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Erin May
Grand Valley State University

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Erin May

Outline Honors Senior Project

Norman Kravitz

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Stem Cells and Breast Cancer

Hello. My name is Erin May, and I am a senior at Grand Valley State University. I have been a member of the Honors College since my freshman year here at Grand Valley State University. For my senior year project, I had decided to write an essay on something I am passionate about. Stem cell research has become a crucial part of the science world, and during my genetics class my junior year, I had learned about tissue bioengineering. This study sparked my curiosity with stem cells. I researched many experiments that used the bioengineering of stem cells to produce new organs via organ printing. I had no idea that this type of science was being used in an everyday setting. It astounds me that even though I am a science major, and am greatly involved in research in my classes, how little I actually know about the miracles of stem cells. Stem cells not only can build organs through organ printing, but they can be manipulated to cure diseases such as Parkinson’s disease, retinal diseases, diabetes, heart diseases and treat different cancers such as leukemia and breast cancer. I want to share my experience of researching theories about stem cells and the many miraculous things they can do. I want to describe my journey, my
misconceptions about embryonic stem cells, and explain the stem cell therapies used to treat breast cancer.

I am a Roman Catholic, and I am pro-choice. I believe that inflicting my own religious and personal beliefs against others goes against the institution that America has instilled. However, I personally am pro-life, because I would never consider an abortion if I were to become pregnant. I believe life begins at conception, and ends with natural death. I have a complex view about life, and about science. I believe that stem cell research in all of its forms (embryonic, adult, and induced pluripotent stem cells) should be funded by the government, for it will allow scientists and researchers to continue the fight against chronic diseases and illnesses. As a woman, a sister, and a potential mother, I want to see a cure for breast cancer during my lifetime. I hope that my dream will become a reality. Through my paper, I hope to recruit learned people to join the fight against breast cancer, to support more federal funding for stem cell research, and hopefully target common misconceptions that give stem cell research a tainted name.

Breast cancer is the second leading cause of death in woman. Metastasis (the rapid growing and mobility of a tumor), tumor relapse, and resistance to therapy are the main causes of death for breast cancer patients. The lack of effective therapies calls for an improved understanding of the molecular mechanisms driving breast cancer progression. In order to understand the multifaceted complexes of breast cancer research, there must be an understanding of stem cells, cancer stem cells, the breast, breast stem cells, and
breast cancer stem cells. Every tissue is composed of its own type of stem cells. Stem cells are homogeneous cells that have the ability to self-renew and separate into many types of mature cells such as tissue, muscle, and blood cells (Edgren). Stem cells create new cells to replace older cells in the entire body. Without stem cells, our bodies would not be able to repair damaged cells. Stem cells are described as pluripotent cells, which means they can become any type of cell in the human body. A single stem cell can be differentiated (turned into) a tissue cell, or a blood cell, or a neural cell, depending on what the body needs. Pluripotent stem cells such as embryonic and induced pluripotent stem cells offer the possibility of a renewable source of replacement cells and tissues (Latfala). Stem cells are unique in their ability to divide and regenerate themselves and in their ability to remain specialized or unspecialized in the tasks of the human body. Stem cells can be isolated and extracted from pluripotent embryonic cells, multipotent adult somatic cells, and induced pluripotent cells (genetically reversed adult somatic cells) to be used in clinical trials, and research methods.

Embryonic stem cells are the most successful type of stem cell to be used in the clinical setting. They are prepared from embryonic tissues, primordial germ cells of late fetuses, and cord blood. All of these reservoirs of these stem cells have multiple potentials, and allow the differentiation of haematopoietic (blood), neural, skeletal, muscle and other tissue cells. Embryonic stem cells can become any cell in the three germ layers (ectoderm, mesoderm, and endoderm) and other specific tissues. “Embryonic stem cells can be used as a vehicle for introducing targeted genetic modifications into the germ line (Solter).” The gold
standard for human embryonic stem cells is the cultures of the entire inner cell mass of the blastocyst.

