18th Annual Science Symposium

May 10th, 2012
Volume II
Foreword

The 18th Annual Science Symposium was held on May 10, 2012. Students enrolled in my Organic Chemistry classes and Dr. Casey Durandet's Physics classes from Paradise Valley Community College (PVCC) participated in the event. Each contributor was responsible for selecting and researching their topic and preparing a paper. A few orally presented their project to their peers. This booklet contains each of those papers.

As an instructor and faculty advisor for this symposium, I want to thank and congratulate each participant for their effort, courage and dedication. By participating, these individuals perpetuate this event annually. I am both proud and honored to present the work of these individuals.

Since I am retiring in June, this will be my last Science Symposium. I want to thank all who have contributed and assisted with these Symposia. The Science symposium showcases the great students that we have at PVCC. Dr. Casey Durandet and Professor Jenny Weitz have agreed to continue the Science Symposium in the future. I want to thank both of them for continuing this legacy.

William L. "Hank" Mancini, PhD
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Effects of Dextroamphetamine to the Brain

Meera Gosalia
April 20, 2012
Abstract:

Dextroamphetamine is in a class of medications called central nervous system stimulants. It works by changing the amounts of certain natural substances in the brain, including dopamine and norepinephrine (2). The most common drug that is a derivative of dextroamphetamine is called Adderall and can be dangerous if not taken in the correct dosages (6).

What is it?

Dextroamphetamine is a psychostimulant drug which is known to produce increased wakefulness and focus as well as decreased fatigue and decreased appetite (7). Two main disorders that this medication helps treat are attention deficit hyperactivity disorder (ADHD) and narcolepsy. Dextroamphetamine is in the class of medications called central nervous system stimulants. It works by changing the amount of certain natural substances to the brain (4).

Here is the chemical structure for dextroamphetamine (1):

![Chemical structure of dextroamphetamine]

Figure 1

The IUPAC name for this drug is (2S)-1-phenylpropan-2-amine. Other names that this drug can go by are: Dexamphetamine, Dexamfetamine, D-Amphetamine, (S)-Amphetamine, (+)-Amphetamine, (+)-Phenaminum, Desamfetamina (12). The brand names are Dexedrine and Dextrostat (10).

Molecular Formula: C₉H₁₃N   Molecular Weight: 135.20622 g/mol (3).

The main metabolic pathway for this drug is:

\[ \text{dextroamphetamine} \rightarrow \text{phenylacetone} \rightarrow \text{benzoic acid} \rightarrow \text{hippuric acid} \] (8).

Another pathway would be:

\[ \text{dextroamphetamine} \rightarrow \text{p-hydroxyamphetamine} \rightarrow \text{p-hydroxynorephedrine} \] (8).

Dextroamphetamine is d-a-methylphenethylamine, and is present in all forms of Dexedrine as the neutral sulfate (4).
Dextroamphetamine is a dextrorotary stereoisomer of the real amphetamine molecule (3). Both, dextroamphetamine and amphetamine act in increasing wakefulness and decreasing fatigue and appetite. Dextroamphetamine is the right handed stereoisomer of amphetamine, the other side being called levodamphetamine (3).

The picture on the left is a diagram of the beginning the first amino acid that started the development of the drugs dopamine, norepinephrine and epinephrine (12).

**History:**

This drug was first introduced from the pharmaceutical company Smith Kline and French (SKF) which introduced it in a nasal inhaler form called Benzedrine in 1932 (1). The company released the product dextroamphetamine after extensive research in 1945 as Dexadrine (1).

Dextroamphetamine/amphetamine is marketed by Shire Pharmaceuticals since 1996 in the U.S (7).

Dextroamphetamine sulfate and amphetamine sulfate tablets contain d-amphetamine and 1-amphetamine salts in the ratio of 3:1 (11).

Dextroamphetamine was originally developed to treat asthma, sleep disorders (narcolepsy) and hyperactivity (4). In 1920, a drug called “ephedrine” was used to treat asthma. In 1932, synthetic ephedrine was solve over the counter and was available without a prescription until 1954. During World War II, amphetamines were given to soldiers and pilots to keep them alert and to fight off fatigue (6).

There are two different forms of this medication dexedrine, either as tablets or capsules and they come as either short-acting (usually 4 hours) or long-acting (6-12 hours) (5).
The shorter-acting medications effects take place in 20 minutes, while the longer-acting ones may take up to an hour before the effects begin to take place (5).

**How does it work?**

Dextroamphetamines stimulate the central nervous system by blocking the reuptake of the neurotransmitters norepinephrine and dopamine into brain cells, thereby increasing the levels of these neurotransmitters in the space between brain cells (13).

When a nerve cell fires, vesicles of norepinephrine and dopamine spread across the synapse to activate the next neuron (2). When a neuron with amphetamine in its neurotransmitter vesicles fire, it will release many more vesicles, and much more dopamine and norepinephrine, than it otherwise would. It does this by lowering the pH of the neurotransmitter vesicle (2). This results in a widespread increase in neural activity in most of the brain. It is this effect that we perceive as a speedy feeling (2).

**Side effects of dextroamphetamine:**

The most common side effects of dextroamphetamine include: Constipation; diarrhea; dizziness; dry mouth; headache; loss of appetite; mild weight loss; nausea; restlessness; trouble sleeping; unpleasant taste; and upset stomach (7).

Severe allergic reactions include: rash; hives; itching; difficulty breathing; tightness in the chest; swelling of the mouth, face, lips, or tongue; blurred vision or other vision changes; change in sexual ability or desire; chest pain or tightness; fainting; fast or irregular heartbeat; hallucinations; mental or mood changes (eg, aggression, hostility, new or worsening behavior or thought problems); numbness of an arm or leg; seizures; severe dizziness or headache; shortness of breath; significant weight loss; sudden vision changes; symptoms of stroke (eg, confusion, one-sided weakness, slurred speech); tremor; uncontrolled speech or muscle movements (eg, tics); unusual weakness or tiredness; vomiting (7).

Short term effects of dextroamphetamine include (10):
- increased heart rate
- increased blood pressure
- reduced appetite
- dilation of the pupils
- feelings of happiness and power

Long term effects of dextroamphetamine abuse include (10):
- insomnia, restless
- “paranoid psychosis”
- hallucinations
- violent and aggressive behavior
Graph 1

(9)
This graph shows how dangerous amphetamines can be when a person becomes too dependent on it. This drug is not something that can be taken recreationally because serious side effects can take place and can ultimately be fatal (9).

Nervous system:

Dextroamphetamine can cause side effects to the brain including overstimulation, restlessness, dizziness, insomnia, euphoria, dyskinesia, dysphoria, tremor, headache, exacerbation of motor and phonic tics and Tourette's syndrome (1). Use of CNS stimulant medications may have precipitated or exacerbated tic disorders in some patients with ADHD. Amphetamines in the central nervous system can effect the brain by causing the release of dopamine from axon terminals, block dopamine reuptake, inhibit the storage of dopamine in vesicles and inhibit the destruction of dopamine by enzymes (5).

Adderall:

Adderall is one of the most common drugs that contain dextroamphetamine. It is a central nervous system stimulant which affects the brain and nerves that will ultimately result in hyperactivity and impulse control (4).
Adderall is a combination of racemic (d,l)-amphetamine aspartate monohydrate, dextroamphetamine saccharate, dextroamphetamine sulfate and racemic (d,l) amphetamine sulfate (1).

Adderall is the only drug that contains 75% dexedrine composition (6).

**Dosage:**

The picture on the left shows every kind of adderall possible with their dosages and what each of them looks like (9).

Dosages vary by each patient. For children 3 to 4 years old, they should start at about 2.5mg per day (9). For children age 6 and over should start a dose of 5mg one or two tablets a day. A high end dose of Adderall for ADHD is about 40mg each day. The first dose of the day should be taken first thing in the morning. If taking adderall two or three times a day, the next doses should be given after four to six hours (9).

If taking adderall for narcolepsy it can range from 5mg to 60mg each day and is usually broken into two or three doses a day (9). Children 6 to 12 years of age should start a dose of 5mg each day with an increase of 5mg each day on a weekly basis if needed. People age 12 years and older should start a dose of 10mg each day. This can be increased by 10mg each daily on a weekly basis if needed (9).

![Figure 3](image)

Adderall tablets and capsules should not be crushed, chewed, broken or opened. It should be swallowed whole. Breaking or opening the capsule may cause too much of the drug to be released at one time (9).

**Methamphetamine:**

Another psychostimulant drug used to help with ADHD. It is another drug that contains amphetamines (13).

![Figure 4](image)
Methamphetamine's chemical structure is similar to that of its parent drug, amphetamine, but has more pronounced effects on the central nervous system (3). Methamphetamines are a powerfully addictive stimulant that, like amphetamines, affects the central nervous system. Methamphetamine was used originally in nasal decongestants and bronchial inhalers (3).

Effects of long time use to the brain can cause associated with an increased risk of Parkinson's disease due to the fact that uncontrolled dopamine release is neurotoxic (7). Long term uptake of methamphetamine abuse can cause neurotoxicity which can lead to persisting cognitive deficits in the brain such as memory, impaired attention and executive function (7). It can also develop a long last psychosis resembling schizophrenia.

**Dopamine structure:**

![Dopamine structure](image)

**Figure 5**

Dopamine is a simple organic chemical in the catecholamine family (2). Its name derives from its chemical structure which consists of an amine group (NH2) linked to a catechol structure called dihydroxyphenylalanine (2). Dopamine is produced in several areas of the brain including the substantia nigra and the ventral tegmental area (2).

**Norepinephrine**
Figure 6

Norepinephrine is synthesized from dopamine by dopamine B- hydroxylase (4). It is released from the adrenal medulla into the blood as a hormone and is also a neurotransmitter in the central nervous system and sympathetic nervous system, where it is released from noradrenergic neurons in the locus coeruleus (4). The actions of norepinephrine are carried out via the binding to adrenergic receptors. It affects parts of the brain such as the amygdale where attention and responses are controlled. It directly increases heart rate, triggering release of glucose from energy stores and increasing blood flow to skeletal muscle (4).

Molecular formula: C₉H₁₁NO₃ (4)

The complete mechanism of how amphetamine is made:

Figure 7

This figure shows the heterogeneous catalysis has been used to reduce the imine bond of Schiff bases formed with phenyl-2-propanone and ammonia or methylamine in order to produce amphetamine26-29 or methamphetamine (13).
Treatment of dextroamphetamine abuse:

When dextroamphetamine is used for a long period of time, it usually creates a dependency; hence, the body cannot function in its absence. This means that when the dosage that the body is used to is stopped in a sudden manner, withdrawal symptoms usually begin. Withdrawal usually means that the body is trying to adjust to functioning without the drug that it is normally used to. The withdrawal symptoms that are experienced by the abusers of amphetamine are usually painful, which is why this is a process that should be overlooked by a medical professional such as a doctor or a nurse (5).

The withdrawal symptoms of amphetamine abuse usually include oversleeping, irritability, irregular heartbeat, mood swings, confusion, memory loss, stomach problems, hallucinations and heart attacks (5). These are symptoms that usually occur only after a few hours after abuse has been stopped or until the time that the next dosage was due to be taken.

To not become addicted to this drug one must take the correct dosages so there will be no dependency on the medication.

Conclusion:

Dextroamphetamine is a very harmful drug if not taken correctly. Being careful and following directions while taking this medication is necessary. Dextroamphetamine has many derivatives and new drugs are being made each year. The two discussed in this paper were the most common drugs to the population at the moment. This drug is considered a Schedule II medication and to obtain it one must have a prescription from a doctor. There has not been a sufficient amount of information regarding the effects internally of this medication. Only a few studies have been done but there is always future research happening. So let’s hope in the next couple of year we will gain new information for this drug and its therapy.
References


13) University of Maryland Medical Center.
Mixed Connective Tissue Disease

Its Components and Biologic Remedies

Mark Gravill

April 20, 2012
Abstract

The following text will introduce the aspects of Mixed Connective Tissue Disease (MCTD), the different components of the disease, and the medicines that are designed for treatment of the malady. MCTD implies the following medical conditions listed from the most severe to the least, Systemic Lupus Erythematosus (SLE), Rheumatoid Arthritis (RA), Scleroderma and Polymyositis. MCTD and each component of it will be described. Also the drugs prescribed for MCTD will be introduced and discussed.

MCTD

MCTD can be described as an uncommon chronic rheumatic disease that has the potential for the onset of symptoms consistent with systemic lupus erythematosus (SLE), polymyositis, scleroderma and rheumatoid arthritis (RA). (1) MCTD is also described as an overlap disease meaning that symptoms from various diseases can occur. It can be a very difficult disease to diagnose as all symptoms do not occur at once. Victims are often first diagnosed with lupus until further symptoms present themselves. (2) Nearly 80 percent of those afflicted with MCTD are women. It has been diagnosed in people ranging in age from 5-80 years old. There is no documented cause or cure but MCTD is believed to be of an autoimmune disorder nature. (3)

An autoimmune disease is one in which the body’s immune system fails to recognize its own tissues and attacks itself. In normal immune systems, regular body tissues are differentiated from antigens (invading virus or bacteria cells). Specific antigens cause a specific immune response to occur. An antigen is recognized by a lymphocyte. The lymphocyte then creates or helps create a mechanism to attack and destroy the invader.

There are two types of lymphocytes. B cells (Bursal equivalent) are part of the humoral (fluid based) immunity system and T cells are the cell based defense. B cells are responsible for the production of antibodies. Antibodies are proteins that attach themselves to antigens and either secrete cytotoxins (cell killers) or mark the antigen for phagocytosis by wandering macrophages. (4) In autoimmune disorders such as MCTD, autoantibodies are created by B cells. Autoantibodies attack the body’s tissue. T cells (Thymus directed) are part of the cell based immunity system and can also cause havoc with an auto immune response by creating cytotoxic cells that attack the body’s own cells by recognizing self-antigens as invaders. Self antigens are proteins that normally would not trigger an immune response. (4)

SLE, RA, scleroderma and polymyositis are also known as collagen vascular disorders. As described in the preceding paragraph, autoimmune disorders imply that the autoantibodies or cytotoxic cells attack the body’s own tissue. (5) In the case of MCTD and its components, the tissue that commonly is attacked is the collagen based connective tissues.

There are four different types of tissue in the human body. Epithelial tissues comprise the skin and the glands. Muscle tissues give the body its motion. Nerve tissues conduct impulses and facilitate communication. Connective tissues comprise the structure
upon which epithelial tissue rests while imbedding nerve and muscle tissue and serving as the vascular transport system. (6) There are many types of connective tissue.

Ironically, the aforementioned leukocytes and lymphocytes are part of the connective tissue family. Unlike muscle, epithelial, and some types of nerve cells, connective tissue cells do not come in direct contact with each other. They are separated by an intracellular matrix consisting of ground substance and fiber. The ground substance is water and glycoproteins in ordinary connective tissue and minerals and plasma in bone and blood respectively. The fiber portion of the extracellular space consists of collagen which is the most abundant protein in the body and is produced by a type of cell called a fibroblast. Collagen is usually the target of the disease process of the autoimmune response.

