Nanotechnology and Drugs

By Joey Sweeney

The health industry is enormous today and will only get larger as the baby-boomers reach old age. With this influx of new patients comes an influx in prescriptions for drugs ranging from lowering cholesterol to increasing libidos. With such a wide range of ailments comes a wide range of pharmaceuticals to help them. These drugs are costly to produce and consequently expensive. With such a huge customer base and an increasing demand, this industry will respond to patients' demands by expanding. As drugs become more complex, and increasingly toxic, new modes of delivery are necessary to transport them to the desired sites in the body. Nanotechnology promises to revolutionize drug delivery by offering targeted administration in addition to more efficient drug dosing.

Drugs can be administered orally, topically, intravenously, rectally, or by inhalation. Each method has advantages and disadvantages. When taking a drug by mouth, some of it is decomposed via stomach acids, bile salts, or metabolized by bacteria in the gut. This method is by far the most common and is easiest for the layman to grasp. Topical administration is typically used to fight epithelial infections. Intravenous administration is most commonly used for insulin injections. Rectal administration is helpful with infants or individuals experiencing frequent emesis. Individuals with asthma or respiratory infections may inhale drugs.

These options for delivery will likely always be around. However, the drugs administered in these ways will undergo a rapid evolution as nanotechnology inevitably engulfs the pharmaceutical industry. Drugs of today have numerous problems which nanotechnology may solve. When someone takes ibuprofen for a headache, the drug does not target the neurons associated only with the headache, it acts on all neurons in that person's body that it can come in contact with. Nanodrugs will be able to target specific tissues in a body and act only in those tissues.

Presently, drug therapy can be very inefficient. To illustrate, let us imagine a patient with a bacterial infection in her inner or middle ear. The most common method of treatment is a broad spectrum (kills many different kinds of bacteria) antibiotic by mouth for ten days. After the drug enters the stomach, acids degrade some of the drug before it moves to the duodenum (top region of the small intestine). Bile is expelled from the gall bladder into the duodenum, which may further degrade some of the drug before it reaches the small intestine. The small intestine takes the vast majority of the nutrients in our food and puts them into our blood for our bodies to utilize. The same is true for drug absorption; the small intestine is the major site at which drugs are transferred to the blood supply and dispersed throughout the body. However, this tract, illustrated in figure 1.1, is not exceptionally efficient, so some of the drug that does survive the stomach and duodenum will be excreted from the body in a bowel movement.

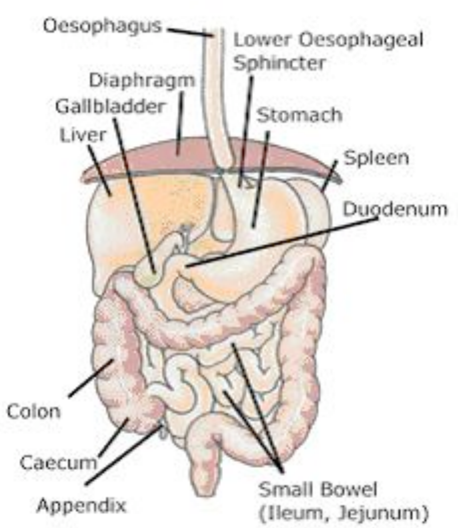

Figure 1.1
http://www.cdd.com.au/images/procedure_gi_tract.gif

The problem with this method is that the antibiotic not only kills the bacteria in the ear, it may also kill bacteria in the sinuses, throat, stomach, intestines, colon, and vaginal epithelium. This poses a risk of pathogenic bacteria colonizing those tissues when the drug treatment subsides.

Antibiotics are not the only drugs that pose problems associated with undesired absorption patterns. Selectivity of drug absorption is so poor that massive dosages are needed often creating worse problems than the ones the drug is intended to alleviate or cure.[1] Most side effects of drugs are a result of them not going to the desired locations in the body. Other adverse effects can be attributed to impure drugs. Often in making pharmaceuticals, undesired products resulting from the chemical reaction are mixed in with the desired product (the drug). Sometimes these are toxic and can cause health complications.[2] These two problems can be solved with nanotechnology. Nanocatalysts designed at the molecular level are more selective and will only make the drug molecule that is desired.[3] Drug molecules may also be coated with nanomaterials to enhance selective delivery.

Nanoparticles are defined as particles with at least two dimensions less than 100 nanometers.[4] A nanometer is one billionth of a meter, which is 250 millionths of an inch. On this scale, materials exhibit properties remarkably different from properties of the bulk material. The most obvious property is the large surface area to volume ratio of nanoparticles. This ratio increases solubility, which increases the absorption rate of drugs.[5]

The positive aspects of nanomedicine have been considered, but are there any drawbacks or potential hazards of this field? Because nanoparticles are so small, the cells of our bodies may not even detect them.[6] This means that these particles may exist indefinitely in our bodies with no way of flushing them out. Although this scenario is highly speculative, it is still a possible hazard.