My initial concerns about embryonic stem cell research were similar to those who still oppose it today. I believed that embryonic stem cell research involved the killing of a potential fetus. I thought that scientists conned pregnant women into giving up their child's life for science. I believed that scientists were killing potential fetuses in the process of retrieving embryonic stem cells. The subject of stem cell research is difficult to understand at times, and if you as a reader have some trouble with this subject, or even this paper, I strongly suggest to do some research on your own. Find answers to the questions you have, or talk to scholars of the field. When I first started to write my paper, I had some misconceptions about stem cell research and my personal beliefs about it. I met with Dean Hiskes, who is an extraordinary academic and has had many years working with stem cells, to discuss my opinions and concerns with the field. She helped me shape my own opinions through understanding the facts about stem cell research, specifically regarding embryonic stem cells. I encourage those who have questions about stem cells, or any subject that you are passionate about, to find the tenacity and curiosity that I had. For you many find out, like I had, that my convictions were tainted by my lack of understanding.

Embryonic stem cells are acquired mainly by two ways. The first is by the fertilization of an egg with sperm (Latfala). These embryos are obtained from the fertility clinics. When couples are trying to have a baby through in vitro fertilization, they usually end up with far more fertilized embryos than they need
or want. Instead of throwing away the frozen embryos, the parents can donate their excess embryos to stem cell research. I believe that this donation is a better use for the miracle of conception, than disregarding that miracle, and tossing the embryos in the trash to rot.

The second method for obtaining embryos is through therapeutic cloning. In therapeutic cloning, the nucleus from one of the patient's cells is removed and merged with a donor egg, replacing the egg's natural nucleus (Edgren). That egg is then stimulated with chemicals or electrical energy designed to make it divide and replicate. Since its nucleus comes from the patient's own cell, the resulting cells should be accepted by the patient's body, meaning no rejection.

Recently, it was discovered that embryonic stem cells can be obtained a third way. Human embryonic stem cell line derivation does not necessarily require embryo destruction. Biopsies from morula-stage embryos (the blastocyst, a hollow ball of cells during the first stage of fetal development from zygote) can derive multiple cell lines. Scientists can use one cell line to take stem, which would allow the embryos to continue developing in vitro allow for the continual maturation of the embryo, without any defects (Edgren). I believe that through this method of extracting embryonic stem cells from only one of the cell lines, the ethical concerns about embryonic stem cell research will become irrelevant, because the life of the embryo is being conserved. However, this is a relatively new technique, so the ethical concerns of embryonic stem cell extraction still have a great influence on the availability of embryos for research. The only negative aspects of using embryonic stem cells are due to its very
limited accessibility due to their ethical concerns, and their high risk of cancer formation. One type of stem cell that does not have any of the ethical concerns surrounding its use in research is the adult stem cell.

Adult stem cells can be found in bone marrow, skin, and other specific tissues of the body. Adult stem cells can self-renew indefinitely, and generate the entire cell types of the organ from which they originate, which potentially regenerates the entire organ from a few cells. Although there are no ethical issues concerning adult stem cells, they have technical issues. “The number of the stem cells in each tissue is generally so small that they require culture and expansion in vitro for the clinical use, because there is a critical difference between embryonic stem cells and adult stem cells in terms of growth (Okochi).” Adult stem cells undergo a rapid turnover rate to “replenish” any lost cells. Culturing adult stem cells requires specific conditions that are usually not satisfied. The growth potential of adult stem cells is limited due to spontaneous differentiation of cells depending on their age and origin. Adult stem cells have no risk of cancer formation, have an unlimited accessibility of stem cells, and need to be a high/full match for immune-compatibility. Adult stem cells are useful in certain types of therapies such as bone marrow transplants (which will be discussed later in this paper). However, I believe we will not find the cure for most diseases and illnesses with the use of adult stem cells.