MCTD can present with a variety of symptoms [1]. These include fatigue, weight loss, fever, Raynaud’s Phenomenon (discoloration of digits due to temperature), myalgia (muscle pain), myositis (muscle inflammation), UV sensitivity, lymphadenopathy (swelling, pain in lymph nodes), sclerodactyly (swelling, tightening of the skin in the digits), dyspnea (shortness of breath), dysphagia (difficulty in swallowing), diarrhea, skin rash (usually on the face), and neuralgia (pain caused by an irritation or damage to a nerve). Arthritis as well as joint abnormalities are usually clinically detected. Knee, shoulder, elbow, and ankle as well as the small joints of the hand wrist and foot are found to be commonly involved.[1]

In lab tests, findings that reveal high levels or titers of RNP antibodies are the definitive marker for the diagnosis of MCTD. Ribonucleoproteic particles play a role in messenger RNA splicing. Anti-RNA recognize and negatively affect these particles. In other words, RNP antibodies can affect the transfer or transcription of codons from the DNA to the RNA. While the identification of this antibody confirms the diagnosis, the antibody itself can be the cause of the presentation of several different symptoms [7]. These symptoms relate to the components of MCTD.

**Systemic Lupus Erythematous**

The SLE component of MCTD on its own is thought to be a hereditary disorder. However, no genetic marker has yet been discovered. Hormones are considered to be a factor taking into account that women are much more likely to be afflicted by lupus [8]. There are four types of lupus. These include SLE, discoid lupus erythematous (DLE), neonatal lupus and drug induced lupus [9]. SLE is the most common of the four and the only form consistent with MCTD.

Lupus has been known as a distinct disorder since the 10th century CE. Lupus means wolf in Latin and erythematous, which is derived from erythma, means redness of the skin. In advanced discoid cases, round rashes occur on the skin of the appendages that resemble wolf bites. However, lupus is best known to present a facial rash that resembles a butterfly. (See figure 1)
Besides the facial rash, people who develop SLE also tend to present with hair loss as the expanded disease process affects deeper tissues than that of DLE. In SLE skin lesions may spread and cause damage to mucous membranes. Also, some that present with SLE have no skin involvement. Early symptoms of SLE are extreme fatigue, weakness, sensitivity to UV light, fever and weight loss.

As SLE progresses, internal organs are often afflicted. Connective tissue in the kidneys can be severely damaged to the point of uremia (toxic buildup of substances normally cleansed from the blood by the kidneys). The nerve tissues can be also involved resulting in headaches, seizures, stroke or psychological problems.

The advanced lupus process is usually named after the organ(s) affected. Over 50% of all SLE patients have some sort of kidney involvement (lupus nephritis) as well as brain involvement (lupus cerebritis). Peripheral neuropathy (ex. Carpal Tunnel Syndrome) accounts for symptoms in more than 20% of SLE patients. (See Figure 2)

Diagnosis of SLE is based on a list of 11 criteria. The American College of Rheumatology states that if a patient presents with 4 or more of the criteria, he or she is deemed to have SLE. Besides the previously mentioned symptoms, the criteria include the presence of various blood factors. They include the anti-DNA antibody as well as the anti-RNA antibodies. Amylase and CPK levels (creatine phosphokinase) can be elevated as well.

Treatments of SLE include both pharmacological and non-pharmacological methods. The categories of medicines that are used to treat SLE include (but are not limited to) NSAIDs (anti-inflammatory drugs such as ibuprofen), corticosteroids (autoimmune suppressing agents such as prednisone) (see figure 3), anti-malarial drugs and cytotoxic agents. Biologic agents (pseudo-enzymes) are currently in use and in development.

Non-pharmacological remedies include exercise, diet and sunscreen or protective clothing when going outdoors.

SLE is by far the most serious component of MCTD. Before corticosteroids were available, 50% of SLE patients died within years. Currently those afflicted with SLE can survive 20 years or longer. There are cases on record of symptoms spontaneously resolving themselves.
Rheumatoid Arthritis

Rheumatoid Arthritis (RA) is a common component of Mixed Connective Tissue Disease. As with MCTD, the disease process predominates in women and while it can present at any age, it seems to initiate more in childbearing years. [13] There are indications of hereditary involvement. Its symptoms date back to ancient Egypt as signs of RA were found in some mummies. Major descriptions are found in medical journals from the industrial revolution.

RA causes inflammation of the synovial tissues (synovium) inside the joints. In MCTD the anti-RNA seems to tie in with this inflammation process. Synovium is a thin section of specialized connective tissue located in the joint capsule or cavity. It is responsible for the production of the fluid that lubricates the joint.

In the case of RA, there is an excess of fluid produced by the membrane which leads to the joint becoming swollen and difficult to move. (See Figure 4) The unneeded inflammation fills the confined space of the cavity, restricting the motion and causing pain. This inflammatory process signals the immune response and leads to the release of destructive enzymes. These enzymes collect in the synovial fluid and attack the connective tissues in the joint cavity. Cartilage that covers the bone surfaces and the bone tissue itself are affected by this process. Usually, RA only affects the peripheral joints (fingers, arm, toes, and leg) but there is record of rare involvement with the spinal column. The erosion of the surfaces and components eventually deform and render the joint incapable of its normal motion.

Diagnosis of the RA component is a complicated process that begins with patient history. This includes an accurate description of the type of pain, its change over time and where it is located. This information as well as family history, combined with a complete physical examination of the joints and x-rays not only distinguish the process but reveal the extent of the damage caused by the disease. (See Figure 5)

Blood tests can reveal the rheumatoid factor, an antibody that is present with rheumatoid arthritis. However not all people with RA test positive for the rheumatoid factor and some test positive for the antibody and never exhibit symptoms of the disease.

Non-pharmacological treatment methods for the RA component are similar to those of the SLE component. Proper rest, exercise and diet help strengthen joints and muscles and relieve stress on damaged joints. Reducing physical as well as mental stress can reduce the recurrences of RA symptoms. Peripheral devices like splints and self help devices
(long shoe horns, zipper pullers) can make living with RA easier and relieve pressure on the joints, allowing time to rest. However rest should be moderated with exercise. Sufferers who are overweight put more pressure on these areas and tend to exhibit a sedentary lifestyle thus allowing the unexercised joints to deteriorate much more quickly.

Pharmacological treatment of RA has evolved greatly in the 20th century. Up until the 1960's analgesics like acetyl salicylic acid (aspirin) were the treatment of choice but caused gastric problems because of the amount needed to offset the pain. NSAIDs (non-steroidal anti-inflammatory drugs) like ibuprofen were introduced and offered prolonged symptom relieving activity as well as less irritation. Compounds containing gold were the initial DMARDs (disease modifying anti-rheumatic drugs) and have been offered to patients with advanced RA for seventy years. Anti-inflammatory DMARDs that came after gold include hydroxychloroquine, which normally is used to treat malaria and sulfasalazine which is a mild immunosuppressant. Lately, these drugs were eclipsed in efficacy by methotrexate.

Methotrexate is an organic compound that was originally used in chemotherapy. It treats cancer by slowing the growth of certain types of cancer cells. It was also found to be a very efficient anti-inflammatory and has since been successfully used in the treatment of RA. Methotrexate is also an anti-metabolite. Methotrexate works as an antagonist to folic acid. (See Figure 6). In its RA application, besides its anti-inflammatory aspects, it also decreases the activity of the immune system. This in turn decreases the autoimmune response damage. Care must be taken when using methotrexate as it compromises the immune system leaving the patient susceptible to viral and bacterial infection [16]. Methotrexate combined with a biologic agent has a very successful history with RA sufferers.

Different types of surgery are available to patients with severe joint damage. Joint replacements are often performed by orthopedic surgeons. Unfortunately artificial joints are not permanent and usually have to be replaced. Damaged tendons can be surgically replaced. Synovial fluid can be drained and synovial tissue can be surgically removed.

Rheumatoid Arthritis can also increase the risk of osteoporosis. It is a condition where bones become weak and fragile particularly if the patient has been treated with corticosteroids. Calcium and Vitamin D supplements as well as hormone therapy should be added to the treatment regimen if osteoporosis is a possibility.

**Scleroderma**

Scleroderma is another autoimmune disorder component of MCTD. As in the other components, scleroderma is most common in women. Localized scleroderma, which usually affects only the skin, is normally associated with MCTD. However systemic scleroderma has also been occasionally linked with the disease. Systemic implies that the heart, lungs, kidneys as well as the skin can be involved. Scleroderma comes from two
Greek words; “sclera” meaning hard and “derma” meaning skin. The disease is marked by an overproduction of collagen causing the hardening of the extremities. Seriousness can range from very mild to life threatening. Skin damage is common as well as esophageal damage due to acid reflux caused by narrowing of the esophagus due to a scleroderma outbreak just above the stomach. Localized outbreaks in other areas are common as well [17]. The autoimmune antibodies that attack the collagen also cause the increase in collagen production in the skin in scleroderma and the blood vessels in Raynaud’s Phenomenon (RP).

RP is a collagen based affection of the small blood vessels in the digits (fingers and toes). With temperature change, the vessels restrict the flow of blood causing a change in color as well as numbness. The color change ranges from the normal hue to white as the blood vessels restrict then to blue as the tissue becomes oxygen starved. (See Figure 7 and 8) Finally the vessels reopen and the digits flush to a bright red [18]. The condition also causes brittle nails that have longitudinal ridges.

Non pharmacological treatments include skin softening lotions and restricting UV exposure. If the lower esophagus is compromised, then heartburn medication is recommended. Sometimes patients lose the padding on the bottom of their feet. In cases such as this, orthotics can relieve the pain associated with walking. Noting that cellular damage occurs every time the skin cells are deprived of oxygen, relocations to more moderate climates have not proven to decrease the pathology of Raynauds.

**Polymyositis**

Polymyositis is the least severe component of MCTD. It is characterized by painful inflammation of the medially located muscle tissue. It usually results in muscle weakness and deterioration that occur in the shoulders or hips. It is also known to attack the more peripheral muscles symmetrically throughout the body. As with the other components, women tend to present with polymyositis more than men and the direct cause is unknown. Bacterial and viral infections as well as the MCTD autoimmune response tend to trigger an onset of the symptoms of this disease process.

Symptoms of polymyositis include the aforementioned weakness, muscle and joint pain, fever, rash, Raynaud’s Phenomenon, difficulty in swallowing, fatigue and weight loss [3].

The onset of muscle weakness can be sudden or slow. As the medial muscles are involved everyday tasks can be severely restricted. Walking, climbing stairs and getting out of a chair can be made quite difficult by polymyositis. Weakness or pain in the shoulders or hips can confine a person to a wheelchair or bed. Muscle damage or weakness in the esophageal muscles can lead to serious digestive problems.
Polymyositis does not usually affect the internal organs but can compromise the respiratory system. The lungs can be affected causing shortness of breath and/or coughing [3].

Lab tests as well as physical examination make up the diagnosis of the disease component. Elevated CPK levels can signal an onset of symptoms. Physical examinations should include electromyography and muscle biopsy. In an EMG the damage to the muscle conductivity is assessed. The biopsy will show the physical damage to the tissue.

Treatments include rest and physical therapy. Restricting activity during outbreaks has proven helpful. Low dose corticosteroids are usually prescribed to limit the inflammation and NSAIDs for the pain. Immunosuppressants may be added when prednisone is not working.

**Biological Medicines**

Biological medicines are also known as biologic response modifiers (BRMs). They have revolutionized the treatment of MCTD. BRMs as a whole are a wide ranging class of drugs that affect immune responses. They are a laboratory synthesis of naturally occurring compounds that our bodies produce. In the case of MCTD, biological medicines reduce or eliminate the autoimmune response. Mostly borne from cancer research, BRMs inhibit specific immune system components [20].

These medications are synthesized proteins that are known as anti-TNF drugs (anti tumor necrosis factor). Examples include Enbrel, Humira and Remicade. These compounds help eliminate abnormal B-cell activity in germinal centers of the lymph nodes. In normal immune responses the germinal sites allow the B and T cells to meet and gather information about the infection. Once the infection is eradicated, the germinal centers fade away. In patients afflicted with an autoimmune disorder such as MCTD, the germinal centers continue the onslaught of antibodies which attack the collagen in the connective tissues. Anti-TNF agents disrupt the activity of the germinal centers resulting in lower production of the anti- RNA antibody. This factor drops the percentage of anti-RNA producing B-cells by up to 40 percent [21].

Unfortunately the side effects of having a decreased B-cell count can include increased susceptibility to opportunistic infections. Patients being treated with anti-TNF BRMs should be vigilant to any signs of infection and notify their physician immediately as their compromised immune system can lead to serious or deadly invasions of bacteria and virus.

**Summary**

MCTD is an overlapping affliction consisting of symptoms of four separate autoimmune disease processes. These processes share the same autoimmune response. MCTD is termed a Collagen Vascular Disease because the autoimmune response attacks the collagen in the connective tissues. If diagnosed early, permanent damage can be mitigated by the use of organic drug compounds as well as synthesized anti-TNF proteins.
Bibliography of Cited References


Cloud Seeding: Modifying the Weather to Enhance Precipitation Using Silver Iodide

Steven Hadeed

April 20th 2012
Abstract:
Silver iodide (AgI) is widely used for weather modification programs to enhance the development of precipitation in storm clouds. Unique properties of silver iodide make it an ideal seeding agent, which include: a similar crystalline structure to ice, the formation of hydrophilic complexes during synthesis and the ability to nucleate at warm temperatures. Silver iodide can serve as condensation nuclei during Hygroscopic seeding to enhance rainfall in warm clouds, and ice nuclei for Glaciogenic seeding to enhance snowfall in cold clouds. This paper examines the interaction of silver iodide with atmospheric moisture, mechanisms of precipitation formation and the effectiveness of cloud seeding operations.

Introduction:
Water can remain in liquid form at temperatures below freezing, referred to as supercooled liquid water. Cloud seeding is a form of weather modification that seeks to enhance amount of precipitation dissipated by storm systems. This is achieved by introducing artificial aerosols into water saturated clouds that serve as cloud nuclei or "seeds"; promote the development and growth of cloud droplets or ice crystals from supercooled water. Two types of cloud seeding are glaciogenic seeding of cold clouds to augment snowfall, and hygroscopic seeding of warm clouds to enhance rainfall.

Historical Background:
Cloud seeding began in 1946 when researchers at General Electric discovered they could induce the condensation of supercooled water and formation of ice by introducing CO2 pellets into storm clouds. This mechanism was based on the Bergeron-Findeisen theory of precipitation formation, which states that due to differences in vapor pressure of ice and water at subfreezing temperatures, ice crystals will gain mass due to vapor deposition and liquid water will lose mass by evaporation (1). Once an ice crystal has reached a mass threshold, it will descend towards the earth as snow, or melt along its descent and fall as rain.

Vincent Schaefer, one of several General Electric researchers, conducted the first cloud seeding experiment in Massachusetts when he flew his plane into a developing storm cloud and released 1.5 kg of dry ice. The dry ice initiated the formation of ice crystals that dissipated in the form of virga, precipitation that evaporated before reaching the ground (2).

In 1947 Bernard Vonnegut, another General Electric researcher, conducted the first cloud seeding experiment using Silver Iodide (AgI) smoke. Silver Iodide was selected because of its similar crystalline structure to ice; making it an ideal nucleus for the formation of ice (2).

These experiments yielded promising results about the potential to modify local weather and enhance the amount of precipitation released during natural storms. This early enthusiasm led to substantial federal and private funding for operational and research programs to further investigate the process of cloud seeding. Studies peaked throughout the 1950’s to the late 1970’s, but many of these experiments produced little scientific evidence and were unable to accurately measure the effect cloud seeding had on precipitation development. This ultimately led many to question the validity of earlier studies and lose interest in exploring weather modification (3).

