Ethical Analysis of The Protein Expression Toolkit

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Introduction

Synthetic Biology is an emerging field of science that fuses Biology with Engineering perspectives (Parens et al., 2009). It introduces the idea that artificial biological functions can be standardized and manipulated as if they were standard parts of a machine. The difference between Synthetic Biology and other forms of genetic engineering is that the emphasis of Synthetic Biology is on creating *artificial products* or *synthetic life* (Parens et al., 2009). While the general public remains unfamiliar with this emerging field of science, the number of projects continues to rise. Therefore, it is important that researchers working on new projects in synthetic biology be aware of the ethical implications and potential public perception of their projects. The objective of this paper is to discuss some of the economic, ethical and social implications of the University of Calgary's 2010 iGEM project.

Project Description

Gene expression refers to the transcription of DNA genetic code into mRNA, which is then translated into amino acid sequences. These amino acid sequences then become functional proteins via post-translational modifications and folding. Protein expression refers to the process of folding that results in a poly-peptide chain becoming a functional protein (Gasser et al., 2008). Expression also includes the concept that the protein must be transported to its correct location in the cell in order to perform its function (Gasser et al., 2008). Genes coding for various proteins (i.e Insulin) can be synthesized using *E. coli* for many therapeutic applications (i.e. treatment of Diabetes Type II). *E. coli* is commonly used in medical research because it is easy to grow, relatively safe to work with and its entire genome has been sequenced. However, even in *E. coli*, it can be difficult to express some recombinant genes. The processes used to produce the desired protein are capable of failure at multiple points. To address this problem, our team is creating a troubleshooting toolkit in which any gene of interest can be inserted. If the gene and its corresponding protein fail to express, the toolkit will report at which step production failed. This point of failure is indicated by the expression of genes coding for green and red fluorescence proteins. The toolkit consists of two separate circuits. The first circuit detects problems with transcription and translation. The second circuit detects the cellular stress responses that are activated by protein misfolding in both the periplasm and the cytoplasm.

Method of Evaluation

Economic

From an economic perspective, our biological toolkit is quite beneficial. Firstly, our toolkit can help increase research efficiency by reducing expenses. Our toolkit can easily be used to determine where protein production is failing. This can allow researchers in the field of Molecular Biology to avoid spending time on avoidable repeated trials without knowing the exact cause of the problem. If our toolkit is used to pinpoint the exact step that is going wrong, it could assist researchers in cutting down on both the time and money spent on troubleshooting.

Undergraduate students, like those who participate in the iGEM competition, constantly confront situations where a constructed circuit containing a desired gene does not express itself properly. In that case, if the students use our toolkit, it could benefit them in two ways. First off, using the toolkit will help save time from troubleshooting on various suspected aspects of their circuits. This is vital for the iGEM competition, as teams have only a single summer to work on their project. Having access to a toolkit like ours can allow them to save the time that might otherwise be spent on troubleshooting. Secondly, it can save the teams money by reducing the use of costly material such as restriction enzymes, buffers and other laboratory supplies on troubleshooting or repeating experiments. Many iGEM students do not have access to huge amounts of funding. Therefore being able to save on wetlab costs can allow them to spend their limited funding on other aspects of the project. Hence, our biological toolkit can increase research efficiency by saving time, and money spent on identifying where protein production is failing.

Social

There are two general views on Synthetic Biology. One takes the precautionary approach, advocating that Synthetic Biology should be considered dangerous until proven safe. Proponents of such views must consider the significant potential that Synthetic Biology has to cause unintentional harms (Parens et al., 2009). In contrast, the pro-actionary approach advocates that Synthetic biology can be considered safe unless otherwise proven harmful. Jay Keasling, a professor of chemical engineering at the University of California, Berkeley, emphasizes understanding the huge potential that synthetic biology has in providing eternal solutions to mankind's current needs (Parens et al., 2009).