Induced pluripotent cells are somatic (any biological cell forming the body, for example a skin cell, a heart cell, or a lung cell) cells that were reversed into an immature cell state. They are very similar to the pluripotent embryonic stem
cells but do not carry with them the ethical concerns. The ability to reprogram somatic cells to a pluripotent state offers tremendous potential for generating a source of patient specific pluripotent stem cells. This is vital for the building of new organs through organ printing and treatment of illness and disease. Patient derived induced pluripotent stem cells are expected to contribute both to treating the patient and do drug screening for the disease. The induced pluripotent stem cells cell technology can be used for the production of cell lines from patients with various diseases (Turksen). Several groups of somatic cells have shown potential to be reprogrammed to a pluripotent state: adult dermal fibroblasts, and epidermal keratinocytes. “Any of these cell types may be suitable for large-scale construction of induced pluripotent stem cell lines and banks since harvest of these cells from adults can be accomplished via noninvasive or minimally invasive medical procedures (Palecek).” Induced pluripotent stem cells lines should retain the ability to differentiate to any cell type in the adult, but the efficiency of differentiation may be varied based on the somatic cell source, donor age, or reprogramming method. Induced pluripotent stem cells provide a new approach to the development of diseases based on a particular genetic trait at the cellular level. This method is not widely used; however, it may provide an alternative derivation method that reduces the ethical concerns associated with embryonic destruction. Induced pluripotent stem cells have a limited accessibility of stem cells, have a high risk of cancer formation, and require a full match for immune compatibility.
When comparing to adult stem cells, implantation of embryonic stem cells has a higher risk for spontaneous differentiation and can develop into cancer. One of the benefits of embryonic stem cells compared to adult stem cells is that there is no requirement for the cells to have immune capability. Embryonic stem cells and induced pluripotent stem cells possess the ability to self-renew and differentiate into progenitor and terminal cells in each of the three embryonic germ layers: ectoderm, mesoderm, and endoderm. Pluripotent stem cells offer the potential to serve as in vitro disease models (Okochi). Long term applications of human pluripotent stem cells include serving as a source of cells for tissue engineering and regenerative medicine applications. Just as adult stem cells, pluripotent stem cells have their limitations and technical issues that impede the translation of pluripotent stem cell research to clinical therapies. Pluripotent stem cells have the ability to cause tumors that exhibit the three germ layers called teratomas inside the body, so methods to ensure products contain no undifferentiated cells will be critical. However the limitations, induced pluripotent stem cells are becoming more and more preferred.

Stem cells can be used to treat diseases through repairing its tissues to replacing disfigured cells in the tissues. Most stem cells are specific to the type of tissues they become. For examples, hematopoietic stem cells are stem cells of bone marrow. Hematopoietic (blood) stem cell transplantation is the oldest and most widely available stem cell therapy. It is used to treat diseases such as leukemia (cancer of the blood or bone marrow), thalassaemias (inherited autosomal recessive blood disorders), sickle cell disease, and myeloid
hypoplasia (anemia or neutropenia) (Nguyen). Bone marrow transplants are the most used stem cell therapy because it is easily harvested, is a low risk to the donor, and does not need to be grown inside the patient before it is transplanted. This is because hematopoietic stem cells continually create all of the new differentiated hematopoietic cells in peripheral circulation, including leucocytes, erythrocytes, and thrombocytes. Another common stem cell therapy is through the use of umbilical cord blood and mesenchymal stem cells.