However, government interest persisted and funding for weather modification research topped $20 million per year during the late 1970’s (4). Evidence for weather modification was demonstrated during the Vietnam War. Operation Popeye was a successful weather modification project conducted by the United States Air Force and Navy that seeded storm clouds and intensified rainfall along the Ho Chi Min Trail (5). Many view Operation Popeye as evidence for the ability to enhance rainfall through cloud seeding, but the inability to replicate past
experiments and obtain sufficient scientific evidence continues to cast doubt on the science of weather modification.

**Current Situation and Demand:**

Cloud seeding operations aimed at enhancing precipitation have been implemented to help alleviate water stress in affected areas and replenish rapidly depleting water tables. In 2001, 150 operational cloud seeding programs were carried out in 37 countries, 66 of which were conducted in 11 U.S. states (6).

Cloud seeding programs can be defined as operational or research programs. Operational cloud seeding programs focus on producing results or achieving a specific objective, such as increasing precipitation. Research programs seek to obtain a greater understanding of the natural processes affected by cloud seeding and determine the mechanisms which cloud seeding occurs (3).

Currently, 48 cloud seeding programs operate in the western **United States** aimed at enhancing snowfall during winter storms; referred to as glaciogenic cloud seeding (7). Operational programs receive no federal funding; are conducted and financed by local-state governments, utility companies and private organizations with very little, if any, research associated with them (7).

However, technological advancements in radar imaging and computer modeling have provided the scientific community with a greater understanding of cloud physics and storm development, allowing for researchers to accurately monitor the effectiveness of cloud seeding programs and develop innovative strategies to enhance precipitation.

**Seeding Agents:**

Silver Iodide and Dry Ice are widely used as glaciogenic seeding agents because of their ability to increase the formation of ice crystals in clouds by nucleation of freezing of cloud droplets (8). Dry Ice has been a successful glaciogenic seeding agent because it can rapidly convert surrounding water vapor and cloud droplets into ice (2). However, the use of dry ice requires dispersal via aircraft and proper storage to prevent sublimation, but it is still used in combination with silver iodide (2).

Silver iodide has been used as a glaciogenic seeding agent for over 60 years and is currently the most commonly used seeding agent worldwide. Three properties of silver iodide make it ideal for field applications are its ability to function as an ice nucleate; fairly low solubility in water which allow for particles to nucleate ice prior to dissolving; stability at high temperatures which permits vaporization and condensation (9).

**Silver Iodide: Properties:**

Silver Iodide is an ionic compound and belongs to a class of chemical compounds known as silver halides. Iodine, with seven outer shell electrons, and silver, with one outer shell electron, ionically bond to fill their outer electron shells. Iodine gains an electron from silver and becomes negatively charged, whereas silver becomes positively charged by the loss of an electron (10).

Silver iodide has a molecular weight of 234.77g/mol, melting point of 558°C, boiling point of 1506°C and is relatively insoluble in water. Silver iodide exists naturally in the mineral odargyrite, or iodyrite, and can be isolated by the dissolution in concentrated hydroiodic acid (HI), followed by evaporation and purification (11).

**Silver Iodide Synthesis: Pyrotechnic and Ground Generator Solutions:**

Silver iodide can be synthesized by reacting silver nitrate (AgNO₃) with sodium iodide (NaI) or potassium iodide (KI) in the presence of a red light source. Silver iodide is highly
photosensitive and rapidly decays upon prolonged exposure to UV light. This red light prevents the oxidation of the silver ion to silver metal during its synthesis.

\[ \text{AgNO}_3 + \text{NaI} \rightarrow \text{AgI} + \text{NaN}_3 \] (11)

**Pyrotechnic Flares:**

Preparation of silver iodide (AgI) solution for weather modification can differ based on the dispersal mechanism. For pyrotechnic flares, solutions must be prepared using silver iodate (AgIO3) to prevent the tendency of AgI to separate into its components, metal silver and iodine; also providing oxygen to enhance the combustion reaction. Powered aluminum and magnesium may be added to maintain the structure of AgI (2). The synthesis of AgI for pyrotechnic flare dispersal is shown by the reduction of silver iodate (12).

\[ \text{AgIO}_3 + 2 \text{Al} \rightarrow \text{AgI} + \text{Al}_2\text{O}_3 \]

**Ground Generator:**

Silver iodide aerosols can also be generated by vaporizing acetone solutions containing 1-2% AgI. Due to the low solubility of AgI in polar solvents, the addition of alkali iodides or ammonium iodides catalyze the dissolution of silver iodide in acetone (13).

The use of alkali iodides, such as sodium or potassium iodide, generate hygroscopic complexes, 2AgI/NaI or 2AgI/KI, and reduce the effectiveness of silver iodide to serve as an ice nuclei in cold cloud seeding. However, these hygroscopic complexes are ideal for warm cloud seeding and alkali iodides are commonly used in the preparation of AgI solution (14).

For winter cloud seeding, ammonium iodide (NH₄I) is used as a solubilizing agent because it limits the formation of strongly hygroscopic byproducts during the synthesis of AgI solution (13).

Further additives and oxidizers are introduced to solution that alters the yield, nucleation mechanism and rate of ice crystallization by silver iodide. These include ammonium perchlorate (NH₄ClO₄), sodium perchlorate (NaClO₄), and paradichlorobenzene (C₆H₄Cl₂) (2). Ammonium perchlorate is shown to increase the amount of freezing nuclei generated per gram of silver iodide, whereas sodium perchlorate can enhance the hygroscopic properties of silver iodide for use in warm cloud seeding (13).

**Structure of Silver Iodide:**

The hexagonal structure of silver iodide is similar ice crystals and ideal for cloud seeding. Bernhard Vonnegut determined that by exposing powered silver iodide to high temperatures it would vaporize; as it cooled, silver iodide particles ranging from 0.01 to 0.1 microns in diameter formed. These hexagonal AgI aerosols were small enough to serve as ice nuclei and transform surrounding supercooled liquid water into ice crystals (15).

**Unique Properties of Silver Iodide:**

Silver iodide undergoes epitaxial growth in a crystalline structure similar to that of ice. Epitaxial growth is the growth of crystals one on top of another crystal with the same orientation (16).
Figure 1: Crystalline structure of Ice (left) and Silver Iodide (right with black circle)  \( \text{(17)} \)

Silver iodide is hydrophobic and weakly interacts with water, but impurities can become embedded in silver iodide molecules. These impurities create hydrophilic binding sites and permit the absorption of water at these locations \( \text{(18)} \). Impurities are hygroscopic byproducts (alkali nitrates or excess alkali iodide) and can arise during the manufacturing of silver iodide, as shown in the reaction below.

\[
\begin{align*}
\text{AgNO}_3 + \text{NaI} & \rightarrow \text{AgI} + \text{NaNO}_3 \\
\text{AgNO}_3 + \text{KI} & \rightarrow \text{Agl} + \text{KNO}_3
\end{align*}
\]

\( \text{(14)} \)

Cloud Moisture: Warm vs. Cold:

Cloud moisture can exist as cloud droplets in warm clouds or ice crystals in cold clouds. In order for droplets and crystals to form, cloud nuclei must be present in sufficient quantity. Cloud nuclei are microscopic aerosols and serve as the building blocks for the development and growth of cloud moisture.

Warm clouds above 0°C contain cloud droplets and develop from the condensation of water vapor onto aerosols known as condensation nuclei. Cold clouds below 0°C contain ice crystals and develop from water vapor deposition onto ice nuclei \( \text{(19)} \).

Table 1: Summary of conditions and formation of precipitation for warm and cold clouds.

<table>
<thead>
<tr>
<th>Cloud Type</th>
<th>Warm Clouds</th>
<th>Cold Clouds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Above 0°C</td>
<td>Below 0°C</td>
</tr>
<tr>
<td>Cloud Nuclei</td>
<td>Condensation Nuclei</td>
<td>Ice/Freezing Nuclei</td>
</tr>
<tr>
<td>Cloud Moisture</td>
<td>Cloud Droplets</td>
<td>Ice Crystals</td>
</tr>
<tr>
<td>Precipitation</td>
<td>Rain</td>
<td>Snow</td>
</tr>
<tr>
<td>Method of Cloud</td>
<td>Hygroscopic AgI</td>
<td>Glaciogenic AgI Ice Nuclei</td>
</tr>
<tr>
<td>Seeding</td>
<td>Condensation Nuclei</td>
<td></td>
</tr>
</tbody>
</table>

Methods of Cloud Seeding: Glaciogenic vs Hygroscopic:

Temperature strongly dictates the type of precipitation that form in clouds. Rain develops through the collision and coalescence of water droplets in warm cloud, and snow forms through ice crystal processes in cold clouds \( \text{(8)} \).

The initiation of precipitation formation is dependent on several environmental conditions, but is largely determined by the concentration of atmospheric aerosols and their reactivity with water. Soluble, hydrophilic, aerosols serve as cloud condensation nuclei, whereas specific properties of some insoluble particles allow them to serve as cloud freezing nuclei or ice.
Weather modification efforts have primarily focused on initiating and accelerating the chemical and physical processes that lead to precipitation formation (4).

Clouds with sufficient amounts of moisture (saturated), but low concentrations of cloud nuclei are ineffective at generating precipitation. These clouds can be “seeded” with silver iodide to serve as artificial condensation nuclei in warm clouds and ice nuclei in cold clouds.

Warm Cloud

Condensation Nuclei:
Warm cloud precipitation develops from collisions of smaller sized droplets that coalesce with one another to form large water droplets. In supersaturated environments, droplet growth is initiated naturally by condensation of moisture onto condensation nuclei or artificially by silver iodide.

Hygroscopic Seeding: Artificial Condensation Nuclei:
During hygroscopic seeding, clouds with sufficient liquid water content are targeted and seeded with hydrophilic aerosols that can serve as condensation nuclei and initiate, or enhance, the collision-coalescence process to form cloud droplets in warm clouds. Salts may be used to seed clouds because of their strong attraction to water, but one drawback is the excessive quantity needed to have an effect.

As mentioned earlier, the use of alkali iodides in the synthesis of silver iodide solution cause impurities to become embedded within the AgI molecule, acting as hydrophilic binding sites and giving silver iodide hygroscopic properties. This makes silver iodide a preferred seeding agent for warm clouds to promote the development of cloud droplets.

Collision-Coalescence:
Once formed, these droplets remain suspended in clouds by updrafts. The turbulent environment of clouds causes droplets to collide with one another, and coalesce into larger drops. As droplets become heavier, they descend through the cloud and continue to grow through collision-coalescence until reaching a critical size and terminal velocity (19). Terminal velocity is directly related to droplet size, with larger droplets having greater velocities (19). Typically, once droplets surpass 40 microns in diameter, terminal velocity exceeds updraft speeds; precipitation develops very rapidly as it falls (20).

Figure 2: Illustrates the process of Collision and Coalescence (19).
Cold Cloud

**Ice/Freezing Nuclei:**

In clouds with temperatures below freezing, water can remain in liquid form; is referred to as supercooled liquid water. In order to freeze in saturated and subfreezing conditions, supercooled water must come in contact with a foreign particle, or freezing nuclei, which initiates the rapid growth of ice crystals by the process of heterogeneous nucleation (3).

**Glaciogenic seeding: Artificial Ice Nuclei**

Clouds targeted for glaciogenic seeding must contain a large volume of supercooled liquid water and relatively low aerosol concentrations. The intended goal for this method of cloud seeding is to facilitate the conversion of supercooled liquid to ice crystals. Clouds are seeded with silver iodide, which serve as ice nuclei and collide with liquid water to initiate the formation of ice crystals by heterogeneous nucleation.

The crystallization temperature threshold is the temperature at which the formations of ice crystals begin; is about -15°C for natural ice nuclei. However, the crystallization threshold temperature for silver iodide is -5°C, significantly warmer compared to natural ice nuclei, expanding the temperature range in which ice crystals develop in clouds by 10°C (2).

**Ice Crystal Processes:**

Once ice crystals form, they can grow by several processes, such as diffusion deposition, accretion (rimming) and aggregation. Ice crystal growth by diffusion deposition results from differences in vapor pressure at saturation between ice and liquid water. Vapor pressure of liquid water is greater than that of ice; creates a pressure gradient between the two phases. Water diffuses from areas of high pressure to low pressure, resulting in the water molecules to gather around ice crystals and freeze. The rate of ice crystallization is directly related to temperature and humidity. This mechanism functions optimally at temperatures below -15°C (27).

Accretion, also known as rimming, is a process of ice growth through collisions with supercooled droplets. Upon collision with an ice crystal, the supercooled liquids freeze and stick to the outer portion (rim) of the ice crystal; lead to the formation of snow pellets. Optimal conditions for this process occur in saturated clouds with temperatures ranging from 0°C to -10°C (22).

Ice crystal growth by aggregation is very similar to that of accretion, but involves the collision and growth between surrounding ice crystals (21).

![Image of ice crystal growth processes]

**Figure 3:** Silver iodide as an Ice Nuclei

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(23)
Dispersal of Silver Iodide for Cloud Seeding Operations

Sowing seeds in clouds

Dispersing rain or snow in targeted clouds using silver iodide.

**From the air:**
1. Silver iodide crystals are released into the cloud.
2. Water droplets coated with silver iodide capture the crystals.
3. Ice crystals stick together and form snow.
4. Snow crystals fall to the ground as rain or snow.

**From the ground:**
- Silver iodide crystals are dispersed using ground generators.

**Figure 4:** Dispersal of Silver Iodide for Cloud Seeding (24)

**Aerial Dispersal:**
Aerial dispersal of silver iodide can be achieved by fitting the wings of aircraft with pyrotechnic flares or acetone generators and flying directly into targeted clouds to disperse silver iodide. This is the most accurate form of cloud seeding, but also the most costly. Pyrotechnic flares produce on average 10–100 g of active seeding agent per minute, compared to 2-3 g per minute using acetone generators (13).

**Figure 5:** Acetone generator (left) and Pyrotechnic flares (right) (13)

**Ground Dispersal:**
Ground generators rely on vertical updrafts to carry silver iodide aerosols into targeted clouds. The amount of silver iodide dispersed is dependent on several variables unique to the location of the generator and the specific cloud type targeted; range from 5-35 g of AgI per hour to 400 g of AgI every 15 minutes (13).
Silver iodide can also be loaded onto artillery shells and launched into targeted clouds. This method of delivery is extremely dangerous and has been used in some remote regions of China and eastern European countries (13).

Figure 6. Artillery Dispersal of Silver Iodide (25)

The amount of cloud moisture that falls as rain is referred to as the precipitation efficiency and is represented as a ratio of the amount of precipitation that reaches the ground to total moisture (26). On average, thunderstorms have a precipitation efficiency of 20% (27). Most of weather modification hypothesis are based increasing precipitation efficiencies.

Reported Success and Controversy:

Weather variability makes it extremely difficult to observe and measure the effects of cloud seeding, or determine if precipitation formed as a result of seeding or natural processes. Since no two storm systems are ever identical, it is impossible to test the effect of seeding with silver iodide against a control.

However, results from cloud seeding programs have reported increases in annual rain and snowfall by 5-20%, but more conservative estimates report 10% increases (6). How these percentages were quantified is questionable and debated often.

