BIOPRINTING: THE ETHICAL APPROACH TO STEM CELLS AND ALTERNATIVE METHODS

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INTRODUCTION: THE DILEMMA OF BIOPRINTING IN ACTION

 Ethics are the guidelines by which society is governed. Ethics are an essential element for any profession in the world today. They are especially necessary for the field of engineering because of all the groundbreaking methods and technologies that are discovered that do not have precedent to be followed on their use and acceptability. In my field of bioengineering, I am governed not only by the code of ethics set by the National Society of Professional Engineers, or NSPE, but also the code of ethics specifically for bioengineers. My ethical conundrum is not simply one of project choice, but one of significant impact to my career path.

 The company, for which I have worked for five years and currently work, has been involved with designing and testing the efficiency of organs that have been bioprinted. The bioprinting process for the testing and designing was contained completely “in house” with Organovo three-dimensional printers. The printers apply both the cells and the structure simultaneously to construct the ideal organ that most nearly resembles the organs in the human body [1]. The research and development of the organs had been making great headway in the field, and based on this success my company had seriously considered taking the next step in the field, which is to put the bioprinted organs into practice.

 The organs that were printed in the lab would be implanted into patients needing a transplant. The intended recipients of the organs would be children. Children and young adults are the ideal recipients of biofabricated organs because the organs would be able to grow and develop along with the developing individual [2]. Despite the fact that young adults and children would benefit the most from these organs, there is still a dilemma of preforming rather untested procedures on such young and innocent patients.

 Due to the risky nature of the procedure, my company had decided that it would use embryonic stem cells to manufacture the organs. They figured that they would use embryonic stem cells because they are known to be more reliable and versatile in any scenario involving creating biological parts. The issue of these cells is relatively well known but there is a large dilemma with the use of them because of the action of taking away a human life in order to procure the cells from the embryo [3]. Both of these dilemmas make it difficult to continue to work for this company, even though this company gave me my start as an engineer.

 The situation was complicated even further when I was approached by another company offering me a position with them a few weeks prior. This company, at the time, had similar ambitions to those of my company currently, however; it was a slightly improved situation. This new company planned on implementing their biofabricated organs in medical use on patients in need of a transplant. They too insisted on the use of their organs for primarily young adults and children, but their method for creating the organs would be different. They planned on using cells from the recipient’s own body to fabricate the organs. This would ensure compatibility with the patient’s body and would eliminate the controversy of stem cells [4]. The problems with changing and working for this company are that they still intend to implant their organs into the youth, who require transplants, and I would be departing from the first company to hire me as an professional engineer.

 After weighing all of my options I have concluded that there are four viable paths from which I have to choose. I could stay with the company I am currently working for and go along with their use of stem cells in bioprinting to create organs for children in need of a transplant. I could attempt to reason with my superiors and try to sway them away from the implantation of the biofabricated organs. I could take the position at the other company leaving my first employer behind to be a part of a company with the same goal as the one I am leaving behind but with a more humane method of doing so. Finally, I realized that I also have the choice to leave the specific area of bioprinting to avoid the difficulty of possibly being responsible for something that advances the field of medicine that could also turn out to be a consequential action.

 Regardless of which path that is chosen, there are medical and bioengineering standards, which are based off the ethical tenets of the field of medicine, that need to be upheld within the work and research that is performed. Also, I have to take into account the code of ethics of engineers in general because I am a practicing professional engineer. The ethical codes of medicine, engineering, and more specifically bioengineering have to be considered in all and any decisions that I make going forward in this process of determining the future of my career as an bioengineer.

**ETHICS BEHIND ORGAN TRANSPLANTATION**

Introduction to Ethics in Engineering

 Ethics can be thought of as a set of rules or guidelines that help people to live and act in a way that is respectful and allows them to be aware of the world around them. Engineers have a code of ethics that governs the way in which they made decisions and advance the technology of society. According to the American Society of Civil Engineer’s article on “The Importance of Understanding Engineering Ethics,” engineers will face ethical challenges that they must confront in their day-to-day lives and overcome through the use of the codes of ethics of which they are required to adhere [5]. Engineers must abide by the codes if they wish to be competent, efficient, and productive in their work environment. Each discipline of engineering has their own specific code of ethics that they abide by in addition to the code of ethics set for engineers in general.

**Ethics in Scope**

 The codes of ethics that directly apply to my situation are the code of ethics for engineers in general and the code of ethics specifically for bioengineers. The code of ethics for all engineers applies to my scenario because it is a blanketing code of ethics that is designed to touch any and every situation that could arise in any engineering field because it is so broad and unspecific [6]. My dilemmas of confronting my superiors about the issues that I have with their methods, leaving the company, and leaving the area of bioengineering altogether are encompassed within the rules of practice section of the general engineering code of ethics. The code for bioengineers is more specific because it touches more on the side of medicine and the medical profession as a whole; it puts engineering ethics in a form that is designed for the medical world [7]. My dilemmas of embryonic stem cells and youth trials are covered within the first tenet of the code for bioengineers. Regardless of the subject matter for the ethical dilemmas that I have, both codes of ethics overlap to some degree in their definition and outlining of the ethical actions of each dilemma.