Umbilical cord blood contains the same kinds of hematopoietic stem cells as bone marrow. Umbilical cord blood has already been used extensively for hematopoietic stem cell therapy and has been used to treat leukemia, hematological diseases and inherited metabolic diseases. Mesenchymal stem cells (multipotent stromal cells) from bone marrow have been reported to play an important role in supporting the maintenance of hematopoietic stem cells. Mesenchymal stem cells are derived from the umbilical cord and the placenta that can divide into many different types of undifferentiated cells. Mesenchymal stem cells are commonly used because they have a low risk of immune rejection when transplanted into a patient. They have the potential to differentiate into many lines of mesenchymal tissue, such as bone, cartilage, fat, tendon, muscle, and ligament (Reya). Mesenchymal stem cells along with hematopoietic stem cells can be used to treat disorders of the neurodegenerative and cardiac systems. Mesenchymal stem cells are more promising to use instead of hematopoietic stem cells or even skeletal myoblasts because they can differentiate into cardiomyocytes and are less provocative to the immune system.
than hematopoietic stem cells. Experiments are still in progress to find the best
cell therapy for neural and heart disease. The gold standard for regenerating
heart muscle so far is endogenous cardiac stem cells (Nguyen). Although there
are treatments and cures for certain illnesses and diseases, there is still no cure
for cancer, and some treatments for certain cancers are available. This is due to
the complexity and unpredictability of cancer cells.

Stem cells and cancer cells share the ability to self-renew. Newly arising
cancer cells appropriate the machinery for self-renewing cell division that is
normally expressed in stem cells. There has been evidence that shows the
many pathways that are classically associated with cancer may also regulate
normal stem cell development. For most cancers, the target cell of transforming
mutations is unknown. There is considerable evidence that certain types of
leukemia arise from mutations that accumulate in hematopoietic stem cells
(Reya).

Cancer stem cells arise from normal stem cells. Several lines of evidence
indicate that cancer stem cells can also arise from mutate progenitor cells.
These can possess substantial replicative ability, but they do not usually have the
self-renewal capacity of stem cells. To become a cancer stem cell, a progenitor
cell must acquire mutations that cause it to regain the property of self-renewal.
Multiple pathways and processes can give rise to cancer stem cells. A small
subgroup of cells in a tumor is essential for its growth. Cancer stem cells can be
the source of all the malignant cells in a primary tumor. They can compose the
small reservoir of drug resistant cells that are responsible for relapse after a
chemotherapy induced remission or they can give rise to distant metastases. The biologic feature of cancer stem cells in each of these instances may differ, suggesting that the acquirement of characteristics associated with tumor progression, such as genetic instability and drug resistance, will also be associated with cancer stem cells (Nguyen). It is becoming evident that a cancer treatment that fails to eliminate cancer stem cells may allow regrowth of the tumor. Therapeutic strategies that specifically target cancer stem cells should eradicate tumors more effectively than current cancer treatments and reduce the risk of relapse and metastasis.

Cancer stem cells have been analyzed and compared to the cells present in different cancers. Scientists have discovered that specific cancers have their own cancer stem cells that make that cancer unique. However, in order to understand the cancer stem cells of a specific cancer, one must understand the organ or tissue that the cancer is attacking. Understanding all the building blocks and connections between cancer and the body will help scientists target specific cancer cells, and leave the rest of the body unaffected (Nguyen). One major type of cancer experienced by 1 in 8 women in United States alone is breast cancer. So, in order to explore this topic of breast cancer further, an explanation of the human breast is necessary for making connections.

The human breast is a complex secretory organ that is composed of an intricate diverging system of epithelial ducts surrounded by a fat pad, which is rich in adipocytes (fat cells), blood vessels, hematopoietic cells, and stromal fibroblasts. The epithelial ducts are lined with an inner layer of luminal epithelial
cells and an outer layer of contractile basal myoepithelial cells that promote the
extrusion of the secreted milk from the alveoli during lactation. These ducts also
lay in the same area that houses other ducts that produce milk during lactation
(Reya). During pregnancy, hormones cause the development and differentiation
of specific cells into secretory cells that produce and secret milk. Once milk is
not needed from the breast (the mother has stopped breast feeding), the
expanded mammary duct is returned to its normal state through a process known
as involution, which involves extensive apoptosis (programmed cell death) and
tissue remodeling. It is when the cells of the breast begin to act spontaneously
and irregularly that cancer can be developed.