From a pro-actionary perspective, our project has a beneficial application to society. For example, our biological toolkit has immense educational value, because it can be used to understand, teach, and apply simple molecular biology concepts. For example, in a high school setting, students begin to be exposed to concepts such as the amplification of proteins using *E. coli*. Often times the students are not aware that during this process many complications may be introduced to the cell by various environmental stresses. Visually reporting the point of production failure can help teach students about the complexity of protein production. The circuit also demonstrates the concept that DNA already present within bacterial cells can be manipulated to create a new function. Therefore, our project serves an educational purpose by enhancing of novice learners' understanding of molecular biology. Similarly, undergraduate students beginning to be exposed to molecular biology techniques (i.e. Transformation), or starting graduate school may find this toolkit helpful to developing the fundamental understanding needed for their future careers.

Relatively speaking, our project is not very controversial. This may allow people who are opposed to synthetic biology to embrace it for its educational purpose with minimal hesitance. The toolkit is also very safe to work with, which would allow it to be introduced at a high school or undergraduate level. Because of its lack of controversy and educational value we feel that our project can have a very positive social impact.

Ethical

Although Synthetic Biology can be used to solve life-threatening issues, such as helping to produce artemisinin for Malaria treatment, it can also be used to cause unintentional harm. For example, one of the well-known incidents was the accidental creation of a mutated mouse poxvirus that had the ability to kill mice that were thought to be resistant (Parens et al., 2009). The astonishing factor was that the intent of the research was not to produce any such virus, but to simply produce a strain that would cause infertility in the mice for pest control (Parens et al., 2009). This is concerning because it shows that even scientists who do not have any negative or harmful intentions can end up producing something as harmful as a biological weapon that humans are not resistant to. Furthermore, bioterrorists could possibly create such biological weapons by reading the instructions online. This is known as the dual-use moral dilemma (Parens et al., 2009).

When analyzing the perils of this dilemma, the issue of open vs. closed source comes into play. Who should be allowed to access the information to manipulate biology to produce an artificial life? Scientists have research integrity and thus invent and innovate for the benefit of mankind. However, what about biohackers, the amateur scientists with easy access to a lab, or someone with malicious intent? All these possible alternatives can lead to the abuse of Synthetic Biology. This is an ethical issue that is relevant to a project like ours because our toolkit makes it easier to express a protein within E. coli as an expression host. While our toolkit helps scientists to produce a protein, it would also make it easier for a biohacker. Synthetic biology may allow the general population to make use of molecular biology techniques. This increases the potential chance of a biohacker working on a malicious project. As synthetic biology techniques and tools become more accessible, measures of regulation and monitoring may become more necessary.

An additional ethical concern that arises from our project has to do with intellectual property. Intellectual property refers to the exclusive rights that a creator has over the biological function that they have designed (Lemley, 2005). At the beginning of the iGEM competition, a group of undergraduate students gather and determine a project to work on over the summer. Many creative ideas are shared during this process. In this situation, one ethical dilemma that can arise is related to intellectual property. Who has the intellectual control over the resulting biological creations if one of the students commercializes a project idea? This is an ethical issue that may arise in many projects, including ours. Therefore, we believe that more regulations are needed to ensure that our toolkit is only available through the iGEM registry.

Conclusion:

In summary, the toolkit created by the Calgary 2010 iGEM is a foundational toolkit that has many beneficial and also concerning implications. Although our toolkit can assist in advancing the understanding of high school, undergraduate and graduate students with molecular biology techniques, it also has its perils. As discussed above, our toolkit can easily be used by biohackers to assist in protein production. In contrast, our toolkit also has the potential to increase research efficiency. At the same time, its applicability can invoke members of the group to take personal advantage of our project by commercializing the toolkit.

In this paper I have discussed some of the implications that our project has from an economic, social, and ethical perspective. I realize that no matter how foundational or direct a project may be in synthetic biology, every project has some concerning ethical issues that it is chained to. In conclusion, we found it absolutely worth wile to have discussed the ethical, economical, and social implications of our project. It has allowed us to understand our project from different perspectives. This is essential because we must ultimately make an attempt to assure the public that although synthetic biology is unfamiliar to them, researchers working on growing number of projects are considering their implications.

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