**Ethics of Embryonic Stem Cells**

 The first ethical dilemma to be addressed is the use of embryonic stem cells in the bioprinting process. The embryonic stem cells are a viable option for the three-dimensional printing of organs because they are compatible like other types of cells used in three-dimensional printers. There is an advantage to using embryonic stem cells over cells that have a more specific purpose, which is that; these cells have the capability to become any other type of cell [8]. According to The Witherspoon Council’s report on the ethics behind stem cell research and application, the fact that these cells are so versatile does not outweigh the conflict that there is an ethical controversy over anything to do with such cells because of the method with which they are obtained. The general ethical question of whether or not to use embryonic stem cells by moral and scientific standards has been a long contested and debated topic that has not made much headway [9]. However, as an engineer, the code of ethics for engineers combines both a humane and scientific viewpoint to judging ethically charged scenarios.

 Not just one code of engineering ethics is sufficient to provide a guide of how this dilemma of using embryonic stem cells in bioprinting is to be addressed. It requires the aspects of both the general code of ethics for engineers and the code of ethics for bioengineers because this topic falls within the field of biology. The general code of ethics for engineers has several tenets that can be directly applied to this ethical dilemma. The first is that engineers must keep public safety, health, and welfare a top priority [6]. The advanced use of embryonic stem cells in bioprinting both coincides with and contradicts this fundamental canon. It is in line with the canon because, with health and welfare as the main focus, the use of these cells fosters the development of the medical field, which indicates that the public is in the best interest. It also opposes the canon because it requires the taking of a human life to obtain the cells to print the organs. This is not keeping the health and welfare of the public as a priority. Due to the conflicting nature of this topic of embryonic stem cells under this canon, it is not easy to make an ethical decision either for or against the use of the cells in this or any scenario.

 A second tenet that is applicable to the dilemma of embryonic stem cells is that engineers must “strive to serve the public interest” [6]. This applies to the problem of embryonic stem cells because this issue is one that is very public and very contested. They general public does not have a specific stance on the issue, therefore; no clear ethical decision can be made. Because of the indecisiveness of the issue, any action would offend a large portion of the public and thus would not be in the public interest.

 A third tenet comes from the bioengineering code of ethics. It is similar to the first tenet from the general code of ethics for engineers but slightly directed towards the medical aspect of ethics. It is close to the first because the codes of ethics share many aspects, which allow them to be compatible in the real world. The tenet from the bioengineering code of ethics says that bioengineers must use their “knowledge and skills to enhance the safety, health, and welfare of the public” [7]. This is different from the first tenet because the interest of the engineers is to enhance the public systems and states of people that already exist. The use of embryonic stem cell, while controversial, would in fact advance the health and welfare of the public because they would quicken the time it will take to successfully transplant biofabricated organs and reduce the need for human donors. The dilemma of using embryonic stem cells in bioprinting is a very controversial topic and is not even easily examined under the scope of any code of engineering ethics.

**Ethics of Youth Experimentation**

 The second issue that must be addressed is the majorly experimental trials of transplantation of biofabricated organs for the youth of society. The tenets of the codes of ethics for engineers in general and bioengineers that applied to the first dilemma apply to this issue as well but in a slightly different manner. The first tenet, which is the fundamental canon from the general code of ethics for engineers that holds a main duty of engineers, is to maintain the safety, health and welfare of the public, similar to the first dilemma, supports and opposes the actions of youth experimentation [6]. The practice of youth experimentation aligns with the canon because transplanting the organs in the patients, who require them, is maintaining the health and welfare of them. Through the acquiring of the organs, the youth are more likely to survive. In addition to it being a solution for them to survive, younger patients are more fitting matches for the printed organs because the organs are able to develop in the patients growing body [2]. The issue also contrasts the canon because experimental trials on people, especially the youth is not a safe thing to do. The haste with which the companies wish to start transplanting organs is not safe because it opens the door for speed rather than safety and the possibility of imperfections that could end up being fatal [10]. This issue also has a very conflicting nature under this tenet because of the benefits of the trials but also the possible catastrophes.

 The second tenet, which is serving the public interest, is opposed by this dilemma of youth experimentation because as a general statement people do not appreciate that idea [6]. The public has a “soft spot” for youth meaning they do not want to see them come to harm in any manner. This issue of experimentation, having the chance of complications, is not in the public interest and therefore against this tenet of the code of ethics for engineers.