Controversy over the validity of cloud seeding operations can be attributed to six factors that highlight the problems and difficulties of weather modification experiments. These six include proceeding with inadequate scientific knowledge, flawed project and planning processes, opposing views among funding agencies and scientists, lack of commitment by principal agencies, changes in project directors, and poor performance by project scientists (28). Many experts also claim the scientific basis for operational programs is weak and not supported by the level of proof required in academic and scientific research (7).

Experiments monitoring the complete chain of events from seeding to the onset of precipitation are limited or nonexistent. Researchers have been unsuccessful at documenting the physical pathway and mechanisms by which seeding enhances precipitation. Specifically there is a lack of evidence and understanding of how cloud seeding affects the natural process of precipitation formation and how seeding agents interact with the microphysical properties of clouds (8).

In 2003, the inability of past and recent research to provide meaningful results led the National Academy of Sciences to report that there remains no convincing evidence of the efficacy of weather modification programs (29).
Concerns about the long term affect on air quality, accumulation and toxicity of silver complexes in soil and aquatic habitats have been voiced by those opposed to cloud seeding. There is also concern that seeding storms upwind, may steal moisture from storm clouds as they move downwind to neighboring communities.

Regardless, cloud seeding operations continue to grow in number as research continues to declines and could be attributed to a favorable cost/benefit ratio. Treatment of storm clouds using ground based generators is relatively inexpensive and worth the potential payoff in additional water, costing a few dollars per acre-foot (325,851 gallons) of water generated (29).

**Conclusion:**

Water is a precious natural resource and essential for the existence of life. Global water scarcity is a serious threat to current and future populations, as access to safe and clean drinking water continue to diminish. Global populations are expected to grow considerably over the next decade, making the need for sustainable water management strategies ever more important. If current rates in population growth and water withdrawal continue, it is estimated that one-third of the global population will experience some form of water stress by the middle of the century (30).

Water levels throughout the western United States continue to decline at an alarming rate as a result of prolonged drought conditions, increased water use amongst residents and dismal water management strategies in agriculture.

States of the Colorado River Basin are dependent on the Colorado River for fresh water and will undergo rapid growth over the next 20 years. Lower Basin States of California, Nevada and Arizona are projected to grow in population by 39%, and Upper Basin States of Colorado, Utah, Wyoming and New Mexico are expected to grow by 26% (6).

The Lower Basin states currently use the maximum apportioned water mandated by the Colorado River Compact, while Upper Basin States will soon be reaching their allotted water levels. If these states are current at, or approaching, their maximum water usage from the Colorado River how will the millions of additional residents gain access to safe drinking water in the future?

Preserving water supplies and developing policies to curtail water use must be viewed with the utmost concern by water managers and governments in order to prevent a catastrophe from occurring.

Weather modification, geo-engineering, climate intervention and resource ecology are promising fields of science with the potential for enhancing our understanding of global change and develop strategies to mitigate future resource scarcity. However, even if future experiments prove that cloud seeding with silver iodide can enhance precipitation, it will not provide enough water to replenish water reserves at the current rate of consumption.

Agriculture accounts for the largest withdrawal of southwestern water supplies, and decades of mismanagement severely threaten the sustainability of communities and industries. High water use crops, such as Arizona and California farmed lettuce, are almost exclusively grown in regions of the country currently under water stress or in regions projected to be at greatest significant risk, greatly compounds the risk of future depletion. States must reorganize their water plans to alter current water consumptions in order to meet the increased demand of the future.

Water conservation is a more realistic and practical approach to addressing the fundamental problem of excessive use and mismanagement of public water supplies, and focuses out attention to developing long term solutions.
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The Mechanism of Homeopathy

Water as a Memory Storage Device, Cellular Communication, and Cytokines

John R. Hayden

April 20, 2012
Abstract:

Although the exact mechanisms are not fully understood, contemporary science is giving new insight into the mechanism of homeopathy. Homeopathy is defined and how homeopathic remedies are prepared is discussed. The mechanism of a healing response requires a signal to be sent, a cellular acceptance and processing of the signal, and a cellular response. Signal mechanisms are examined. A sample homeopathic medication is examined. The future of homeopathy is discussed.

To the vast majority of Americans, homeopathy is a mystery. The mystery somehow involves those little blue tubes, sprays and creams, labeled with Latin names and Roman numerals. Here they are, sitting on the shelf of the health-food store, claiming to be real medications. Homeopathic medications are, in fact, regulated by the FDA as drugs. Since 1938, they have required the same standards as pharmaceuticals in quality, labeling and marketing. Scientific critics and skeptics dismiss them as nothing other than placebos, or ridicule them as sham. Homeopathic practitioners praise them as completely safe and effective, without the negative side-effects of pharmacological drugs. Much of the world population just seems to accept them, and use them, as they appear to work.

So, the question regarding homeopathic medication is: IF they work, HOW do they work? There are actually several answers to this question. The short answer is: Quite well, thank you. The long answer is: A minute quantity of a substance, actually the water memory of that substance, triggers a healing response in the body. The technical answer to how homeopathy works is: We don’t really know completely how it works. This paper seeks to examine some of the scientific possibilities and potential explanations for homeopathy, as well as some of the challenges and problems regarding its understanding. Although this paper cannot be regarded as exhaustive, every effort has been given to provide a balanced and comprehensive examination of the present state of understanding of the scientific mysteries of homeopathy.

According to the Homeopathic Pharmacopoeia of the United States Revision Service 2004, homeopathy “is the art and science of healing the sick by using substances capable of causing the same symptoms, syndromes and conditions when administered to healthy people.” It is sometimes used interchangeably with, or confused with, Naturopathy which is a system of medicine based upon the healing power of nature. Principles of homeopathy date back to Hippocrates and Paracelsus. “Modern“ homeopathy dates back the late 1700’s when Dr. Samuel Hahnemann, a physician from Leipzig, Germany, discovered the concept of similars, that “like cures like.” Homeopathy also uses the principle of “minimum dose,” which envisions that the symptoms from a large amount are reversed by taking a small amount. The concept of “proving” suggests that agents such as herbs, chemicals, et cetera, produce certain symptoms in normal healthy humans. These agents, in extremely diluted forms, are used to cure diseases which produce the similar “proved” symptoms in the healthy individuals. Hahnemann “proved” that Cincona bark gave malaria symptoms, and was also effective in curing malaria. He discovered that the more dilute the preparation usually gave a more dramatic result. Additionally, he developed the scale, noted in a combination of Arabic and Roman numerals, used to measure homeopathic dilution. “X” (or “D”) refers to dilution to one part in ten. “C” refers to dilution to the hundredth. 1X equals one part in ten, 2X is dilution twice which equals one part in 100, 3X equals one part in 1000.
### Homeopathic Remedy Potencies

<table>
<thead>
<tr>
<th>Dilution</th>
<th>Concentration</th>
<th>Decimal Scale</th>
<th>Centesimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/10</td>
<td>10%</td>
<td>10(-1)</td>
<td>D1 or 1X</td>
</tr>
<tr>
<td>1/100</td>
<td>1%</td>
<td>10(-2)</td>
<td>D2 or 2X</td>
</tr>
<tr>
<td>1/1,000</td>
<td>0.1%</td>
<td>10(-3)</td>
<td>D3 or 3X</td>
</tr>
<tr>
<td>1/10,000</td>
<td>0.01%</td>
<td>10(-4)</td>
<td>D4 or 4X</td>
</tr>
<tr>
<td>1/100,000</td>
<td>0.001%</td>
<td>10(-5)</td>
<td>D5 or 5X</td>
</tr>
<tr>
<td>1/1,000,000</td>
<td>0.0001%</td>
<td>10(-6)</td>
<td>D6 or 6X</td>
</tr>
<tr>
<td>1/1,000,000,000,000</td>
<td>Avogadro's Law 10(-12)</td>
<td>D12 or 12X</td>
<td>6C</td>
</tr>
</tbody>
</table>

At 12C or $10^{-24}$, there may be one molecule (or none) of the original substance, and yet the “remedy” will apparently have a homeopathic medical effect.1 “Lower dilutions are for physical symptoms, higher dilutions can effect emotions, and multiple dilutions can have a broader effect.”2 Another explanation is “the level of dilution… does not correspond to strength: a 30 C is not stronger than a 6C. The difference is their level of action. While a 6C is suitable for local symptoms, a 30C or higher is appropriate for general conditions.”3 Some homeopathic remedies use a water and alcohol tincture which is diluted. During each dilution, the homeopathic preparation is vigorously shaken, a process known as “succussion.” The final dilution is sprayed onto a sugar pill. The white sugar pills, as such, do not have any medicinal value. But these pills act as vehicles or carriers for the medicines.

Theoretically, anything which causes a response can be prepared as a homeopathic dilution, including plants, minerals, tissue extracts, diseased tissue and zoological materials, such as venoms. A homeopathic medicine diluted at least to a 4C has no known toxicity, no known side effects, and no interaction with other medicines. Low dilutions are very close to the original herbal or mineral state of the original substance. However, according to the definition of similars, where “like cures like” (if a lot of a substance causes a symptom, and infinitesimal small amount of that substance remedies that symptom) not every substance is appropriate. The substance has to “prove” a symptom. For example, while homeopathic ragweed might be appropriate to treat allergies, and homeopathic cobra venom to treat stiff joints, it would not, by strict definition, be appropriate to prepare dilutions of morphine to relieve pain, and expect them to homeopathic because they do not by their nature cause or “prove” a symptom. (Theoretically, a homeopathic preparation of morphine might be effective to relieve nausea because retching is a symptom of alkaloid toxicity).

The concept of similars is not completely unknown to conventional medicine. A tiny fragment of cell wall, or killed virus in a vaccine triggers immunity in the body, and small but increasing doses of allergens are used to produce allergic desensitization. (An interesting recent development in genetics is the utilization of alternate, secondary codons [3-unit bits of mRNA] to produce amino acids for pathogens which just don’t work well enough to produce disease, but can stimulate an effective immune response).
The premise of homeopathy is that the infinitesimal amount of a substance sends a signal to the human body, which triggers the human body to produce a healing response. A bee sting releases venom into the body which, in most cases, causes inflammation at the bee sting site. The human body responds to this inflammation by releasing anti-inflammatory chemicals, and the sting sight eventually calms down. Homeopathy is like the signal of the bee sting, without the venom and pain, which stimulates a perfectly modulated anti-inflammatory response. (There are, in fact, homeopathic remedies which are useful in relieving insect stings and the inflammation and pain caused by poisonous plants).

The first part of the mechanism of homeopathy is that a substance which causes a physical symptom in the body is diluted and carried to the body as a water memory.

What exactly is water memory? Water is unique, ubiquitous, and universal. It is generally regarded absolutely necessary for life as we understand it. It is what we search for when looking for life on other planets. Hydrogen, one of the components of water, is by far the most plentiful element in the universe. Water has some remarkable characteristics. It is a universal solvent. Water has perhaps the greatest capacity to store energy of any substance, which is usually understood to be its specific heat capacity. This capacity goes beyond the storage of heat only but goes into storage of many kinds of energy. There are many more ways for water molecules to absorb energy without increasing translational kinetic energy. This energy storage capacity of water implies that the rotational and vibrational kinetic energies are neglected in this approximation.

Energy Storage Capacity of Water

Water is a molecule consisting of one oxygen atom and two hydrogen atoms. All atoms in a water molecule are in constant motion, in what can be depicted as three distinct basic vibrations, as shown below. Each form of molecular motion has a distinct energy level.
The water molecule is polar, with the oxygen end being more negative in charge than the hydrogen end. Because of this polar characteristic, each water molecule is capable of forming bonds with adjacent water molecules. The H-bonds are non-specific, electrostatic and 10 to 100 times weaker than covalent chemical bonds. Water, as a substance, is not visualized as a single molecule, but as an infinite H-bonded molecular system or network. Any alien molecule will cause a defect in this lattice, a perturbation, and large concentrations of different substances result in the formation of separate lattice systems. The technical description of this is called polaron theory: polaron = a topological defect + vicinal polarization.  

"An interesting feature of hydrogen bonding is its polarizability, which is manifested as a continuous background in the infra-red spectrum." Contemporary science is investigating the universe "filled with an intrinsic jitter, the busy hum of static." This groundbreaking research seeks to "how the universe stores information, which may constitute the most basic units of existence." (Perhaps this "background hum" functions as the carrier signal of water.)

Additionally, water has the capability of forming H-bonded clusters. Water is a mixture of mono-, di-, tri-, tetra-, penta-, hexa-, (and so on) molecular clusters. More than forty different cluster formations have been found experimentally in pure water! Molecular movement of a single water molecule has been estimated at $10^{15}$ to $10^{15}$ events per second. However, the timescale of human biological processes broadly ranges from $10^8$ to one event per second. Understanding how a substance which vibrates so fast could possibly relate to an organism which moves and lives so slowly is a challenge. How is it possible that something which moves so fast provides a coherent and useful signal?  

Coherence and memory of various timescale dynamics of water may be organized fractally, with faster processes imbedded into slower ones. Only very recently, could the possibilities of such vast signal-compression be adequately described. Fractals are used to describe geometric patterns in nature, and are typically self-similar patterns, where self-similar means they are "the same from near as from far."

These unique properties of water make it probably the most appropriate medium for a homeopathic signal, if there is one. If this signal carried in water is possible, why is it presently so hard to detect or prove? One reason is the limitations of present technology. It is unscientific to presume, that, because one does not know how to read a signal, that the signal is not there to read. Neuroscientists at Berkley face a similar challenge regarding advancing the "relatively primitive" present day technology to be able to "read" human thought. "The field is held back by its clunky machinery, in particular the fMRI." No one can deny the signal of human thought is present in its magnificent complexity, we just cannot yet read that signal externally. However, the human body in its consciousness reads that signal quite well. It may be inferred that the human body is the ultimate reader of the homeopathic signal. The human body, with its immune system, has the potential of hundreds (if not thousands) of possible healing responses. "The remedy can be seen as a sender, the prover as a receiver. The trick is to get as pure and full a signal without noise." And "the challenge appears to be choosing the correct remedy."
A second reason that the homeopathic signal in water has been difficult to prove, is that there is a separation between the "scientific" and "esoteric" worlds of science and understanding. Writers M. J. Pangman and Melanie Evans note in the March/April 2012 issue of The Well Being Journal that "liquid crystals (of water) are a special phase of matter with orientational order. Like solid crystals, they are extremely efficient at transferring signals; the repeating pattern provides a pathway for the efficient flow of energy and information." Their paper, though compelling, discusses the vital properties of water, cell receptors which attract electromagnetic signals, vortices and the quantum properties of water without giving any technical data. Mainline researchers who have tried to prove water memory have been openly ridiculed. The major homeopathic companies zoom past water memory without explanation, or use animal-based research which side-steps the potential legal challenges.