Breast cancer is the third major human cancer in which cancer stem cells
have been definitely identified. Breast cancer stem cells have been recently
identified and purified based on their surface antigen expression. In metastatic
(final step in malignancy) breast cancer, “cells with a specific cell surface antigen
profile of CD44-positive and CD24-negative could successfully establish
themselves as a tumor (Jordan).” This antigen profile has been closely studied
and used in research labs to predict and target breast cancer. It has been shown
that purified CD44-positive and CD24-negative cells could differentiate and give
rise to cells similar to those found in the major tumor population (May). The
recognition of mammary epithelial stem cells has led to the hypothesis that these
may be at the root of breast cancer.

One theory proposes that breast cancer stem cells resulted from the
deregulation of normal stem cell self-renewal and differentiation pathways,
resulting in cancer cells with both self-renewal and differentiation capabilities. Evidence for this theory arises from the similarities between normal stem cells and cancer stem cells and that normal stem cells are highly susceptible to mutations and oncogenic transformation due to their long lifespans. Breast cancer stem cells are likely to originate from basal mammary stem cells due to the similarities between the surface profile of basal cells and the breast cancer stem cells they discovered.

The second theory suggests that breast cancer stem cells develop from epithelial-mesenchymal transition (abnormal activation of latent embryonic programming in stem cells). Cells that undergone this are susceptible to transformation and have many characteristics and behaviors similar to those of normal and neoplastic stem cells (Jordan). Epithelial-mesenchymal transition can establish cancer cells with the mobile and invasive capabilities associated with the fast movement of the cancer cells. Tumor progression is driven by cancer stem cells that show the ability to self-renew and the ability to regenerate the phenotypic heterogeneity of parental tumor. Cancer stem cells have been involved in starting and supporting primary tumor growth and in driving the formation of metastasis at different sites.

Breast cancer stem cells have the ability to self-renew and a potential to differentiate, generating cells with a variety of phenotypes within tumors. Another important feature of breast cancer stem cells is their ability to differentiate into non-stem breast cancer cells. This occurs inside the body as well as under standard growth conditions in the lab. Breast cancer stem cells can be derived
from mammalian differentiated epithelial cells. It has been found that retinoic acid plays a role in the control of self renewal versus differentiations of breast cancer stem cells. ATRA, an inducer of retinoid signaling, decreases formation of cells in the mammary region and either induces genes expressed in differentiated breast cancer cells or down regulates several programs involved in breast cancer stem cell self-renewal (Jordan). Genes may not have a causal relationship with breast cancer may still be correlated with outcome. Therefore care must be taken when relating the prognostic value of a gene profile to the involvement of a molecular target in the progression of that disease.

Breast cancer stem cells demonstrate resistance to chemotherapy and radiotherapy. The mechanisms of chemoresistance are thought to arise from metabolic quiescence, a high level of expression of anti-apoptotic proteins and the presence of multi-drug resistance transporters. The drug resistance in breast cancer stem cells is associated with alteration in self-renewal at cell fate signaling pathways of the cells. However, resistance is not a universal characteristic of breast cancer stem cells. It can be depleted by radiotherapy. Specific targeting of these populations leads to a diminishing of cancerous breast stem cells. Also, these resistant populations have been use in a number of chemotherapeutics used to treat breast cancer. The proportion of CD44+CD24- cells was increased in breast cancer patients after treatment with chemotherapeutic drugs. Of the 1% of cells that survived chemotherapy, 30-35% of them were CD44+CD24- cells (May). Trastuzumab, an antibody composed of many identical cells, in particular has been used successfully to treat HER2-
positive, early and metastatic breast cancer. It has been shown that the 
overexpression of the HER-2 gene is associated with estrogen receptor-negative 
characteristics in women. The HER receptors are proteins that are rooted in the 
cell membrane and give off molecular signals from outside the cell to inside the 
cell, and turn genes on and off. The HER proteins also stimulate cell production. 
In breast cancer HER2 is over-expressed, and causes cancer cells to reproduce 
uncontrollably (Reya). It has been shown that trastuzumab improved overall 
survival for women with metastatic breast cancer. In early stage breast cancer, it 
reduces the risk of cancer returning after surgery. However it can cause serious 
heart problems which may resolve if treatment is stopped.

