The bone marrow starts to produce too many white blood cells and disrupts bodily balance. These extra cells are different from normal ones in the fact that they don't function properly or fight diseases like a usual white blood cell would. This also makes it so that the bone marrow produces fewer red blood cells. Allogeneic stem cell transplants are common types of transplantations used in the treatment of leukemia. It requires extracting healthy stem cells from a donor, most often blood cells. Then, the blood and stem cells are separated. The blood is returned to the donor. After removing as many cancer cells as possible through chemotherapy, the stem cells are transplanted into the patient.

https://www.lls.org/treatment/types-treatment/stem-cell-transplantation/allogeneic-stem-cell-transplantation

https://www.hematology.org/education/patients/blood-cancers/leukemia#:~:text=Leukemia%20is%20a%20type%20of,red%20blood%20cells%20and%20platelets.

ADDITIONAL VOCABULARY (USED IN OUR RESEARCH/PRESENTATION):

Blastocyst: A small group of dividing cells. A blastocyst is the early stage of an embryo.

Embryo: The embryo is the earliest development stage of a living organism or a newly fertilized egg.

RESEARCH:

STEM CELL COMPONENTS:
The dominating transcription factors in both embryonic and induced pluripotent stem cells are Oct4, Sox2, and Nanog. They are the key to why the embryonic stem cell is undifferentiated and can self-renew. Oct4 is known as "one of the most important transcription factors required to maintain an undifferentiated state and pluripotent of human embryonic stem cells." Sox2 reverses the configuration of differentiated somatic stem cells back into a pluripotent state. It helps regulate Oct4 and the expression of genes. It works best with a partner, in this case Oct4. Sox2 appears to prompt Oct4 into action and thus induces pluripotency. While doing so, it also preserves its expression as well as that of Oct4 when used in tandem with it. Nanog manages cell fate while it develops and can assist in preventing differentiation. It also works with Oct4 in a system of transcription factors.

https://pubmed.ncbi.nlm.nih.gov/20132009/#:~:text=Oct4%2C%20Sox2%2C%20and%20Nanog%20are,embryonic%20stem%20cells%20(ESCs).

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4235945/#:~:text=The%20transcription%20factors%20Oct4%2C%20Sox2%2C%20Klf4%20and%20Nanog%20act%20as,important%20role%20in%20biological%20processes.

IDENTIFYING SIMILARITIES BETWEEN LEUKEMIA CELLS AND STEM CELLS (IN TRANSCRIPTION FACTORS):
We attempted to categorize our research for this subtopic into 2 sections. In the first section, we researched similarities between stem cells and normal cells, normal cells and cancerous cells, and cancerous/leukemia cells and stem cells. In the second subsection, we aimed to identify the indirect connection between stem cells and cancer cells by obtaining information on stem cells and normals cells, and normal cells and cancer cells.

Stem cells and normal cells

Stem cells and normal cells originate in similar places, but they are not very related or alike in terms of structure aside from select transcription factors. Sox2 and Nanog are limited to stem cells and are not found in normal cells, but Oct4 can be found in skin cells. In stem cells, Oct4 is used together with Sox2 and Nanog, but in normal cells the latter two transcription factors are not present. This could be what ultimately separates the two kinds of cells.

Normal cells and cancer cells

Some human cells share transcription factors with cancer cells. The transcription factor AP1 is seen in the liver, and breast cancer is shared with cells in the uterus. The MYC transcription factor found in breast, colon, tongue, lung, and leukemia cancer is shared with lung cells, and ETS1, commonly found in the prostate, ovary, and breast cancers, is shared with blood and lung cells. Oct4, Sox2, and Nanog were also discovered in the bladder, lung, skin, liver, and pancreatic cancer shared with skin cells.

Cancer cells (leukemia) and stem cells

Now through our research displayed above, you may notice a similarity. Oct4, Sox2, and Nanog have been found in bladder, lung, skin, and pancreatic cancer cells. But going back to the stem cell elements category and the composition of a stem cell, Oct4, Sox2, and Nanog are the main transcription factors of a stem cell. So Oct4, Sox2, and Nanog are the transcription factors that make cancer cells and stem cells indirectly connected.

