

## **Prospectus**

**Device for Establishing Thin Hydrogel Coatings on Cell Surfaces for Cell Delivery and Tissue Engineering Applications**  
(Technical Topic)

**The Impact of Drug use on United States Policy and Societal Norms**  
(STS Topic)

By

Gabriel Popescu

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Technical Project Team Members: Matthew Kim and Noah Vanterve

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signed: Gabriel V. Popescu

Approved: \_\_\_\_\_ Date \_\_\_\_\_  
Rider Foley, Department of Engineering and Society

Approved: \_\_\_\_\_ Date \_\_\_\_\_  
Chris Highley, Department of Biomedical Engineering

## **Introduction**

For lab experiments involving cell cultures of stem cells, the cells must undergo a process of encapsulation in order to protect the cells from rupturing or dying. In order to encapsulate the cells, the researcher must apply very exact volumes of polymer solution and perform a series of washes. This process is currently done manually and can be very tedious and time consuming, which may limit progress in the field. In a world where more and more tedious tasks such as this one are being done by machines, it seems reasonable that the process of cell encapsulation process can be done by a machine as well. The technical topic discussed in this paper aims at improving the process of cell encapsulation through automation. Cell encapsulation has been primary technique for delivering cell-based therapy in cases of cell transplantation, organ replacement, and the continuous and controlled delivery of drugs. Encapsulation technique involves enclosing the cell within a polymeric matrix surrounded by a semipermeable membrane. The covered membrane of cell has various purposes including allowing the bi-directional diffusion of nutrients, oxygen, and waste and the secretion of the therapeutic product, preventing immune reaction of cell, and protecting a cell from shear stress and pressure while injection (Lim, Lee, & Atala, 2008). Widely used cell encapsulation method involves using polymers to coat cell by cross-linking them and centrifuging out unbound polymers out to have only encapsulated cells (Prakash, Bhathena, & Chen, 2007). The goal of this capstone design project is to develop a device capable of exposing single cell suspensions to multiple aqueous solutions. The automation of the device with electrical input is also a part of the prototype, since, the purpose of developing the device is to save time and effort while preparing encapsulation for the therapeutic delivery of cell.

The STS topic of this paper takes an entirely different route. Various substances have had influence on shaping cultural norms in the United States as different drugs often show up recreationally in social situations. The federal government has historically had a big role in regulating substance use among American citizens in what has been called the War on Drugs. The War on Drugs has been an effort by the federal government to reduce the prevalence of drug use among the general population through regulations and prohibitions, claiming to be in an effort to promote public health. This 'war' has had widespread effects across the entire globe including racial profiling, family separation, and political unrest. These efforts to prohibit use of a substance have shown to not necessarily decrease drug use, but actually quite the opposite. Programs like DARE (Drug Abuse Resistance Education) that were aimed at teaching children from a young age to stay away from drugs ironically increased drug use among teenagers (Wolchover, 2012). In this thesis, I plan to analyze prohibition of alcohol, criminalization of marijuana, the psychedelic hippie movement in the 60s, the crack epidemic in the 80s, and the modern-day opioid epidemic as well as causes and effects of legal involvement in these scenarios. In this thesis I will argue that a youthful fascination with drugs has been weaponized to silence and discriminate against minority and lower income communities through the War on Drugs.

## **Technical Topic**

Cell encapsulation has been an essential technique required for effective cell delivery into target medium usually for therapeutic purposes and often used for cell transplantation, organ replacement, and drug delivery. Cell encapsulation refers to the technique of enclosing the biological active material within a polymeric matrix by a semipermeable membrane (Lim et al., 2008). The main purpose of encapsulating cells is to prevent immune reactions caused arise from

cell or drug injection, therefore, reducing the need for use of immunosuppressants (Olabisi, 2015).

The most widely used technique for cell encapsulation involves a manual process of involving redundant washing and incubation processes, and therefore, the current method is time-consuming, tedious, and most likely prone to human error. According to Jack Whitewolf, a graduate student working in Dr. Highley's lab, the basic cell encapsulation procedure with only 2-layers for coating roughly takes a couple of hours involving centrifugation and exchanging of solution and each added layer add additional 25-35 minutes.