When used in combination with conventional chemotherapeutic drugs, 
trastuzumab results in a response rate of between 50 and 84% (Nguyen). 
However, the majority of patients develop resistance within one year of the start 
of treatment. Resistance is thought to be at least in part due to the role of the 
cancer stem cell population. The interaction between CD44 and hyaluron (a 
sugar that is widely distributed in connective, epithelial, neural tissues) and has 
been shown form a resistance to trastuzumab by interfering with the connection 
of the antibody to the Her2 receptor on the cell surface. Trastuzumab is also 
being studied for the treatment of other cancers. It has been used with some 
success in women with uterine papillary serous carcinomas that overexpress 
HER2/neu protein. However, any treatment that risks the presence of a drug-
resistant population that can regenerate a tumor after treatment has serious 
consequences for therapy.
Another therapy against breast cancer stem cells may be heat shock protein 90. Heat shock protein 90 is a member of the group of proteins known as molecular chaperones, which act as facilitators and quality control factors for the correct folding, assembly and transport of nascent and mature proteins within the cell (Nyugen). A number of anti-heat shock protein 90 drugs are currently being developed as anti-cancer agents.

The most important features of heat shock protein 90 as an anti-cancer target is the ability to simultaneously inhibit multiple-signaling pathways and its drug selectivity. The selectivity of the drug is achieved by the specific characteristics of heat shock protein 90 function in cancer cells and stem cells. Heat shock protein 90 functions to exclusively control the folding and stability of numerous transcription factors and signaling intermediates inside the body, which includes some key regulators of breast cancer (Nguyen). The association of such a wide range of signaling receptors, intermediates and transcriptional mediators with the common chaperone, makes heat shock protein 90 an attractive target to simultaneously inhibit multiple cellular pathways in cancer. Many proteins that heat shock protein 90 control mediates fundamental cellular processes such as apoptosis, cell cycle, and cell proliferation and differentiation, many of which are essential to the establishment and survival of cancer and cancer stem cells. Higher levels of heat shock protein 90 expressions have been observed in cancer cells and the inhibition of heat shock protein 90 has been linked to cancer and stem cell differentiation (Hanahan).
The inhibition of a number of these pathways through targeting of heat shock protein 90 is already being harnessed to develop anti-cancer agents. In most cases, these drugs are selective for cancer cells, due to the fact that heat shock protein 90 is over-expressed into cancerous cells compared to normal cells. However, there is little known about the difference in the heat shock protein 90 mediated signaling pathways in cancer stem cell compared to cancer cells or indeed, normal stem cells. If there is no sufficient difference between heat shock protein 90 expression and function in normal stem cells compared to cancer stem cells, there is a risk that anti-heat shock protein 90 drugs may deplete the normal stem cell population that are essential for correct organ homeostasis. Comparative analysis of the biochemistry and cell biology of somatic and cancer stem cells populations should be essential component of these drug development programs.

Some information on cancer stem cells signaling has been obtained from studying the pathways that underlie the unique features of stem cells, such as self renewal. Some of the else pathways are directly chaperoned by heat shock protein 90 while others are indirectly linked to heat shock protein 90 as they lead to downstream activation of intermediates of pathways that are chaperoned by heat shock protein 90 (Hanahan).