 The last tenet that is applicable to the situation is the bioengineering tenet that a bioengineer’s knowledge and skills must be used to advance the welfare, health, and safety of the public [7]. The dilemma of experimentation on the youth does in fact agree with this tenet because, despite the risk, the medical field is being shaped and is evolving for the better of the public. The ability of bioprinting to print intricate systems of blood vessels and organs is being put into practice through the experimentation [11]. The issue of experimental trials on the youth of society, although not as contested as embryonic stem cells, is still a contested issue within the codes of engineering ethics.

**Ethics of Voicing Grievances**

 Unlike the first two issues, the issue of voicing grievances with a superior incorporates completely different aspects of the code of ethics for engineers. They have less to do with the science and development and more to do with the personal convictions involved with being an engineer. The first tenet from the code of ethics that applies to this issue of voicing my grievances is “if an engineer’s judgment is overruled under circumstances that endanger life, they shall notify their employer” [6]. This tenet is applicable to the situation because the endeavors that the company wishes to accomplish could potentially endanger the lives of the unborn through the use of embryonic stem cells and the youth through the experimental implantations.

 The other tenet that applies to this dilemma is “engineers shall disclose all known or potential conflicts of interest that could influence their quality of work” [6]. This is applicable to my dilemma because there are many issues that I personally have with the actions that the company wishes to pursue. It highlights that it is my duty to voice my concerns of my convictions to my superiors and allow them to make decisions from that point forward. The engineering code of ethics does in fact support the dilemma of voicing grievances to superiors wholeheartedly, and it allows that to be a viable action for me going forward in my decision-making process.

**Ethics of Changing Employers**

 The general ideas of the tenets of ethics that are used in this section are based on being honorable and responsible when dealing with different firms of engineers. The first two tenets can be combined to assess this dilemma. They are the tenets of conducting oneself as an engineering honorably and responsibly and being guided in their relations with honesty and integrity [6]. These tenets address directly the issue of leaving one firm for another. As outlined by these tenets, it is ethical to change firms as long as it is done honorably, openly, and with integrity. Therefore, changing firms would be an ethically viable option in and of itself.

 The third tenet involves the conduct of the other firm that is contacting me. The tenet requires them to act with integrity and to not try to attract another company’s engineer by false pretenses [6]. As long as the company that is trying to acquire my employment does it by ethical and honest means, then their acquiring of my employment is ethical. The dilemma of switching companies is ethical within the confines of the code of ethics of engineering as long as the means to switch companies are ethical.

**Ethics of Leaving Bioprinting**

 The last dilemma deals with leaving the specific field of bioprinting altogether. There are two tenets in the engineering code of ethics that apply to this issue. They are the tenets of conducting oneself honorably and responsibly and “performing services in areas of their competence” [6]. The first tenet of honorable and responsible conduct applies to this situation similarly to that of changing companies. The way with which engineers conducts themselves when departing from a place where they work must be with dignity and respect in order for it to be considered ethical.

 The second tenet of performing services within their areas of competence is a major ethical issue. If an engineer is performing a service in an area in which they have little or no training, they will be incapable of succeeding in the task that they were assigned and they will surely disappoint the client. The dilemma of leaving an area of expertise in engineering is only ethical if the person leaves their company honorably and if they take their services to a field that they are capable working in.

# CONCLUSION: DECISIONS BASED ON THE ETHICAL CODES

 Despite all of the ethical analysis that I have done in all of the aspects of the situation that I am in, I can honestly say that there is no easy decision to be made. The best choice that I see for myself is to first talk to my current employer about the current situation of the company and voice my concerns. I have decided that this is the best first course of action because the dilemmas of bioprinting with embryonic stem cells and experimental implantation of those organs into the youth of society. If they understand where I am coming from and agree to stay with the current affairs of just testing and optimizing the printing process, then everything will be fine. If they should hear what I have to say and decide to continue on with their current plans, then I will have to leave the company but must do so honorably and respectfully so as to not offend anyone or seem unethical. I do not believe that transferring to the alternate company is an option. Although they are not printing with the controversial embryonic stem cells, they are still planning on the experimental implantation on the youth, which is too much of a risk to willingly accept. My only other option will be to find a firm content on development and research of bioprinting or completely change my career path and find another discipline of bioengineering with which I am well versed. This process of making ethical decisions would have been completely impractical and improbably without the use of the engineering codes of ethics. The codes of ethics clearly helped to outline the best possible choices that can be made within the realm of engineering.

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**ACKNOWLEDGMENTS**

 I would like to thank Julianne McAdoo, Beth Newborg, and the library staff for their assistance with the formatting and outlining of the necessary material for this paper. Also I would like to thank Tyler Stoney for editing this paper and James Ciabattoni and Kyle Monto for their assistance with brainstorming and formatting this paper.

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