Our capstone project team aims to design and prototype a device that will automate the multilayering cell encapsulation process based on parameters that are input into an Arduino controlled program. We were unable to find a significant research evidence on automation of cell encapsulation process and assume it was not a topic of interest. Therefore, our prototype, if constructed as intended, would provide a good starting point for development of an automated lab procedure for cell coating that would provide a more efficient usage of time and energy for researchers in labs. By making laboratory research less labor intensive, this device could potentially lead to enhancing the performance of labs and speeding up the rate of new innovations in the field. Also, the automated process would improve production of drugs and the tissue engineering process and possibly lead to lowering the price of related therapies, making them more readily available to patients.

Current multilayer cell encapsulation is a manual process involving centrifugation and exchanging of solutions requiring several hours of time as well as being an inefficient system which has proved to be very tedious to researchers and can lead to a great deal of human error. Other than possible technician error, multiple centrifugations and the exchanging of solutions is

very energy intensive process and this process tends to put undesired stress on cells.

Additionally, after analysis of current literature, there appears to be a device that assists with the coating process of cells (Zhang, 2013), but no device that will fully automate the process, allowing all of the coating layers to be applied to the cells with the use of a microcontroller system.

Our team's proposed device intends to automate the multilayer cell encapsulation process with the use of a porous membrane and computer-based input with an Arduino program. The currently planned prototype has 4 valves that will be controlled by the Arduino input: two for the two layers of coating solutions, one valve for the PBS solution used to re-suspend the cells above the porous membrane, and one for the elimination of used and unwanted solutions. After placing cells into the device, each cell layering process will be automated simply by first using pre-connected solution with layering polymers, vacuuming out, and re-suspending the membrane and vacuuming out again. The prototype device seeks to eliminate the usage of centrifugation and exchanging of solution during the multilayer encapsulation process, thus, saving energy and avoiding unwanted stress on cells and possible technician error involving applied volumes of solution. Another possible benefit of automated encapsulation process is that researchers may participate in different research activities while the device is taking care of repetitive encapsulation process.

Aside from all the benefits that this prototype can potentially bring, it is worth mentioning that it is unlikely that the device would significantly shorten the actual time of multilayer encapsulation process because, according to Jack Whitewolf, the incubation time of cell after each encapsulation process, which roughly takes between 15-20 minutes, work as a limiting factor. As it is mentioned above, there were not much attempt on automating the

multilayering cell encapsulation process so far. Therefore, building the prototype device for automated cell encapsulation process would give good starting point for others to assess what benefits can gain from the automated process and follow on to improve the existing technique to another level.

## **STS Topic**

There are many reasons an individual might begin experimenting with drugs. These reasons include physical need, boredom and a desire to experiment, depression and anxiety, and to give themselves a competitive edge in society (National Institute of Drug Abuse, 2014). As taught in schools, drugs can pose a huge health risk to a user. As a result, the government has taken an effort to reduce the prevalence of such substances through a series of bans and prohibitions. Strict penalties and jail time have been implemented for a wide range of drug crimes. This effort, known as the War on Drugs, has not necessarily succeeded at the aforementioned goal, but has had widespread effects that have changed the culture of the United States. Author Jarret Zigon describes the War on Drugs as a ‘situation’. The paper “What Is a Situation?: An Assemblage Ethnography of the Drug War” describes this ‘war’ as “a nontotalizable assemblage widely diffused across different global scales that allows us to conceptualize how persons and objects that are geographically, socioeconomically, and culturally distributed get caught up in shared conditions that significantly affect their possible ways of being-in-the-world” (Zigon, 2015, p. 1). This essentially says that the War on Drugs is so widespread and circumstantially specific that you cannot encompass it all in one definition. In this thesis, I plan on looking at the situation that is the War on Drugs and some resulting widespread effects through the co-production framework, which relies on the belief that society and technology build off and inspire development in each other. Using the example of drugs,

many of these substances were developed due to medical practitioners recognizing the potential therapeutic qualities they may have. These drug technologies then make a huge impact on medical care and society evolves as a result. However, after being in use for a portion of time, negative side effects may have shown up. As a result, the drug must be changed in a way, starting the cycle over again. Often rather than changing the drug, it is outlawed all together. But this does not necessarily mean that it will stop impacting society or evolving. In the case of marijuana, although being criminalized in the 1930s, it was still grown illegally. Over time, strains of marijuana may have become more potent than others and different groups have also integrated the drug into their culture (Stuyt, 2018).

In this paper's analysis of the War on Drugs I will start out by answering 'what is a drug?'. A drug is simply defined as a medicine or other substance which has a physiological or psychological effect when ingested or otherwise introduced into the body. These effects can take on a number of forms. For example, opioids, which are currently responsible for countless deaths nationwide, act on block pain receptors which produces a calming yet very addicting feeling (Pathan & Williams, 2012). Studies have shown that these effects become desirable during early adulthood, as a result of changing social roles (Staff et al., 2010). Throughout time this has become more and more prevalent. Survey based data would indicate that earlier generations did not have as strong of a relationship with substances (Staff et al., 2010).

Due to the destructive nature that some substances can have, lawmakers have made an effort to reduce drug use through threats of punitive measures. However, this has been shown to not be effective. The earliest example of a criminalization of a drug in the United States was prohibition of alcohol in the 1920s. Prohibition did not dissuade people from drinking, rather made the negative effects alcohol can have more pronounced (Levine & Reinerman, 1991).

People would either turn to bootleggers who smuggled alcohol into the United States or homemade, generally more unsafe, moonshine to get inebriated. This led to a spike in the prison population as well as treatments for alcohol related ailments (Levine & Reinerman, 1991). Due to its failure, the law outlawing alcohol was overturned. This brings up the question, why would similar, flawed, measures be applied to other substances?

Elected officials have used fallible assumptions in order to rally support for anti-drug legislation. It will often be implied that substance abuse problems arise as a result of the physical characteristics of a neighborhood or as a result of the customs of a group of people. However, statistics indicate that substance abuse arises fairly normatively among vastly diverse communities (Covington, 1997). This is apparent in the case of marijuana, whose ban in the United States coincided with an influx of Mexican immigrants. Politicians argued that cannabis would cause a user to become violent and began using the word ‘marijuana’ to subtly associate the plant with people of Latino descent (Pagano, 2018). This cannabis ban is still in effect throughout the majority of the country. This almost century long ban has done more harm than good as marijuana laws justify putting minor drug offenders in prison, vastly increasing the prison population and placing a burden on the American taxpayer.

The stringency of marijuana laws has also had negative health effects on some users. Within the past year, several cases of a disease related to vaping, or inhaling a vaporized form of nicotine or cannabis from an electronic cigarette, have been seen across the country. Initially a safer alternative to smoking cigarettes, electronic cigarettes became very prevalent among younger populations. While it was initially speculated that this disease was due to nicotine products, further studies indicated that the primary cause of this disease has actually been illegal THC products. THC cartridges purchased from an illegal source are often cut with chemicals such as



vitamin E that can be deadly if inhaled (Sun, 2019). It is clear that the laws have not dissuaded people from using cannabis and if there were a safer way to obtain THC products then illegal cartridges would not be putting anyone's health at risk.

Drug related incarcerations have also affected family dynamics in areas that have a high arrest rate for drug use. Oftentimes, a mother can be imprisoned for a minor drug crime, separating her from her young children. Aside from the implication it has on the mother's life, separating her from her children will affect their psychological development, which can lead to similar patterns of crime from them in the future (Bush-Baskette, 2000).

Another example of a drug movement silenced by federal regulations is the hippie movement in the sixties. LSD and psilocybin mushrooms began being used recreationally. Shortly after these drugs saw recreational use, lawmakers voted make these drugs Schedule I, essentially stopping all research into them. This is a more curious example because the primary demographic for psychedelic drug use has historically been more affluent generally white males (Smart & Fejer, 1969). Furthermore, the little research that does exist on psychedelic compounds has shown to be promising in treatment of depression. The government's involvement in regulating these substances essentially blocks medical research into potential treatments for depression, supporting the notion that the War on Drugs is not interested in people's wellbeing.