From this information, how do stem cells relate to leukemia cells and why is this information useful? We uncovered that the transcriptional factor MYC is found in leukemia, and is also found in lung cancer. And if you recall, the trio of Oct4, Sox2, and Nanog are also found in lung cancer. This shows that, although indirectly, stem cells and leukemia cells are related. By better understanding the components of both leukemia and stem cells, we're better equipped to apply this information to create a stem cell with the specific transcription factors we have discovered, similar to how scientists found a vaccine for the Coronavirus by discovering the connections between existent vaccines and the properties of COVID-19 itself. We will elaborate more on this in our Conclusion.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7464564/table/cancers-12-02296-t001/?report=objectonly

https://www.ncbi.nlm.nih.gov/gene/2113#gene-expression

https://www.sciencebuddies.org/science-fair-projects/project-information/BioMed_p009/medical-biotechnology/how-direct-reprogramming-can-transform-one-type-of-cell-straight-into-another

BENEFICIAL TRANSCRIPTION FACTORS FOR LEUKEMIA AND CANCER CELL RESEARCH:

Identifying transcription factors that have beneficial properties is crucial to understanding how we can use them in leukemia cell transplantation—especially transcription factors that are in leukemia that have beneficial properties. This section will detail some of the transcription factors listed in the section above and some that weren't listed. There are also a few transcription factors that were not detailed as they have a less significant role in treating cancer.

AP1 - Activator Protein 1 is a vital regulator and mediator for anti-tumor/cancer immune system responses, nuclear gene expression, proliferation (cell division), viral infections, and cell death. It has been most commonly used to regulate breast cancer cells.

HIF1 - Hypoxia-inducible factor 1 is one of the most common transcription factors that are oxygen-dependent. They are used to stimulate the transcription of several genes and cells.

STAT3 - Signal transducer and activator of transcription 3 is mainly used to control cell proliferation or the division of a cell, the migration status of a cell, and induce cell self-destruction, thereby limiting the reproduction of cancerous cells.

MYC - Myelocytomatosis oncogene or MYC has two main roles in eliminating cancer cells. It both minimizes pathways that stimulate cancer cell multiplication and activates cancer cell death or destruction that allows new cellular components to be produced. It is additionally used in transplants to allow cancer patients to survive lethal doses of chemotherapy and is a promoter of cell proliferation.

ETS1 - The ETS-1 transcriptional factor is used as a form of regulation of cell division or proliferation, and cell death or apoptosis of healthy cells and cancerous/tumor cells.

RUNX1 - The RUNX1 transcription factor plays a huge part in muscle regeneration and regulates muscle stem cell proliferation and differentiation of cells. It is a key transcription factor in leukemia cells and is both good and bad, depending on where it could be used. For example in leukemia, bodily mutations that are passed down in RUNX1 cause the transcription factor to initiate further effects of leukemia and have been seen as responsible for recurrent chromosomal translocations which is a diagnosis of cellular diseases. But it also has a positive effect, which is that it plays a role in hematopoiesis which is the formation of blood cells and occurs during embryonic/somatic development.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9266363/

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7464564/

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6100431/

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3941237/

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5742424/#:~:text=RUNX1%20is%20a%20recurrently%20mutated,AML%20they%20are%20initiating%20events.

IS DIRECT REPROGRAMMING THE MOST *ETHICAL* METHOD OF CELLULAR REPROGRAMMING?:

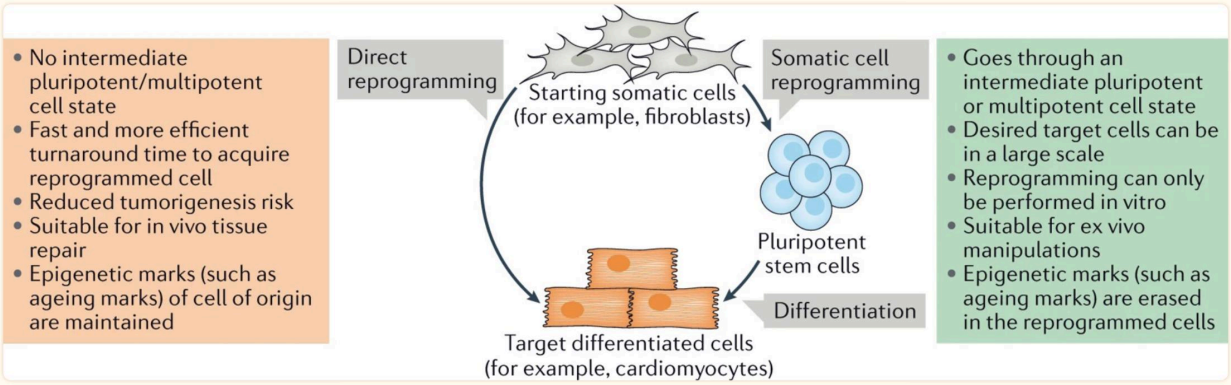
There are multiple types of cellular reprogramming: somatic/adult cell nuclear transfer, cell fusion, direct reprogramming, and the usage of iPSCs. In our hypothesis/thesis, we hypothesized that the cellular reprogramming method of direct reprogramming would be the most effective and ethical. And, through some extensive research, we have discovered that this is the case. Our research has revealed that the method of direct reprogramming is the most ethical because it does not require embryonic stem cells to take place, and it is more efficient than other methods.

In the somatic/adult cell nuclear transfer method the nucleus of a normal somatic cell is injected into an egg that has had its nucleus and chromatin removed. When the nucleus from the somatic cell is transferred to the egg that no longer has its nucleus, some of the protein from the somatic cell is also transferred to the egg but the volume of the innards of the egg dilutes the somatic nucleus protein, allowing for embryonic factors to reprogram the somatic chromatin. This process leads to the development of a regular blastocyst which can be reprogrammed into iPSCs used for transplantation. Although this is one of the more ethical methods of reprogramming, it's a bit inefficient.

Cell fusion takes place through the fusion of 2 specially selected cells that create a desired stem cell outcome used to develop a cell with 2 distinctly different nuclei. The objective of most cases of cell fusion involves the 2 nuclei merging, creating a special hybrid cell. For example, scientists have fused embryonic stem cells and fibroblasts to create the embryonic stem cell-fibroblast hybrid cell. This has proven to be useful but requires the use of embryonic stem cells, which may be unethical and can have low success rates due to the rarity of a hybrid cell being produced-.

Direct reprogramming, also known as transdifferentiation, involves select transcription factors being presented to a target differentiated cell, most often somatic cells. Direct reprogramming is very efficient compared to other methods since it could change one differentiated cell into another without an intermediate pluripotent/multipotent state in between. This was first completed using the transcription factor of MYOD being used on mouse cells but now has evolved to use different transcription factors depending on the type of cell being reprogrammed.

With somatic cells, the transcription factors used are Oct4, Sox2, Klf4, and cMYC. These created an induced pluripotent stem cell that can later be converted into a different cell type. Another method of this is lineage reprogramming, which converts a cell directly using transcription factors like Ngn3, Pdx1, and MAFA. Direct reprogramming has been used to create all manner of cells efficiently and is one of the best ways to reprogram a cell.



https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8161510/#:~:text=Lineage%2Dspecific%20transcription%20factors%20are,chromatin%20conformation)%20and%20activating%20others.

WHY ARE STEM CELLS ETHICAL TO USE IN TRANSPLANTATIONS:
Induced pluripotent stem cells are simply adult somatic stem cells that have been reprogrammed. This way, stem cells can be obtained without destroying embryos like embryonic stem cells might.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5765738/#:~:text=Current%20ethical%20controversies%20regarding%20stem,embryos%20and%20human%2Danimal%20chimeras.

ETHICAL CONSIDERATIONS STEM CELLS
Embryonic stem cells come from embryos, so retrieving them is a controversial task. However, this method would cause political and religious conflicts on the methods that are involved in extracting and destroying the embryo. Additionally, under specific circumstances iPSC has the potential to produce embryos, adding to the controversy over the usage of embryonic stem cells.