Gene therapy delivered directly to a particularly stubborn type of breast cancer cell causes the cells to self-destruct, lowers the chance of recurrence and helps increase the effectiveness of some types of chemotherapy. Scientists have found in cellular and mouse studies the gene mutation BikDD significantly
reduced treatment-resistant breast cancer stem cells by blocking the activity of three proteins in the GBcl-2 family (May). This genetic approach increased the benefits of lapatinib, one of the most common chemotherapy drugs for HER2-positive breast cancer (May). Lapatinib is an orally active drug used to treat breast cancer. It is composed of two tyrosine kinase inhibitors which disrupt the HER2 protein. It is used for the treatment of patients with advanced or metastatic breast cancer whose tumors over-expressed HER2 protein (May).

Another recent finding is that epithelial cells can be induced to take on stem cell properties by forcing them to undergo epithelial-mesenchymal transition. This change from epithelial cells to mobile mesenchymal stem cells is an important step in metastasis. During normal embryonic development, epithelial-mesenchymal transition serves to loosen cell to cell contacts and to enhance intrinsic cell motility, thus paving the way for the extensive cell movements required for gastrulation and organogenesis. In normal adult tissues, the typically dormant epithelial-mesenchymal transition program is reactivated during wound repair and tissue regeneration. Dysregulation of epithelial-mesenchymal transition however can lead to pathologic conditions such as organ fibrosis and tissue destruction. Non-metastatic cancer cells may harness the epithelial-mesenchymal transition program to attain the migratory and invasive potential required for metastatic progression.

There is increasing evidence of similar cellular hierarchies in the normal and malignant mammary gland. The gene expression profile of CD44+/CD24 breast cancer cells, enrich for cells with tumor-initiating capabilities more closely
resembles that of CD44+/CD24 cells from the normal breast than CD44+/CD24 cells isolated from the same tumor (May). Breast cancers have long been recognized as a remarkably diverse and heterogeneous set of malignancies, owing mostly to their classification into numerous histological subtypes on the basis of several histopathological criteria. In recent years, cytogenetic and mutational analyses- in conjunction with molecular profiling technologies- have revealed that this histologic heterogeneity is underpinned by diverse gene expression signatures, though to represent the different cell lineages of the mammary gland and stages of mammary epithelial cell differentiation. Using genomic profiling at least six breast cancer intrinsic subtypes have been identified on the basis of their distinct molecular signatures rather than their clinical or histopathology behavior.

The findings that link epithelial-mesenchymal transition, cancer stem cell traits drug resistance and enhanced metastatic competence suggest that targeting the epithelial-mesenchymal transition and cancer stem cell phenotype may hold considerable therapeutic promise. The anti-diabetic drug metformin, which has long been recognized for its beneficial effects in breast cancer, was recently shown to selectively kill breast cancer stem cells inside the body (Reya). Moreover the combination of metformin and DNA damaging agent doxorubicin reduced tumor mass and prevented relapse more effectively than either drug alone. Residual cell populations recovered from these tumors after the combined treatment were devoid of cancer stem cells demonstrating that the therapeutic prowess of metformin is linked to its ability to kill cancer stem cells. The need to
combine conventional chemotherapies, radiotherapies, or endocrine therapies with drugs targeting the self-renewal, survival and drug resistance of cells with an epithelial-mesenchymal transition and cancer stem cell phenotype is key to stop the progression of breast cancer (May).

Stem cell research has become an extremely important subject in our world. Stem cells can help find cures and treatments for diseases and illnesses such as Parkinson’s diseases, leukemia, and even breast cancer. Although there are some ethical concerns about stem cell research (embryonic stem cell research in particular), I hope that my paper has given insight to the miracles it can provide. Through my own experiences that I have shared, I hope that my readers can relate and learn from my misconceptions. The goal of this paper was to inform those who may not know a lot about stem cell research in hope that they may be educated citizens. Ignorance is the foundation that bans stem cell research. If ignorance is halted, cures for major diseases and illnesses can be discovered.
References:


