

Gastro-enteric Nanotechnology for Increased Drug Efficacy

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Introduction

Pharmacotherapy is the use of drugs (both chemically and biologically based) for the treatment of medical conditions. The most common form of pharmacotherapeutic treatment is orally ingestible medication. Examples include taking Tylenol to treat a headache or Claritin for allergies. Generic oral intake drugs are broken down and absorbed into the bloodstream by the natural processes of the human digestive system. Although orally ingested medications are effective means of treating some conditions such as mere headaches (Tylenol) or allergies (Claritin), they are inadequate in treating more serious illnesses, especially those that plague the digestive system (i.e. intestinal tumors or ulcers).

The Problem

The ineffectiveness of oral medication is the result of two key problems in regards to controllability of the treatment. The first problem is that most drugs dissolve prematurely within the stomach or early parts of the human digestive system. As a result, the drugs are less effective at treating sickness located further through the gut (the large and small intestine as shown through figure 1). The second problem is that there is huge variability in digestive processes (temperature, acidity) from one patient to the next. Thus, an ingestible treatment may have a different impact on different people. Both of these issues reduce the controllability of the treatment and thus may decrease the overall success of it.

The Solution

Targeted drug delivery - the release of an orally ingested drug at a specific location - is the most promising solution to this problem. Researchers define a successful drug delivery system as one that is able to 'retain' (hold a drug), 'evade' (avoid early release of drug due to acidity, temperature, etc.), 'target' (identify a specific area), and 'release' (at the targeted area).

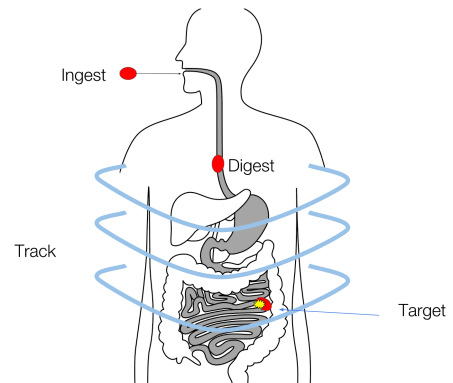


Figure 1: Generic Targeted Drug Delivery system

The most prevalent application of targeted drug delivery is chemotherapy. Most chemotherapeutic treatments are not extremely effective because normally functioning cells are often affected by the toxic chemicals along with the cancerous ones. By targeting this treatment, less healthy cells may be harmed.

Team teal is underway in developing a targeted drug delivery system. However, there already exist targeted drug delivery systems to learn from. These existing and developing drug delivery

technologies are often too complex, difficult to manufacture, and expensive. Despite these shortcomings, it is necessary to understand both the strengths and limitations of existing solutions. Therefore, this paper will first discuss three different methods: drug coating, implantation, and mechanical release. Within the discussion of each method, this paper will analyze the pros and cons of each, in order to bolster knowledge and justify Team Teal's developmental strategy and direction.

Existing Solutions

Coated Capsules:

This method of targeted drug delivery involves coating a drug carrying capsule with various chemicals that can help prevent early disintegration caused by pH and temperature. In practice, this method can range from simple to complex.

The simplest method is used to develop delayed release, or extended release, medication. Pills are covered in an enteric coating, a specific polymer, that prevents breakdown in typical stomach acidity. The strength of this method is found in its simplicity. Although this method does not increase drug controllability, it is beneficial in that it simply lengthens the time before the pill is digested, allowing it to venture further through the digestive system, and release the medication closer to the desired location.

A second, more complex, method involves coating a capsule or pill in hydrogels that are responsive to variations in pH. A hydrogel is a gel made up of polymers and water and is typically used to create thin membrane-like materials. The idea is that these capsules will disintegrate and release their contents only at very specific pH values. This method adds slightly more treatment controllability as the desired release location can be chosen based off changing acidity. However, the more intricate chemical composition does require a more complicated manufacture process.

Implantations:

A different branch of targeted drug delivery research diverges from oral ingestion and aims to bypass the digestive system entirely by implanting a drug filled, gel-based capsule directly at the desired site of treatment. In evaluating the strengths and limitations of an ingestible capsule designed for targeted drug release, it is important to understand this branch of research because it serves to affirm the hypothesis

that, in fact, it is more beneficial to deliver the drug directly to a targeted site. This branch of research uses innovative release technologies. When triggered with an ultrasonic pulse, the temperature of the capsule will rise causing the gel barrier to contract and the contents of the capsule to be released. An advantage of this method is that it allows the medication to be released at a time determined by an outside source, and thus provides the patient or doctor with more control. This result is a more effective treatment regimen. A disadvantage, however, is that the implantation of the capsule most likely requires surgery which is a far more complex procedure than simply ingesting a pill.

Mechanical Release:

A third category focuses on electrical, rather than chemical, solutions. Purdue recently released research on a new method of drug delivery using physical properties. Their approach is to implant or place a magnet on a patient's body near the desired drug release location (such as on the lower stomach over the small intestine). The patient will then ingest a drug carrying capsule imbedded with a Nichrome (highly resistive) wire. When the capsule passes through the area of the digestive system under the magnet, the magnetic field will induce a current in the wire, causing it to break and release the drug contents. While implantation could once again require a complicated procedure, the use of physical rather than chemical phenomena provides a simplified, more easily manufactured targeted drug delivery solution.

Conclusion

There is a lot to learn from current targeted drug delivery systems. First, it is important to understand the intricacies of the human digestive system in order to develop a safe product that is also robust to the digestive environment. Second, it is beneficial to recognize the majority of the existing targeted drug delivery systems utilize complex chemical systems. Team Teal's search for a simpler solution is therefore justified. A simpler solution, such as Purdue's electrical approach, would be new and innovative. If successful, Team Teal's design could greatly impact the medical field.

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