Embryonic stem cells, which are part of the pluripotent cell category, also have the potential to trigger an immune system response. In this situation the body will assault the stem cells, mistaking them for foreign harmful cells. Another possibility could be that the stem cells simply fail to properly function, or even fall under the circumstances listed above. Adult stem cells do not have the same capabilities as embryonic or induced stem cells and can't be used to treat the same amount of diseases. While iPSCs are an alternative, it takes an extensive amount of additional effort to produce these stem cells. And embryonic stem cells are almost completely out of the ethical picture.

Another issue that you may not have considered is the fact that while most people would eventually find a donor, the other percentage of people may find it extremely difficult or even impossible to find a suitable match for their specific situation. The risks in experimenting with stem cell transplantation also would have life-changing side effects such as further cancer formation and induced infections. Plus the aspect of differentiation of a stem cell presents challenges in that if the stem cell does not fully differentiate, it could cause tumors or cancerous formation.
https://www.mayoclinic.org/tests-procedures/bone-marrow-transplant/in-depth/stem-cells/art-20048117#:~:text=Adult%20stem%20cells%20may%20not%20be%20able%20to%20be%20manipulated,by%20the%20cells%20during%20replication.

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2598267/#:~:text=The%20risks%20to%20research%20participants,during%20neurosurgery%20and%20postoperative%20infection.

WHY IS CELLULAR REPROGRAMMING ETHICAL:
The reprogramming of somatic cells into induced pluripotent stem cells effectively avoids the ethical problems listed above regarding the specific uses of embryonic stem cell research. The cellular reprogramming field is still a fairly new field that is still being explored, and with this, learning more about it is essential to its further development. By further developing cellular reprogramming, we could be evolving into a new phase of cellular research, a better understanding of human development, how diseases begin, and how to treat them.

ETHICAL CONSIDERATIONS OF CELLULAR REPROGRAMMING:
With any type of research as advanced as that of cellular reprogramming, there will inevitably be issues related to the potential for cancerous or tumour formation, and other diseases that may come along with the whole process. This suggests that the triggered changes involved in the research may not be worth the outcome.

CONCLUSION:

We stated previously in our initial hypothesis/thesis that, "*if* a directly reprogrammed stem cell that is based on existing stem cell properties is used, *then* it will provide better rates of success in leukemia treatments, *because* of the potential that stem cells and cellular reprogramming have in this field." Based on our guiding problem/testable question, "can we use a reprogrammed stem cell to enhance the effects of cell transplants for leukemia", we were able to formulate an effective ethical solution to our problem, and support our hypothesis/thesis.

A directly reprogrammed stem cell would enhance the effectiveness of leukemia cell transplants because of the efficiency of direct reprogramming, the properties of stem cells, and the potential transcription factors such as AP1, HIF1, STAT3, MYC, ETS1, and RUNX1 have in being used to treat cancer successfully.

Using the method of direct reprogramming to reprogram a cell is indeed the most ethical and is simultaneously the easiest and also efficient because not only can it be used to reprogram stem cells, but it can reprogram average somatic cells if necessary. Direct reprogramming also has a higher success rate than methods like cell fusion, is simpler than somatic/adult cell nuclear transfer, and can produce a wide variety of cells. It would better the rates of success in leukemia bone marrow transplants

Attaining a stronger understanding of leukemia, stem cell, normal cell, and cancer cell transcription factors and properties, applying this information would be a crucial stepping stone in taking it to the next level–using it in real life. Similar to how our scientists discovered a cure for COVID-19. Researchers had to obtain a very detailed understanding of the Coronavirus itself to find out how to use it in a vaccine. This project could someday, should we choose to pursue this topic further, help with transplants and research of illnesses in the future.

The ethicality of stem cells and cellular reprogramming is a very controversial topic in that the production of embryonic stem cells involves the destruction of the blastocyst. Embryonic stem cells also produce embryos in rare cases, but this circumstance adds to the tension of using stem cells. Additionally, in almost any kind of experiment as complicated as stem cell transplants, there are always possibilities of mission failure or unintended consequences to the body.

How would we take this project a step further?
To continue this project, we could fully design a stem cell at more advanced levels. If we were to continue this, we would also try to apply our newly found knowledge to an experimental project. We could also consult a professional in the field who has experience in this field of study; being able to talk one-on-one with a professional would provide us with even more detailed information that would be based on their personal experiences.