WATER MEMORY - THE THIRD RAIL

The issue of "water memory" is fraught with controversy. Is it magical thinking or quantum physics? Two major homeopathic companies, Boiron and Heel, largely pass over the troublesome subject with no explanation. Public controversy, name-calling and a ruined career have done little to settle this issue. In 1988, the French doctor Jacques Benveniste, working with allergens, announced he had proof that homeopathic dilution had an effect on basophils, which are white blood cells. This announcement caused a media sensation in France, where homeopathic medicine is common. Benveniste published a paper in the British medical journal, Nature, which tried unsuccessfully to reproduce his results. A major scientific scandal resulted. Each party accused the other of faulty scientific process, as each party's results appeared to be influenced by their own scientific bias. The results appeared to be influenced by the expectation of the researcher. (Though scientific irrational, these conflicting results are related to quantum physics and Heisenberg principles that Albert Einstein called "spooky." In theory, this is precisely the effect one should expect by the memory storage potential ability unique to water. The ability of water to store the mental intention of the observer is the subject of the amazing work of the Japanese researcher Dr. Masaru Emoto and his remarkable photographs of water crystals. Dr. Benveniste died in 2004, largely discredited. In 2010, HIV discoverer and Nobel laureate Doctor Luc Montagnier announced his intention to follow in the steps of Benveniste. Montagnier claims to "have found that DNA produces structural changes in water, which persist at very high dilutions, and which lead to resonant electromagnetic signals that we can measure (italics added)." Regarding the work of Benveniste, Montagnier asserts "I think he was mostly right, but the problem was that his results weren't 100% reproducible," and as to homeopathy: "high dilutions of something are not nothing, they are water structures which mimic the original molecules...these are real phenomena which deserve further study." Curiously, the Nature paper was never retracted.
A probable third reason for a lack of evidence of the memory storage properties of water is a lack of serious research by orthodox science into virtually any of the remarkable properties of water. Water is ubiquitous, deceptively simple, and taken for granted. "The exceptional presence of this hyperdense H-bond network gives it unique possibilities to accommodate embedded molecules." Yet according to Yves Maréchal, in the last century, there has been an absolute dearth of published materials regarding the amazing properties of water, and he lists only seven such documents, some of which are eighty years old!

In 2007, just before his death, preeminent materials researcher Rustum Roy released a technical paper which suggests that "water can be ‘imprinted’ by different surfaces and solutes through a process analogous to a phenomenon well known in material science. Epitaxy – the transmission of structural information from the surface of one material (usually a crystalline solid) to another (usually a liquid) – occurs without any transfer of material [6]. The result is to induce the liquid to change its structure in the region close to the crystalline substrate, and possibly precipitate or crystallize in a predetermined structure or morphology, the stuff of homeopathy and the putative memory of water." Interestingly, although he worked extensively in the United States, Roy is from India which is a culture that historically readily accepts the medical application of homeopathy, and has no cultural bias against the concept of water as a memory storage device. His paper, in abstract, states:

The key stumbling block to serious consideration of homeopathy is the presumed “implausibility” of biological activity for homeopathic medicines in which the source material is diluted past Avogadro’s number of molecules. Such an argument relies heavily on the assumptions of elementary chemistry (and biochemistry), in which the material composition of a solution, (dilution factors and ligand–receptor interactions), is the essential consideration.

In contrast, materials science focuses on the three-dimensional complex network structure of the condensed phase of water itself, rather than the original solute molecules. The nanoheterogeneous structure of water can be determined by interactive phenomena such as epitaxy (the transmission of structural information from the surface of one material to another without the transfer of any matter), temperature–pressure processes during succussion, and formation of colloidal nanobubbles containing gaseous inclusions of oxygen, nitrogen, carbon dioxide, and possibly the remedy source material.

Preliminary data obtained using Raman and Ultra-Violet–Visible (UV–VIS) spectroscopy illustrate the ability to distinguish two different homeopathic medicines (Nux vomica and Natrum muriaticum) from one another and to differentiate, within a given medicine, the 6c, 12c, and 30c potencies. Materials science concepts and experimental tools offer a new approach to contemporary science, for making significant advances in the basic science studies of homeopathic medicines.
However, MANY valid questions remain: If water is a memory storage device, how does one wipe the memory storage clean? Water has been around for a long time, wouldn’t it be holding memory of other substances? Would the memory of these other substances interfere with the desired signal? Although the exact mechanism is unknown, it is reasoned that the physical pounding process of succussion, the vigorous pounding or shaking which accompanies the dilution process, is what creates the signal and also wipes any previous memory storage clean. Finally, the transference or imprinting of the homeopathic signal onto the milk sugar pill is problematic. “Homeopaths speak of the ‘vibration’ of the substance being transmitted or of a profound change in the molecular structure in the pill, but neither has been demonstrated.”\textsuperscript{18} Recently, Boiron changed the packaging of its blue tubes of homeopathic remedies, from clear to frosted, to resist the laser light of cash-register scanners, which, in theory could alter the water memory signal. Some liquid homeopathic preparations advise to repeat the succession to the bottle just before use, presumably to re-align the homeopathic signal to the contents inside. Other questions remain, could a cell-phone held in the same pocket or vicinity of a homeopathic remedy alter or destroy the signal held in the water memory?

**The second part of the mechanism of homeopathy is the body receiving the water memory signal.**

*What happens when a homeopathic signal is sent to the body?* Homeopathic remedies are regarded as information-medicines or energy-medicines. They work via the nervous system and can be applied to any area rich in sensitive nerves, such as the tongue, skin, eyes, or rectum. The tip of the tongue is particularly rich in nerves. The remedy should be dosed only as often as the body needs it, beginning with once every fifteen minutes until the body reacts, once the body has initiated a healing response, and repeated as necessary.\textsuperscript{3} The brain helps regulate immune response. The healing response occurs largely in the connective tissues of the body, which includes the blood.

*Information molecules* have been seen as the basic units of a language used by the cells to communicate across the endocrine, neurological, gastrointestinal, and immune system. *Ligands* is the term used for any natural or man-made substance which binds selectively to its own receptor surface of a cell. The *presently known* molecules of information include amino acids, steroids, and peptides, which diffuse throughout the body, suspended in water. The chemical messenger binds to the receptor on the cell membrane. A typical cell may have seventy or more different types of receptors floating on the cell membrane, with each receptor type numbered by 100,000 or more, all listening for a signal. Once the receptor receives the message, it transmits the signal into the cell interior, which changes the activity of the cell. The receptors on the cell membrane can be regarded as the control panel of the cell’s activity.\textsuperscript{19} *Although the exact mechanism presently is not fully known,* it appears that the body’s receptors can “hear” and “read” the homeopathic message held in the water.
The third part of the mechanism of homeopathy is the body is stimulated into producing a healing response.

*What is a healing response?* The body is capable of a vast myriad of healing responses. However, responses fall broadly into two groups: The *inflammatory response* is relatively non-specific and occurs quickly whenever tissues are injured. The *immune response* is specific and takes longer to initiate. An important part of the homeopathic process are *cytokines*, which were unknown until 1965 and the discovery of interleukin-2. Since that initial discovery, additional *dozens* have been discovered. Cytokines “regulate many bodily processes, including reproduction, growth and development, homocostasis, blood clotting, and the immune response.”

Cytokines are small glycoproteins found in femtomolar and picomolar concentrations in the blood, which when bound to their receptors in a hormone-like fashion, elicit certain responses. Cytokines are able to individually elicit such responses but usually works in “groups” to achieve a better overall effect. Almost all biological systems are influenced by cytokines, including the induction of sleep.

In 1997, Hartmut Heine published a paper on *antihomotoxic* drugs and the *immunological bystander reaction*, which relies upon part of the immune system for its effects. Microphages are immune system cells which destroy invaders by surrounding them and digesting them, a process called *phagocytosis*. When a microphage comes into contact with the antihomotoxic drug or antigen, it phagocytes the material, processes it, and adds it to its amino acid motif which is placed upon its surface. Immature lymphocytes (other immune cells) accept or “read” the motif, and become mature Th3 cells. The Th3 cells eventually wander into a lymph node which duplicates, and mass produces the motif into “motivated” clones. Motivated clones are attracted to various areas, especially those areas resulting from inflammation. (Inflammation is not always a bad thing, as it is a marker the body places when there is injury or something wrong. Inflammation often itself activates a healing response.) The motivated clones can react with other inflammatory lymphocytes to produce anti-inflammatory cytokines which reduces the inflammation, and also results in the production of antibodies. Antigen insult leads to inflammation, which results in antibody production. Amino acid presentation does not have to be identical to cause the response. When a similar agent is presented, a reduced level of inflammation occurs which is a down-regulation to a more normal state. It is as though the body is saying, “Calm down, I have seen something like this before.” This down-regulation appears to occur ONLY with antigens at very low dosing. This bystander reaction works by *bioregulation* and not suppression. The illustration shows how this principle can be used to tell the body to reduce inflammation in *arthritic joints.*
(It is interesting to note, that upon close examination, this visual is representative of homeopathic response study produced in animals, not humans.)

The day will come when medical researchers will theorize and plan a desired healing result, and will seek to program a homeopathic signal or message to bring about that exact therapeutic effect. Indeed, that day actually is here. Dr. Daniel Rubin ND, in a double-blind placebo trial, has had success in the homeopathic “proving” of a substance called COBAT to treat fibromyalgia. “This may be the first molecular data showing adaptogenic effect...activity at the mRNA level... COBAT acts as an immune modulator, and appears to provide just the right amount.” This has been termed the “Goldilocks” effect— not too much, not too little—just the right amount.”

In conclusion, the way that homeopathy appears to work is through initiating a sort of synthetic feedback of the body’s homeostasis. Though intriguing, it is certainly not well understood scientifically. Even one of its great advocates, Jacques Benveniste, described homeopathy as being "like shaking your car keys in the Seine at Paris and then discovering that water taken from the mouth of the river would start your car!" It appears to be a signal which triggers the body to produce a healing response. It is the quiet whisper in the body’s ear.
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The Effects of Alcohol on Prescription Drugs

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Organic Chemistry 235

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Abstract

Alcohol can be detrimental to your health, and even more detrimental if consumed with medications. I feel that it is extremely important to know what effects might occur when alcohol and prescription medications are ingested and being processed simultaneously. In this paper it will be discussed how alcohol affects the body while on both prescription medication and over the counter drugs.

Background

For us to completely understand how alcohol reacts with medications, we must first explain why and how alcohol is digested. "Practically every animal from the fruit fly to the elephant has a way to break down ethyl alcohol because ethyl alcohol is found everywhere in nature.\(^1\)

![Ethyl Alcohol Structure](image)

This is the structure of ethyl alcohol. Molecular Formula: CH\(_3\)CH\(_2\)OH.\(^2\)

Every time you eat a piece of fresh fruit, drink a glass of fresh orange juice, or have a slice of freshly baked bread, then chances are that you are getting trace amounts of alcohol along with it. It is not uncommon to see intoxicated birds which have eaten fermented fruit. Monkeys are known to seek out fermented fruit for the intoxicating effect, and Indian elephants have been known to break into breweries or wineries to drink up what is stored there. Not only are we constantly ingesting alcohol along with the food we eat, our own bodies produce alcohol as a part of the digestive process. Our digestive tracts contain millions of micro-organisms which are necessary for us to properly digest our food. Among these micro-organisms are yeasts which produce alcohol from sugars within our own bodies. With alcohol so omnipresent in nature, it is necessary that animals have a way to break alcohol down; otherwise, it would just accumulate in the body and no animal could function properly because the animals would always be constantly intoxicated.\(^3\) So, now that we determined that alcohol must be digested within the body, let’s learn how this process takes place.

Alcohol digestion goes through many steps and will affect many different organ systems. Here are the many steps, starting from the 1st point of ingestion, your mouth. The metabolized alcohol flows through your stomach walls into your bloodstream and into your small intestine.

Most of the alcohol you drink is absorbed through the duodenum, part of the small intestine. From there it flows into your liver. In the liver, an enzyme similar to gastric ADH metabolizes the alcohol, which is converted to energy by a coenzyme called nicotinamide adenine dinucleotide (NAD). NAD is also used to convert the glucose you get from other carbohydrates
to energy; while NAD is being used for alcohol, glucose conversion grinds to a halt. The normal, healthy liver can process about 1/2 ounce of pure alcohol (that's 6 to 12 ounces of beer, 5 ounces of wine, or 1 ounce of spirits) in an hour. The rest flows on to your heart. Entering your heart, alcohol reduces the force with which your heart muscle contracts. You pump out slightly less blood, blood vessels all over your body relax, and your blood pressure goes down temporarily. The contractions soon return to normal, but the blood vessels may remain relaxed and your blood pressure lower for as long as half an hour. Meanwhile, alcohol flows in blood from your heart through your pulmonary vein to your lungs. Now you breathe out a tiny bit of alcohol every time you exhale. Then the newly oxygenated, still alcohol-laden blood flows back through the pulmonary artery to your heart, and up and out through the aorta. In your blood, alcohol raises your level of high-density lipoproteins (HDLs), although not necessarily the good ones that carry cholesterol out of your body. Alcohol also makes blood less likely to clot, temporarily reducing your risk of heart attack and stroke. Alcohol makes blood vessels expand, so more warm blood flows up from the center of your body to the surface of the skin. You feel warmer and, if your skin is fair, you may flush and turn pink. (Asians, who tend to make less alcohol dehydrogenase than do Caucasians, often experience a characteristic flushing when they drink even small amounts of alcohol.) At the same time, tiny amounts of alcohol are being excreted out through your pores, and your perspiration smells of alcohol. Alcohol is a sedative. When it reaches your brain, it slows the transmission of impulses between nerve cells that control your ability to think and move. That's why your thinking may be fuzzy, your judgment impaired, your tongue twisted, your vision blurred, and your muscles rubbery. Now, let's see the chemical breakdown of alcohol.

First, fermentation is used to make ethanol. Ethanol is made by the breakdown of glucose; this process is in the figure below.

![Chemical breakdown of alcohol](image)

End material: Ethanol: \(2(\text{CH}_3\text{-CH}_2\text{-OH})\)
Now that ethanol is made, it can be found in various drinks that are ingested, such as beer, wine, and spirits. After ingesting ethanol, it is then broken down to acetate and dumped into the bloodstream. As seen in the figure below.  

![Diagram of ethanol metabolism](image)

To explain further how the breakdown of ethanol occurs is figures and explanation below.  

"More than 90% of the ethyl alcohol that enters the body is completely oxidized to acetic acid. This process occurs primarily in the liver. The remainder of the alcohol is not metabolized and is excreted either in the sweat, urine, or given off in one’s breath. There are several routes of metabolism of ethyl alcohol in the body. The major pathways involve the liver and in particular the oxidation of ethyl alcohol by alcohol dehydrogenase (ADH).

The major route of metabolism of ethyl alcohol is its oxidation in the liver catalyzed by the cytosolic enzyme alcohol dehydrogenase (ADH). It catalyzes the following reaction:

\[
\text{CH}_3\text{CH}_2\text{OH} + \text{NAD}^+ \rightarrow \text{CH}_3\text{CHO} + \text{NADH} + \text{H}^+.
\]

This reaction produces acetaldehyde, a highly toxic substance.

The second step of ethanol metabolism is catalyzed by acetaldehyde dehydrogenase. This enzyme converts acetaldehyde to acetic acid, which is a normal metabolite in humans and hence is nontoxic.
There are some implications that occur with alcohol metabolism and need to be addressed to fully understand how metabolism of alcohol occurs. Alcohol may have implications for tissue damage from ethanol, particularly in the liver. Alcohol metabolism produces excess amounts of NADH (Nicotinamide Adenine Dinucleotide plus Hydrogen). This excess of NADH can lead to acidosis from lactic acid build-up and hypoglycemia from lack of glucose synthesis. It can also lead to weight gain, fatty liver, and heart attack.¹

Now that the breakdown of ethanol has been clarified, the last topic to be educated on is how organs and the organ systems of the body are affected by this digestion. The first major organ affected is your liver. An association between alcohol consumption and liver disease has been known for over 200 years. In fact, the most common cause of illness and death from liver disease is from long-term alcohol consumption. Since the liver is the primary site of alcohol metabolism, it is not surprising that it is particularly susceptible to alcohol-related injury. The injury to the liver from long-term drinking apparently comes not only from ethanol, but also from the dangerous products generated upon the metabolism of ethanol. These include acetaldehyde and highly reactive molecules called free radicals. (Free radicals are a group of elements or atoms usually passing intact from one compound to another, therefore in an uncombined form. As free, it is usually short lived and highly reactive.)²

Example of free radicle: (each of these reactions creates a free radicle by the dot shown next to the molecule)⁷

\[
\text{Cl}^\cdot + \text{H} - \text{CH}_3 \rightarrow \text{HCl} + \cdot\text{CH}_3
\]
\[
\text{Cl}^\cdot + \text{Cl} - \text{CH}_3 \rightarrow \text{Cl}^\cdot + \text{CH}_2\text{Cl}
\]
\[
\text{Cl}^\cdot + \text{H} - \text{CH}_2\text{Cl} \rightarrow \text{HCl} + \cdot\text{CH}_2\text{Cl}
\]
\[
\text{Cl}^\cdot + \text{Cl} - \text{CH}_2\text{Cl} \rightarrow \text{Cl}^\cdot + \text{CH}_2\text{Cl}_2
\]
\[\text{etc.} \rightarrow \text{CCl}_4\]

The structure of acetaldehyde:⁷

![Structure of Acetaldehyde](image)
The second major organ system affected is the kidneys. The major functions of the kidneys are to regulate the volume and composition of the fluids and electrolytes in the body. They help in the supply of nutrients to the cells of the body and in clearing cellular waste as well as providing stable conditions for the cells to function. The substances regulated by the kidneys include water, sodium, potassium, calcium, and phosphate in the fluids surrounding the various cells. In addition, the kidneys regulate the acid-base balance which is important in maintaining cell structure, permeability, and metabolic activity. Further, the kidneys produce hormones that influence numerous physiological processes. Because of their involvement in all these important bodily processes, alcohol has the potential to influence and/or compromise these functions of the kidneys and thus has the potential to induce severe consequences for the functioning of the organism. Lastly, the brain is extremely affected by the amount of alcohol that has been consumed. Alcohol's direct action on the brain is as a depressant. It generally decreases the activity of the nervous system. One could ask how it could be a depressant if after one or two drinks, a person tends to talk more and become more active. The answer is that alcohol can cause disinhibition, i.e., inhibits cells and circuits in the brain which themselves are normally inhibitory.

Now onto the discussion of how alcohol affects medications. More than 2,800 prescription drugs are available in the United States, and physicians write 14 billion prescriptions annually; in addition, approximately 2,000 medications are available without prescription. Approximately 70 percent of the adult population consumes alcohol at least occasionally, and 10 percent drink daily. About 60 percent of men and 30 percent of women have had one or more adverse alcohol-related life events. Together with the data on medication use, these statistics suggest that some concurrent use of alcohol and medications is inevitable.

Next, how medications are effected by alcohol in the body. To exert its desired effect, a drug generally must travel through the bloodstream to its site of action, where it produces some change in an organ or tissue. The drug's effects then diminish as it is processed (metabolized) by enzymes and eliminated from the body. Alcohol behaves similarly, traveling through the bloodstream, acting upon the brain to cause intoxication, and finally being metabolized and eliminated, principally by the liver. The extent to which an administered dose of a drug reaches its site of action may be termed its availability. Alcohol can influence the effectiveness of a drug by altering its availability.

Typical alcohol-drug interactions include the following: First, an acute dose of alcohol (a single drink or several drinks over several hours) may inhibit a drug's metabolism by competing with the drug for the same set of metabolizing enzymes. This interaction prolongs and enhances the drug's availability, potentially increasing the patient's risk of experiencing harmful side effects from the drug. Second, in contrast, chronic (long-term) alcohol ingestion may activate drug-metabolizing enzymes, thus decreasing the drug's availability and diminishing its effects. After these enzymes have been activated, they remain so even in the absence of alcohol, affecting the metabolism of certain drugs for several weeks after cessation of drinking. Thus, a
recently abstinent chronic drinker may need higher doses of medications than those required by nondrinkers to achieve therapeutic levels of certain drugs. Third, enzymes activated by chronic alcohol consumption transform some drugs into toxic chemicals that can damage the liver or other organs. Fourth, alcohol can magnify the inhibitory effects of sedative and narcotic drugs at their sites of action in the brain. To add to the complexity of these interactions, some drugs affect the metabolism of alcohol, thus altering its potential for intoxication and the adverse effects associated with alcohol consumption.8

Let’s look at a few more drug, alcohol interactions. Many drugs interact with alcohol, resulting in undesirable outcomes. There are two types of alcohol drug interactions: pharmacokinetic and pharmacodynamics. Pharmacokinetic interactions occur when alcohol alters the metabolism or excretion of the drug or vice versa. Pharmacodynamics interactions refer to the additive effects of alcohol and certain drugs, particularly in the central nervous system (CNS) (e.g., sedation) without affecting the pharmacokinetics of the drug. In the second one Alcohol is primarily metabolized in the liver by several enzymes. The most important enzymes are aldehyde dehydrogenase and CYP2E1. In people consuming alcohol only occasionally, CYP2E1 metabolizes only a small fraction of the ingested alcohol. In contrast, chronic heavy drinking can increase CYP2E1 activity up to ten-fold, resulting in higher proportion of alcohol being metabolized by CYP2E1 rather than alcohol dehydrogenase. Therefore, in some cases, the effect of alcohol on the interacting drug may be different, depending on chronic or acute alcohol use. There are a number of classes of drugs that can potentially interact with alcohol (e.g., antibiotics, antidepressants, sedative/hypnotics, opioids, anticoagulants, etc). The included chart summarizes common alcohol-medication interactions including precautions and recommendations for alcohol consumption.9

Here are a few medications that have major interactions with alcohol and what should be done to prevent any health problems.9

<table>
<thead>
<tr>
<th>Drug/Drug Class</th>
<th>Effect(s) and Proposed Mechanism(s)</th>
<th>Recommendations/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long-Acting Morphine</td>
<td>-Increased morphine release rate and absorption, which may lead to potentially fatal doses. Alcohol interacts with the extended-release mechanism and causes a dose dumping effect. - In an <em>in vitro</em> study, alcohol was found to affect <em>Kadian</em>’s extended release mechanism. However, <em>in vivo</em> studies done in the U.S. showed that dose dumping is not a problem.</td>
<td>-Tell patients to avoid alcohol and alcohol-containing drugs (<em>NyQuil</em>, etc). -Alcohol is contraindicated according to Canadian <em>Kadian</em> monograph.</td>
</tr>
</tbody>
</table>
| Tricyclic Antidepressants (e.g., amitriptyline, etc) | -Excessive CNS depression and impaired psychomotor performance.  
- Acute alcohol ingestion may inhibit the first-pass hepatic metabolism of tricyclic antidepressants. | -Warn patients taking tricyclic antidepressants of enhanced CNS depression, especially within the first week of treatment and with the more sedating tricyclics such as amitriptyline and doxepin. |
|---|---|---|
| Insulin | -Enhanced glucose-lowering action of insulin.  
- Enhanced release of insulin following a glucose load and inhibition of gluconeogenesis. | -Tell patients to limit alcohol consumption and avoid drinking on an empty stomach.  
- Monitor for hypoglycemia if the combination is used. |
| Metformin (*Glucophage*, etc) | -Theoretically, an increased risk for lactic acidosis.  
- Potentiate metformin effect on lactate metabolism. | -Tell patients to limit alcohol consumption.  
- Monitor for signs and symptoms of lactic acidosis if the combination is used. |
| First generation antihistamines (e.g., diphenhydramine, chlorpheniramine, hydroxyzine, etc) | -Enhanced CNS depression and impaired psychomotor performance.  
- Interactions are more pronounced in elderly patients.  
- There are no documented cases with nonsedating antihistamines. | -Tell patients to limit alcohol consumption.  
- Monitor for signs and symptoms of CNS depression if the combination is used. |
| Cephalosporins (cefofivamide, cefotetan [Cefotan], Canada only: moxalactam [Moxam], cefamandole [Mandol]) | -Disulfiram-like reactions.  
- These cephalosporins contain a moiety that is structurally related to disulfiram and may inhibit aldehyde dehydrogenase, thereby leading to accumulation of acetaldehyde, a metabolite of alcohol. | -Tell patients to avoid alcohol while taking these cephalosporins and for 2 to 3 days after discontinuing the drug. |
| Metronidazole (*Flagyl*) | -Disulfiram-like reaction. M- etronidazole inhibits aldehyde dehydrogenase, which leads to accumulation of acetaldehyde, a metabolite of alcohol.  
- Vaginal preparations have also been reported to interact with alcohol. | -Tell patients to avoid alcohol or alcohol-containing drugs while taking metronidazole and for at least 1 day after stopping the drug.  
- Monitor for flushing, nausea, and vomiting if the combination is used. |
| Atypical antipsychotics (Seroquel and Abilify) | -Excessive CNS depression and impaired psychomotor performance.  
- Enhanced orthostatic | -Tell patients to avoid alcohol use beyond the occasional one or two drinks. |
<table>
<thead>
<tr>
<th>Benzodiazepines</th>
<th>Warn against moderate to large amounts of alcohol.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Small amount of alcohol especially if taken with food probably causes little additive CNS depression unless alertness is required (e.g., driving).</td>
</tr>
<tr>
<td></td>
<td>- Keep in mind that some benzodiazepines (e.g., flurazepam, clonazepam, etc) used at night for sedation are still present in appreciable amounts the next morning and the interaction continues.</td>
</tr>
<tr>
<td></td>
<td>- Monitor for excessive CNS depression if the combination is used.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Warfarin</th>
<th>Monitor INRs if patient has more than 3 alcoholic drinks a day or if there is a significant change in the amount of alcohol intake.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Warn patients of increased risk of falls when under the influence of alcohol, which may result in bleeding injuries.</td>
</tr>
</tbody>
</table>

**Conclusion:**

In conclusion, medications and alcohol are important. They both can help alter your body for the better but, together can become deadly if you are not knowledgeable of their interactions. Hopefully, this paper better explained how to avoid these costly interactions.
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Stem Cells

A Medical Breakthrough in Fighting Debilitating Diseases and Reversing Aging

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Organic Chemistry 236
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April 20, 2012
ABSTRACT

Recent advancements in stem cell research offered hope to patients who can benefit from transplants and provide cell replacement therapy to treat life threatening diseases such as diabetes, Parkinson's disease, Alzheimer's, heart failure, cancer and many more. Cells have the ability to regenerate and replace any cell in the body to fight off diseases. Scientists have also discovered a breakthrough in anti-aging therapies. Some scientists show evidence that through technology, aged cells can return back to its young, healthy, cell. Stem cell research is a medical breakthrough that will benefit the future generation to live a prolonged life.

INTRODUCTION

According to The National Institutes of Health, stem cells are cells that have the potential to develop into some or many different cell types in the body. Stem cells can divide, without limit, to replenish other cells for as long as the person or animal is still alive. After the stem cell divides, the cells can either remain a stem cell or become another type of cell with a more specialized function, such as a muscle cell, a red blood cell, or a brain cell (1).

Stem cells can come from different sources. Pluripotent stem cells, adult cells that have been genetically reprogrammed to an embryonic stem cell-like state, can be isolated from the human embryos after a few days old. They can be made in the laboratory. The National Institutes of Health also states that stem cells can be derived from a fetal tissue. However, in 2007, induced pluripotent stem cells (iPSCs) were introduced Scientists identified ways that some adult stem cells may be reprogrammed genetically to assume a "stem cell-like state." iPSCs are adult cells that have been genetically reprogrammed to an embryonic stem cell-like trait to meet the properties of a certain cell (1).

In 2009, President George W. Bush passed the law allowing funding for stem cell research, an ethical controversy arise as to how to create a stem cell without harming living embryos (2). An ethical problem arose to produce a pluripotent stem cell without creating an embryo. An option considered was oocyte assisted reprogramming (OAR), an oocyte is the scientific term for "egg." In OAR, the somatic cells would be altered before being transferred into the nucleus to form a pluripotent rather than and a totipotent, which is an embryo. Margaret Haerey, editor and author of most Opposing Viewpoint articles and young adult books, states that those who supported the Stem Cell Research Enhancement Act were looking at the scientific approach how the embryonic stem cells can better the life of many humans. The aim was finding cures for diseases, such as Parkinson's, diabetes, cancer, Alzheimer's, heart disease, and spinal cord injuries that can be scientifically cured with stem cells. Most people are so caught up on the ethical controversy rather than how it will benefit those already living. Relieving human suffering is a strong incentive, and scientists agree that embryonic stem cells are the medical breakthrough that will fight against these life threatening diseases (3). Bill Frist, physician and former U.S. senator from Tennessee, believes, an embryo is a genetically distinct, human form of life. However, regardless of his faith, he believes stem cells are a fact of science (4). A non-controversial source of stem cells is non-embryonic adult stem cells that are in many organs and tissues. These somatic stem cells remain non-dividing in the tissue until they need more cells to fight diseases or repair tissue injury (1).
HISTORY

Peggy J. Parks, author of Stem Cells, states that stem cells are the most "emotion-charged," highly publicized, and political medical research of today. In 2001, former President Bush became the first president to allow funding for embryonic stem cell research. The only issue was that the funding could only be used for old embryo’s that had already been destroyed, not through the stem cells derived from the new embryos. Federal funding for embryonic research had many restrictions; most embryonic stem cells research was funded through private grants and donations. Parks states that the scientific breakthrough of stem cells was announced in November 2007 (5).

Scientist James A. Thompson of Wisconsin and Shinya Yamanaka of Kyoto University of Japan used human skin cells to grow stem cells. Thompson’s group added four genes from the amputate foreskin of a newborn boy. The cells were programmed to become induced pluripotent stem cells, also known as ISP. Yamanaka had the same results from the face of a thirty-six year-old woman. Eventually, other scientists made the same observations and had the same outcome. Therefore, ISP cells may be reprogrammed to match embryonic stem cells. Parks and scientists believe that it was necessary to move forward with this research (5). Although some experts believe that using human embryonic stem cells for research is unethical, stem cell research is vital because patients are able to donate cord blood for future needs. Stem cells can also transform into many cells of the body and can cure major diseases and injuries. Not to mention, they are used as an anti-aging therapy.

WHEN DOES LIFE BEGIN?

Naomi Bromberg Bar-Yam, author of the article "Two Rights Make a Dilemma: Ethical Questions in Stem Cell Research," addresses the ethical issue of "when does life begin?" Scientists and ethicists believe that stem cells are just lumps of microscopic cells that must be used for research to enhance human life. Traditional views believe that stem cells are an ethical issue, and anything derived from embryos or fetuses is wrong. However, some people say life begins when the mother can feel the baby moving in her womb. The National Bioethics Advisory Commission argues that the stage of the embryonic development determines the level of protection is issued. In other words, stem cells will not be derived if the fetus is more than ten weeks old. The issue will continue to arise even when laws are made (6). Most people view cloning somatic cells as cloning human beings (7). The International Society for Stem Cell Research is attempting to find ethical ways to use embryonic stem cells without creating controversy with Christian’s. They want to be able to treat a person without having to kill a person or embryo (8).