While politicians go to great lengths to restrict some drugs, there are others that there seem to intentionally be in abundance. These drugs are opioid based prescription painkillers, whose purpose is to remedy severe pain following a surgery. While pharmaceutical companies were aware of how addictive these products are, they would provide incentives to doctors to overprescribe them in an effort to profit off of widespread addiction (Dasgupta, Beletsky, & Ciccarone, 2018). After these intentions were revealed, the over-prescription of these painkillers

saw a decrease, but if an individual has developed an opioid addiction already, this addiction lingers regardless of changes in distribution. While the number of painkillers prescribed has decreased, opioid related deaths have actually increased due to economic and social pressures as well as a general desire to seek refuge from trauma (Dasgupta et al., 2018).

## **Research Questions and Methods**

The question that I will be directing my research around is ‘How has drug use influenced the politics and societal norms of the United States?’. This is an important question to look into, because it is undeniable that drug use has had some impact on American society, whether it be for better or for worse. Drugs have been used by politicians in power to influence elections and discriminate against minority groups, so it is important to analyze the source of some of this corruption. In order to answer this question, I will do a case study on the situation that is the War on Drugs, primarily from a sociological standpoint so I can discuss trends relating to different groups of people. I plan to look at how money is being used in politics to influence the war on drugs. For instance, private prisons are known to profit greatly at the expense of minor drug offenders (Melber, 2014). The reach of the US started war on drugs has diffused around the world. Due to American interference in other countries as well as America being viewed as somewhat of an example to other countries, the war on drugs has had vast global effects (Zigon, 2015). Due to the prolonged nature of the War on Drugs, I will also do a historical analysis. I will construct a timeline of various significant events relating to the War on Drugs. Examples of entries I will have in this timeline include the passage of the 18<sup>th</sup> Amendment criminalizing alcohol, the 21<sup>st</sup> Amendment repealing prohibition, the criminalization of marijuana, the psychedelic movement of the sixties, the crack epidemic in the eighties, the start of the opioid epidemic. Throughout the events detailed above on this timeline, these substances clearly had an

impact on the society of the United States. People in turn responded by making changes to the drugs themselves or norms surrounding the drugs. In turn, both the drugs and society evolve together. Due to this relationship, I will also be looking at these events in my case study through the lens of co-production. A substantial amount of my analysis will focus on how the drugs began to be produced, what impact they had on groups of people, and how this in turn evolved the drug technology. Some specifics will include how some states have begun decriminalizing marijuana, with California being the first to legalize medical use and Colorado being the first to legalize recreational use (Trumble & Kasai, 2017). The timeline I construct will serve as a good way to springboard into discussion about the implications of the various laws and regulations. I also plan on conducting personal interviews with individuals that have been affected by some of these laws. This will provide a good way to examine the effects of the War on Drugs on the individual as well, rather than just groups of people.

## **Conclusion**

The technical portion of this prospectus deals with cell encapsulation. Application of different solutions is often a very tedious part of experiments involving cell cultures. Our team proposes an Arduino based device to control a series of syringes that will apply the solutions in exact concentrations. This will not only make these experiments less tedious but will also allow for more reliable results as human error will no longer be a concern. The STS part of this thesis will apply the co-production framework to answer the question ‘How has drug use influenced the politics and societal norms of the United States?’. Starting now and throughout the spring, I will research historical based evidence to look at drug trends over time, but also look at the topic from a sociological perspective in order to draw conclusions about how the War on Drugs has affected different groups of people in different ways. I will put together the aforementioned

timeline around January so I can give myself time throughout the spring to add details to each event. I will send out the survey mentioned in the above section in January or February in order to give myself time throughout March and April to perform an ethnographic analysis on the results. I am expecting all of this research to come together by May in order to present a completed thesis paper in which I analyze the failures of the War on Drugs.

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