Many methods of nanodelivery have been proposed, but very few are being successfully developed. Phares is a pharmaceutical company that introduced the first nanodelivery system. They discovered a way to get relatively water insoluble drugs to solubilize in our bodies via nanotechnology. Phospholipids are the components that comprise the membranes of our cells. They have a region that likes water and a region that dislikes water (hydrophilic and hydrophobic, respectively). Phares uses these phospholipids, illustrated in figure 1.2, to aid in delivery of water insoluble drugs. These drugs are in contact with the hydrophobic region of the phospholipids, while the hydrophilic portion of the phospholipid is in contact with our water rich fluids. The lipid matrix may be liquid filled in soft gelatine capsules, solidified in order to be loaded into hard gelatine capsules or even further compressed as tablets.[7]

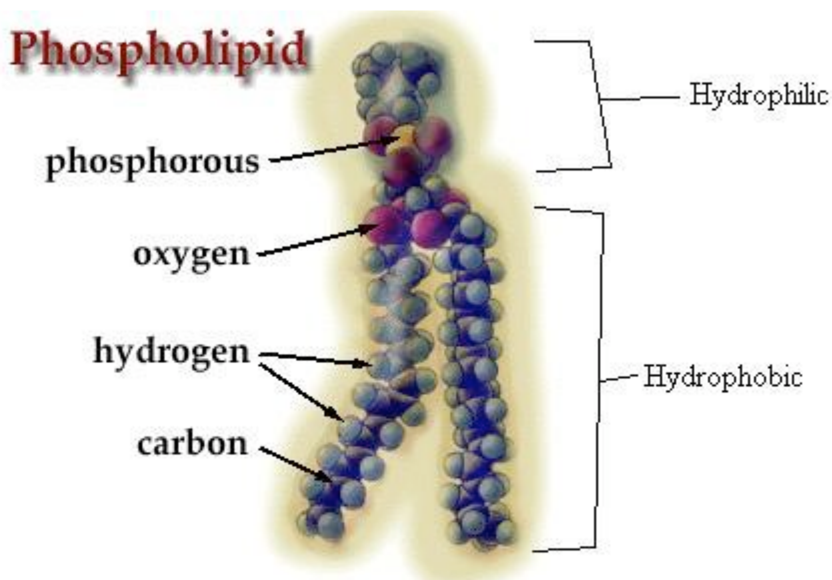

Figure 1.2

http://www.brooklyn.cuny.edu/bc/ahp/MBG/MBG3/Phospho.01A.html

Although certain applications of nanotechnology may be toxic, the majority of medical applications will be beneficial. Since nanodelivery promises precision administration, smaller dosages will be required to have the same effect as the non-nanodelivered drugs. With these smaller doses come fewer harmful side effects. In order for individuals to become comfortable with ingesting nanoparticles, they must be convinced that these nanoparticles are safe for them and safe for the environment. Biotechnology has encountered problems, especially in Europe, with people feeling that innovations in the field will somehow cause serious harm to the flora and fauna of the earth.[8]

To reduce the chances of an international backlash against nanotechnology, laymen need to be educated in the field and frank discussions of the positive and negative ramifications of nano must be addressed. However, informing people prematurely (before any products are ready for market) could potentially be disastrous.[9]

The pharmaceutical industry makes huge profits from their expensive drugs. In order for the average individual to acquire these drugs, they utilize insurance to dampen the blows made to their pocketbooks. Although insurance companies pay for drugs, they sometimes do not pay for the prescribed drugs. I worked in an independent pharmacy for an extended period of time starting in winter of 2003. I observed numerous ethically questionable tactics employed by one particular insurance provider. A patient's carrier refused to pay for a prescription anti-inflammatory. When we contacted the company we were told that over the counter ibuprofen was better for the patient. Because the prescription was expensive, the patient had to buy what the insurance company would pay for.

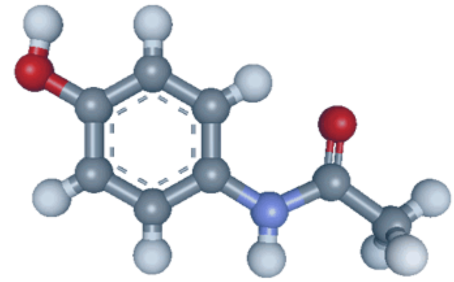

Figure 1.3
http://jchemed.chem.wisc.edu/Journal/Issues/2003/Feb/Images/JCE2003p176fig1.gif

Over the past two decades, insurance companies have been trying pry themselves between physicians, pharmacists, and patients in order to turn a profit. If these companies continue unregulated, they will essentially force patients to ignore their doctors in order to make more money for their insurance company. Obviously, this defeats the purpose of seeing a doctor or consulting a pharmacist. Since insurance companies are unwilling to spend money on a more expensive drug that is very effective when a cheaper, less effective drug is available, we can assume that this trend will continue with nanodrugs. Nanodrugs will be very costly to research and produce, initially; so insurance companies will be less likely to pay for them if an older, cheaper, and less effective drug is still effective.

In conclusion, nanodrugs are the future of healthcare and are full of promise. However, a tremendous amount of research needs to be conducted before nano is a common sight in pharmacies. Insurance reform will also be necessary to maintain the physicians' and pharmacists' role of counseling patients on drug therapies. Without cooperation from insurance companies, nanodrugs may be out of reach, financially, for most of the world.

This student-produced report is part of a larger pamphlet on nanotechnologies circa 2005, the partial output of a course on "Nanotechnology and Society" (Science and Technology Studies, Section 84405, by C. Tahan) which was taught in the spring semester of 2005 at the University of Wisconsin-Madison. Visit http://tahan.com/charlie/nanosociety/course201/ for the other reports and more information.

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[6] *Nanotechnology, Small matter, many unknowns*. Swiss Re report.

[7] http://www.phares.biz/index.htm

[8] S. Krimsky and A. Plough, *The Release of Genetically Modified Organisms into the Environment: The Case of Ice Minus*

[9] Ibid.