A CURE FOR LIFE THREATENING DISEASES

Adult stem cells are capable of changing into limited types of cells. Adult stem cells, also known as somatic stem cells, are undifferentiated cells found throughout the body after embryonic
development. Somatic cells multiply by cell division to replenish dying cells and regenerate damaged tissues. The human body is made up of trillions of cells of more than two hundred types that are produced by stem cells. Somatic cells have the ability to generate into any cell type depending on the tissue. Unlike embryonic stem cells, the use of adult stem cells in research and therapy is not considered to be controversial because they are derived from adult tissue rather than destroyed human embryos. Scientists are able to see how stem cells can prevent and treat diseases in the body by implanting them into particular diseases in the laboratory. Once the stem cell is cloned and implanted in the body, the cell can identify the major injury in the immune system and fix it. The stem cell also identifies other injuries and transforms into the cell type of any particular tissue. However, if the cells are not cloned, the body may recognize the cell to be foreign and reject it. Most scientists believe that cloning stem cells to match the patients’ cells is vital to obtain a successful recovery. Parks was able to conclude that scientists believe that stem cells are the new breakthrough and will improve the survival rate of all life-threatening diseases in the future (3). The National Institutes of Health states that researching stem cells help scientists and doctors see how stem cells transform. Some cancers and diseases can be explained by examining the stem cells as well (1).

**Figure 1: Magnified image of embryonic stem cells (7)**

Many scientists are trying to find new breakthroughs by using stem cells to treat major life-threatening diseases. Then they can transplant cells to help treat the diseases (1). Kristen Monroe, Ronald Miller, and Jerome Toibs, authors of *Fundamentals of the Stem Cell Debate: The Scientific, Religious, Ethical and Political Issues*, state different therapeutic uses of stem cells for major injuries and diseases. The authors explain how stem cells are therapeutic for not only spinal cord injuries but for other problems that occur throughout the nervous system. Stem cells that are implanted into the injured brain can migrate to the site of the injury. The cells pick up the cues from the injury and transforms into the appropriate cell type. The ability of the stem cells to migrate through the nervous system benefits other parts the body to be healed. For
instance, stem cells can distribute protein to strengthen injured tissues as well as strengthening the spinal cord. Although the stem cells’ main focus is to treat the spinal cord injury, stem cells also treats other injuries in the body (9).

Diseases, such as Parkinson’s disease and Alzheimer’s, have claimed the lives of almost 100,000 Americans in 2005. Parkinson’s disease is when the nerve cells in the brain deteriorate and die, and they also stop producing a vital chemical known as dopamine. Dopamine is needed for proper function of the nervous system and smooth, coordinated muscle movement. Alzheimer’s disease is characterized by an abnormal buildup of proteins in the brain known as plagues and tangles. Although scientist do not know what causes these major diseases, most scientist hope that continued research with stem cells will increase their knowledge about Alzheimer’s and Parkinson’s and eventually lead to a cure. Parks states that studies, performed with mice in 2001, led to researchers concluding that early implantation of stem cells in humans can possibly “forestall” or prevent degenerative brain diseases from forming (5). Between the year 1960 and 2003, most people who were diagnosed with cancer of the bone marrow, cancer of the immune system, and cancer of the blood had higher death rates. As shown in Figure 2, Leukemia and Lymphoma Society provided statistics that illustrate the improved survival rate due to treatments with bone marrow and stem cells derived from the umbilical cord (5).

![Figure 2: improved survival rate due to bone marrow treatments and derived stem cells (5)](image)

“In a clinical trial announced in 2007, fifteen patients with type 1 diabetes were treated with transfusions of stem cells from their own blood and were able to stop taking insulin injections because their bodies began producing the hormone naturally” (5). The greatest hope for scientists is that stem cells will someday enable them to grow human organs. With the continuous waiting list for an organ transplant, this is the most vital breakthrough. In 2006, a research team from Great Britain used stem cells from umbilical cord blood to grow a human liver. Once they gathered the blood cells and stimulated the cells to help multiply quickly, the team added hormones and chemicals to transform the cells into liver cells. The team created several tiny
livers, and they are certain that within several years they would have the ability to create a large liver to be used in clinical trials (5). Stem cell research is vital because this field has many unknowns, and it may take years for diverse diseases to be cured. The continuous research and new development for treatments has made this much closer to reality (5).

DONATE BLOOD FROM THE UMBILICAL CORD

The Leukemia and Lymphoma Society states that the National Marrow Donor Program has created a bank with more than seven million stem cell donors (5). Blood derived from umbilical cords can be donated from the comfort of the patient’s home. Bonnie Rochman, an author of “Women’s Health” in Time Magazine, states that doctors persuade their patients to donate their baby’s blood in case relatives will need their blood one day. Rochman introduces a way to be a donor by introducing the free-mail-in kit to doctors about how to donate the cord blood from the umbilical cord to the national registry. There are profit bankers where patients can store the blood from the umbilical cord to be donated to the public or the family. According to Time Magazine, ninety-nine percent of umbilical cords are disposed. Donating cord blood has been a non-controversial source of stem cells because numerous umbilical cords are disposed to the garbage rather than treating diseases. Rochman states, “Cord blood is already being used in therapy regimens for patients with cancer, sickle-cell anemia, marrow failure and genetic diseases that call for transplants (10).”

BIOTIME REJUVENATES AGING CELLS WITH IPS TECHNOLOGY

Just as embryos develop into adult humans with a variety of specialized cells, human embryonic stem cells can be developed into any healthy tissue and may be transplanted into people suffering from aging and age-related diseases. According to Life Extensions, human aging cells can be reprogramed to their embryonic state; these cells are classified as induced pluripotent stem cells or iP. However, some studies have shown that iP do not work as well as human embryonic stem cells in stimulating the production of telomerase. Telomerase is an “enzyme that maintains the healthy cells by keeping the length of their telomeres intact (11).” As shown in Figure 3, telomeres are found at the ends of chromosomes, once the cells divide, it loses some of its units the make up the telomeres causing the telomeres to shorten and eventually the cells die (7).
The clock of cellular aging resides at the very ends of the chromosomes, regions called "telomeres." Shown here in a blue color are stained human chromosomes, and the telomeric DNA is stained bright yellow.

**Figure 3: Magnified image of telomeres at the end of chromosomes (7)**

"In 2010, LEF contributed $2 million to BioTime's subsidiary ReCyte Therapeutics to help develop novel, innovative, regenerative therapies to treat the diseases of aging and, perhaps, aging itself (11)." West presented evidence of restoring the telomeres length and restoring the life span of aged human cells to the cells seen in young tissues. BioTime scientists have measured the life span of five aged human cells that have been returned to the embryonic state using transcriptional reprogramming. These life spans exceeded the life expectancy of the original aged cells; this provided "the first definitive evidence that such technologies provide a means of manufacturing young cells genetically identical to the cells of an aged patient," (11).

**Figure 4: Diagram of cell rejuvenation (12)**
STAY YOUNG FOREVER

Stem cells can be regenerated to pro-long human life as an anti-aging therapy. Gregory M. Fahy, who has a PhD in cryobiology, asked Dr. Michael West, who has a PhD in cellular aging and is also the chief executive officer of BioTime, a series of general questions about using embryonic stem cells as an anti-aging therapy. West’s discoveries on the reversal of developmental aging related to the field of regenerative medicine. West defines regenerative medicine as the collection of technologies that utilizes embryonic pluripotent stem cells and their derivatives to regenerate tissues in the body destroyed from diseases and degenerate cells from aging. Humans age because the immortal reproductive cells that are built within develop into differentiated cells and lose the capacity to divide (7). Therefore, the body cells have a finite life span causing the tissues to age or deteriorate from diseases. The body’s inadequate ability to generate new cells is linked to the body’s inability to repair itself as the body ages. The goal for anti-aging is to discover a way to transfer the immortality of reproductive cells into the body in order to increase the potential life span of individual human beings. Immortal cells can be found when a sperm and egg unite; “the resulting cells continue the germ line by forming a small cluster of immortal cells that go on to make new body and new immortal reproductive cells of a new human being, a cycle that continues forever.” West explains that there are tissues in the human body that have evolved a source of regenerative cells, also known as adult stem cells. These stem cells help repair the tissues when damaged. Unfortunately, some tissues only have regenerative cells for a certain amount of time before they fail. Stem cells derived from the embryo can help regenerate the body and form an anti-aging therapy. West said that certain tissues in the human body cannot regenerate themselves, thus allowing human to age. Stem cells cloned to each tissue then will prevent the body from aging. These stem cells would allow the body to manufacture all cell types in the human body to keep the heart, liver, and cornea always functioning (7). Scientists want to use stem cells because researchers who use the line will not have to go through rigorous procedure to get the stem cell back. Once established, a cell line can be grown in the laboratory and other researchers can use those (1).
**THE STEM CELL FACE LIFT**

Dr. Giampapa is the founder of the worldwide, patented Stem Cell Facelift. "The technique used by Dr. Giampapa consists of a triple layer grafting technique with different growth factor combinations in the deep tissues, as opposed to just below the skin surface." The "Stem Cell Face-Lift" is a nonsurgical procedure and is a complete facial rejuvenation procedure. It also reduces the need for repeated Botox because it has a long-term outcome. The procedure restores the shape of the face, as well as, blending color irregularities caused by the aging process and environmental sun exposure. As shown in Figure 6, the procedure consisted of transplanting adult stem cells and fat from the lower abdominal or medial thigh area, and stimulating them, as well as, "the local stem cells within three layers of the face with specific stem cell growth factors, is a revolutionary technique of facial rejuvenation." The transplanted fat cells are hormone-like substances that enhance skin quality and the tissues under the cheeks. It stimulates a signal to the cells within the skin and the transplanted fat from the abdominal to restore them. This procedure has natural results in completely removing the evidence of aging (14).
CONCLUSION

Despite the ethical dilemma on stem cell research, this is the most vital medical breakthrough of today. Stem cell research is crucial because patients are able to donate cord blood for future needs. Stem cells can also transform into many cells of the body to be able to rejuvenate various tissues throughout the body. Major diseases and injuries may potentially be cured through continuous research. Also, stem cells can be used as anti-aging therapies to pro-long human life. David Christensen, author of “Patients, Not Politics,” states that “Living, breathing people who have been treated by stem cells—some who would have otherwise died—are signs of the great hope of stem-cell research,” (5).

I believe with continuous research, stem cells will become the biggest breakthrough for future generations. It is amazing how close scientists have come to curing life threatening diseases. Knowing that the scientists have created several tiny organs gives me hope that in the future large organs can be created. Science is constantly growing and I believe that the government should continue funding Stem Cell Research. In addition, stem cells can be regenerated to pro-long human life as an anti-aging therapy. I am really curious to see how “young” people will look in the future. Anti-aging is a topic that is very intriguing to me and the fact that scientists
have been able to regenerate cells and make their life span longer than the aged cell is amazing to me. After all, I would love to stay young forever.
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Space Flight

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PHY 111 Section 11870

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Abstract: This project is concerned with the scientific principles behind rocket mechanics. It starts with the basics, defining and describing the science involved including relevant equations and then takes a look at the history of rocketry. This report ends with an in-depth description of the model rocket and launch system that was built to demonstrate the properties of a rocket.

The basic idea for a modern day rocket dates back to ancient China while the basic mathematical principles which allow us to reach the moon have been around since the seventeenth century (Braun & Ordway, 1966). However, the technology to make spaceflight a reality lagged far behind the initial ideas and subsequent mathematical understanding. Unfortunately, like so many pioneering thinkers before the first person to reason that it might be possible to leave this planet and travel into space was ridiculed for those ideas (Kluger, 1999). His name is Robert Goddard and according to Kluger (1999) he “... would ultimately be hailed as the father of modern rocketry.”

This report seeks to inform the reader on the basics of rocketry. The first section lays the groundwork defining and describing the subject starting with Newton's laws and working towards the mathematical equations used to describe rocket motion. This section ends with an overview of different mission types. The second section focuses on the history of rocket engines and gives a glimpse into the future of rocketry. The last section deals with amateur rocketry and details the compressed air and water fueled soda bottle rocket which was built as part of this project.

Any discussion of motion appropriately starts with Isaac Newton's laws of motion. According to Columbia University Press (2011), Newton first laid out his three laws of motion in the book Philosophiae Naturalis Principia Mathematica published in 1687. However, Galileo was the first to reason out the idea of inertia although it was Newton who formalized it (Serway & Vuille, 2012, p. 88). Newton's first law according to Serway and Vuille (2012) states: “An object moves with a velocity that is constant in magnitude and direction unless a non-zero net force acts on it” (p. 88). In other words objects at rest tend to stay at rest and objects in motion tend to stay in motion. This law is useful in solving problems related to rockets by introducing into an equation one of the most powerful ideas of mathematics; that idea being zero. Being able to state that a value is non-existent allows the creation of equations that equal zero and is why this law is useful in helping to describe the motion of rockets.

Newton's second law is used to describe the force, acceleration, and mass of an object in motion, “the acceleration [a] of an object is directly proportional to the net force [F] acting on it and inversely proportional to its mass [m],” or $F = m \cdot a$ (Serway & Vuille, 2012 p.89). This equation will come up again in the discussion of the forces acting on a rocket but in a more complicated form.

Newton's third law is known to many by the well-known saying: for every action there is an equal and opposite reaction. A more formal definition, “If object 1 and object 2 interact, the force $F_{12}$ exerted by object 1 on object 2 is equal in magnitude but opposite in direction to the force $F_{21}$ exerted by object 2 on object 1.” (Serway & Vuille, 2012 p. 95) This law explains why rockets work. The exact forces acting on a rocket are described next.
According to Benson (n.d.) in the article “Forces on a Rocket,” there are four forces that act on a rocket in flight: “weight, thrust, and the aerodynamic forces, lift and drag.” (This article and others by Benson is part of a larger work titled: Beginner’s Guide to Rockets, which will be referenced heavily throughout the rest of this section.)

The first force is weight and it is detailed by Benson (n.d.) in “Rocket Weight.” He describes it using the vector components of magnitude and direction:

The magnitude of this force depends on the mass of all of the parts of the rocket itself, plus the amount of fuel, plus any payload on board. The weight is distributed throughout the rocket, but we can often think of it as collected and acting through a single point called the center of gravity. In flight, the rocket rotates about the center of gravity, but the direction of the weight force always remains toward the center of the Earth.

According to Benson (n.d.) determining the center of gravity of an actual rocket is much more complex than finding the center of gravity of a model rocket. A model rocket is relatively small and lightweight and its center of gravity can be estimated by simply attempting to find the point where the rocket balances horizontally on an edge or when hanging from a string (Benson n.d.). It would be a bit impractical to try and find a full scale rocket’s center of gravity by hanging it from a string and calculations are needed instead. Any rocket's center of gravity can be found using a variation of this equation: 

\[ d_{cg} \cdot W = d_n \cdot w_n + d_b \cdot w_b + d_f \cdot w_f \]

The distance of the center of gravity from a reference line \((d_{cg})\) times the weight \((W)\) of the rocket equals the distances \((d_n, d_b, d_f)\) from the same reference line times the weights \((w_n, w_b, w_f)\) of the rocket's components see illustration 1 which includes two additional components (Benson, n.d.).

Illustration 1: Determining center of gravity using reference line

The second force Benson (n.d.) describes is thrust in “Rocket Thrust” as: “The direction of the thrust is normally along the longitudinal axis of the rocket through the rocket center of gravity. The magnitude of the thrust can be determined by the general thrust equation [derived later in this paper].” Another closely related topic to thrust is specific impulse. Benson (n.d.) defines specific impulse in the same article as: “The efficiency of the propulsion system . . . the ratio of the amount of thrust produced to the weight flow of the propellants.” Whereas thrust describes the amount of force generated by the engine(s).

The last two forces acting on a rocket when combined are known as the aerodynamic force. The first of these last two is known as drag. Benson (n.d.) states in “Rocket Aerodynamics” that drag, “ . . . is [a force that is] opposed to the direction of motion,” while the other force is, “ . . . lift . . . which acts perpendicular to the direction of motion. The lift and drag act through the center of pressure which is the average location of the aerodynamic forces on an object.” It is important to note that these last two forces act through the center of pressure. The
location of the center of pressure will determine whether or not a rocket will be stable in flight; according to Benson (n.d.) in “Rocket Stability,” the center of pressure must be located below the center of gravity for the aerodynamic force to keep a rocket moving in the desired direction.

Now that the four forces acting on a rocket have been defined it is possible to generate equations that describe those forces mathematically.

As mentioned earlier the magnitude of a rocket's thrust can be found using the general thrust equation. It is derived from Newton's second law: \( F = ma \). When dealing with conventional chemical rockets this equation does not take into account the loss of mass as the rocket's fuel is consumed (Benson, n.d.). Instead a modified version of this law defined in “General Thrust Equation” as, “. . . the change in momentum of an object with a change in time. Momentum is the object's mass (m) times the velocity (v). So, between two times (t1) and (t2), the force is given by: \( F = \frac{m \cdot (v_2 - v_1)}{(t_2 - t_1)} \). This equation works well for solids but cannot be used for forces dealing with moving fluids like the exhaust from a rocket's engine, according to Benson (n.d.) in “General Thrust Equation.”

For a moving fluid, the important parameter is the mass flow rate. Mass flow rate is the amount of mass moving through a given plane over some amount of time. Its dimensions are mass/time . . . and it is equal to the density [r] times the velocity [v] times the area [a]. Aerodynamicists denote this parameter as \( \dot{m} \) [\( \dot{m} = r \cdot v \cdot a \)]. Since the mass flow rate already contains the time dependence (mass/time) . . . we can express the change in momentum across the propulsion device as the change in the mass flow rate times the velocity. We will denote the exit of the device as station "e" and the free stream as station "o". Then \( F = \dot{m} \cdot v_e - \dot{m} \cdot v_o \) . . . Across the exit area we may encounter an additional force term equal to the exit area \( A_e \) times the exit pressure \( p_e \) minus the free stream pressure \( p_o \). The general thrust equation is then given by: \( F = \dot{m} \cdot v_e - \dot{m} \cdot v_o + p_e - p_o A_e \). Since a rocket carries its own oxygen on board, the free stream mass flow rate is zero and the second term of the general equation drops out. \( F = \dot{m} \cdot v_e + p_e - p_o A_e \).

Using the general thrust equation specific impulse can be derived and the procedure is described by Benson (n.d.) in “Specific Impulse.”

We define a new velocity called the equivalent velocity \( [v_{eq}] \) to be the velocity on the right hand side of the . . . equation: \( v_{eq} = v_e + \frac{p_e - p_o A_e}{\dot{m}} \). Then the rocket thrust equation becomes: \( F = \dot{m} \cdot v_{eq} \). The total impulse (I) of a rocket is defined as the average thrust times the total time of firing. \( [I = F \cdot \Delta t] \) . . . Since the thrust may change with time, we can also define an integral equation for the total impulse. Using the symbol (Sdt) for the integral, we have: \( [I = S F \cdot dt] \). Substituting the equation for thrust given above: \( I = S (\dot{m} \cdot v_{eq}) dt \). Assuming the equivalent velocity remains constant with time, we can integrate the equation to get: \( I = \dot{m} \cdot v_{eq} \) where \( \dot{m} \) is the total mass of the propellant. We can divide this equation by the weight of the propellants to define the specific impulse. The specific impulse \( [I_{sp}] \) is given by: \( I_{sp} = \frac{v_{eq}}{g_o} \) where \( g_o \) is the gravitational acceleration.
constant.

In order to develop equations for lift and drag the lift coefficient and the drag coefficient must first be determined which requires the use of a wind tunnel in addition to the equations. The following information from Benson (n.d.) in “The Lift Coefficient” deals with the lift coefficient, however, the same applies to the drag coefficient. He says:

The lift coefficient is a number that engineers use to model all of the complex dependencies of shape, inclination, and some flow conditions on lift. This equation is simply a rearrangement of the lift equation where we solve for the lift coefficient in terms of the other variables. The lift coefficient \( C_l \) is equal to the lift \( L \) divided by the quantity: density \( \rho \) times half the velocity \( v \) squared times the wing area \( A_w \).

\[
C_l = \frac{L}{(r \cdot \frac{v^2}{2} \cdot A_w)}
\]

Benson elaborates on the use of the wind tunnel:

Engineers usually determine the value of the lift coefficient by using models in a wind tunnel. Within the tunnel we can set the velocity, density, and area of the model and measure the lift produced. Through division, we arrive at a value for the lift coefficient. We can then predict the lift that will be produced under a different set of velocity, density (altitude), and area conditions using the lift equation. (The lift coefficient, n.d.)

The drag coefficient \( C_d \) and drag force \( D \) replace the lift coefficient and lift force respectively. Benson (n.d.) tells us in “The Lift Coefficient” and “The Drag Coefficient,” the equations for lift and drag are then found by isolating the force variable in the coefficient equation and are shown here: \( L = C_l \frac{A \cdot \rho \cdot v^2}{2} \) \( D = C_d \frac{A \cdot \rho \cdot v^2}{2} \) where \( \rho \) = density.

In order to determine where these forces act on the rocket the center of pressure must be located. The equation to find the center of pressure cannot be derived without the use of calculus which is outside the scope of this project and is given by Benson (n.d.) in “Center of Pressure - cp” as:

In general, determining the center of pressure (cp) is a very complicated procedure because the pressure changes around the object. Determining the center of pressure requires the use of calculus and a knowledge of the pressure distribution around the body. We can characterize the pressure variation around the surface as a function \( p(x) \) which indicates that the pressure depends on the distance \( x \) from a reference line usually taken as the leading edge of the object. If we can determine the form of the function, there are methods to perform a calculus integration of the equation. We will use the symbols "\( S[ ] \)dx" . . . denote the integration of a continuous function. Then the center of pressure can be determined from: \( cp = (S[ x \cdot p(x)]dx) / (S[p(x)]dx) \) (Center of pressure - cp, n.d.).

In order to develop the ideas presented later a short discussion of mission types is in order. There are basically four types of space missions possible and the rockets used to propel a space vehicle may or may not vary based on these basic mission types. The four types can be
broken down into two sets of two, they will either be manned or unmanned and interplanetary or interstellar. Manned missions according to Angelo (1999) in the *Dictionary of Space Technology* are: "An aerospace vehicle or system that is occupied by one or more persons, male or female. The terms "crewed," "human," or "personed" are preferred today in the aerospace literature." An unmanned mission would then be one in which humans are not present inside the vehicle or system. Angelo (1999) also defines interplanetary mission as occurring, "between the planets; within the solar system," while interstellar missions occur: "between or among the stars." At this stage in our technological development manned missions have only reached as far as the moon. Unmanned missions however have not only surpassed the moon but some vehicles continue their interstellar journey away from Earth toward an unknown future.

Interstellar manned missions on the other hand are impossible for many reasons, time of flight being one of the most critical. The technology necessary to move fast enough to get to the closest star within a human life-span has not yet been invented. There are various solutions to this problem that have been proposed. Two of them according to Battersby (2011) in "Beam Riders" are: "... nuclear-powered rockets ... [or] a great space elevator ascending on a cable of carbon nanotubes." (2011) The future of rocketry including a closer look at theoretical and evolving engine ideas concludes the next section which starts with a brief look at rocketry's history.

According to Braun and Ordway (1966) in their book *History of Rocketry and Space Travel* the exact history of rockets is unclear but probably dates back to the ancient Chinese and their black powder. (It is important to note that while the *History of Rocketry and Space Travel* was written in the early 1960’s and the information may or may not be outdated, Braun and Ordway go into great detail on the subject. Their information is sufficient for the scope of this paper.) What is clear from a historical perspective is that the action-reaction principle behind Newton’s third law was well known to the ancient Greeks. One of the earliest known demonstrations of Newton’s third law is Archytas’ pigeon dating to approximately 360 B.C. (Braun & Ordway, 1966, p. 22). It consisted of a small mechanical pigeon connected to a string that was propelled forward by steam coming from small exhaust ports. Another device that shows that the ancient Greeks were familiar with the principles of motion is the aeolopile which was invented some two or three hundred years after Archytas created his pigeon, see illustration 2 which shows both Archytas' pigeon and the aeolopile (Braun & Ordway, 1966, p. 80).

A thousand years or so after those first devices the most likely inventors of the rocket are the Chinese. According to Sietzen they, “... developed rudimentary forms of rockets, adapted from solid gunpowder...” (Sietzen, 2002, p. 190). He goes on to say that from the time of the ancient Chinese until the late 1800’s the aim of most rocket developers was to create weapons (Sietzen, 2002, p. 190).

The end of the 19th century ushered in the development of the field rockets as possible vehicles to the stars as opposed to instruments of destruction. One man in particular Russian
born Konstantin Tsiolkovsky can be credited with much of this theoretical development. Sietzen relates: “Over the next eight decades, [since his birth] his writings and teachings would form the basis of modern spaceflight goals and systems, including multistage rockets, winged shuttlcraft, space stations, and interplanetary missions.” (2002)

It wasn’t until the early 20th century however that modern rocketry really began to take-off. In America a man named Robert Goddard reasoned that rockets would only reach beyond our atmosphere if they had a different form of fuel (Sietzen, 2002). Kluger (1999) tells Goddard’s story in an article titled “Robert Goddard.” He relates that Goddard understood that Newton’s third law allowed for rocket travel outside of Earth’s atmosphere. When Goddard presented this idea to the world he was treated like a fool and a madman in the press. The New York Times seized upon one of his reports and printed an editorial basically saying he lacked the common knowledge of a high school student. Another newspaper, discussing one of Goddard’s vacuum test firings mocked that he missed his target (the moon) by exactly 238,799½ miles. What this article missed is that this test was proof that a rocket would indeed work in the vacuum of space and could theoretically reach the moon. It also proved that Goddard’s understanding of physics was beyond his time; he is now known as the father of modern U.S. rocketry (Kluger, 1999).

Around the same time that Goddard was working on his ideas, a group of European rocket enthusiasts formed the Society for Space Travel its purpose being: “to better promote rocket development and space exploration themes.” (Sietzen, 2002.). This group included, among others, Herman Oberth and Werner Von Braun. Sietzen (2002) relates that Oberth’s contribution to the modern age of rocketry included: “writings and space advocacy . . . includ[ing] engineering and mathematical models for interplanetary rocket flights . . .” and goes on to tell us that Werner von Braun designed the Saturn V booster. The rockets designed by these men have been propelling humans and our machines into space for over 50 years, and they came up with most of the ideas that are still at the forefront of propulsion technology.

The simplest rocket designs are chemical rockets which use fuel defined by Angelo (1999) as: “a fuel that depends on an oxidizer for combustion or the development of thrust, such as liquid or solid rocket fuel or internal combustion engine fuel; as distinguished from nuclear fuel (i.e., uranium235).” These rockets according to Choueiri (2009),

... do launch all spacecraft from Earth’s surface and can make midcourse corrections. But they are impractical for powering deep-space explorations because they would require huge quantities of fuel—too much to be lifted into orbit practically and affordably. Placing a pound (0.45 kilogram) of anything into Earth orbit costs as much as $10,000.

Jenkins (2008), in his book *Space Shuttle: The History of the National Space Transportation System* explains that the Space Shuttle uses chemical rockets. Its main engines use liquid hydrogen and liquid oxygen as fuel. (2008, p. 412) Its solid rocket boosters as the name suggests uses solid fuel 85 percent of which is aluminum powder and ammonium perchlorate. (2008, p. 426) Because of the limitations and costs mentioned by Choueiri this
vehicle will never get us much farther than a close Earth orbit.

The drawbacks of chemical rockets have long been known to rocket scientists and they have been searching for alternatives since the beginning. The idea of an electric propulsion system was originally proposed almost 80 years ago. According to Reisz and Rodgers (2003), "in 1947 Braun asked Ernst Stuhlinger to research the concept of electric propulsion as written in Herman Oberth's book, Possibilities of Space Flight, published in 1929..." Choueiri (2009) informs that, "Stuhlinger [was] a member of Wernher von Braun's legendary team of German rocket scientists that spearheaded the U.S. Space program..." A few years later the first electric rocket was successfully built and tested by engineers at NASA (Choueiri, 2009). Currently, electric rockets or plasma propulsion systems fall into three categories: ion drives, Hall thrusters and Magnetoplasmadynamic Thrusters (MPDT) (Choueiri, 2009) all three types are elaborated upon next.

The first type an ion engine is according to Angelo (1999): "An electrostatic rocket engine in which a propellant (e.g., cesium, mercury, argon, or xenon) is ionized and the propellant ions are accelerated by an imposed electric field to very high exhaust velocity." In 1998 Deep Space 1 was launched and its ion thrusters were still working 4 years later according to Reisz and Rodgers (2003). Choueiri (2009) relates that the ion drive, "... traces its roots to the ideas of... Robert H. Goddard, [which were] formed when he was still a graduate student... a century ago." As advanced as these engines are compared to chemical rockets they, "suffer from a major shortcoming, called space-charge limitation, that severely reduces their thrust density..." (Choueiri, 2009). The second type of plasma engine called a Hall thruster seeks to overcome this problem.

Choueiri (2009) explains that the Hall thruster, "relies on a fundamental effect discovered in 1879 by Edwin H. Hall... [who] showed that when electric and magnetic fields are set perpendicular to each other inside a conductor, an electric current (called the Hall current) flows in a direction that is perpendicular to both fields." Over two hundred of these thrusters have been used on satellites, but these engines suffer from mechanical break-down due to erosion from the plasma. The third class of thrusters, the MPDT also has issues with erosion but are capable of producing much larger thrust than Hall thrusters (Choueiri, 2009).

Choueiri (2009) elaborates, "A single MPD engine about the size of an average household pail can process about a million watts of electric power from a solar or nuclear source into thrust... which is substantially larger than the maximum power limits of ion or Hall thrusters of the same size." A new design minimizing the problems MPDT's are known to have has recently been completed that could, "... potentially drive a nuclear-powered vessel hauling heavy cargo and people to the moon and Mars..." (Choueiri, 2009).

Another type of magnetoplasma rocket currently being developed for space flight is the Variable Specific Impulse Magnetoplasma Rocket (VASIMR.) According to the National Aeronautics and Space Administration (NASA) in an article titled "Propulsion Systems of the Future":

...not only would VASIMR allow for faster space travel, it would have some pretty incredible side benefits, as well. For example, NASA researchers believe that VASIMR would be able to travel to Mars much more quickly than a contemporary chemical-
powered rocket, and then, once there, to refuel on Mars for the return flight to Earth. The VASIMR engine could also even help protect astronauts from the dangerous effects of radiation during their trip. In the less-distant future, VASIMR could even help keep the International Space Station (ISS) in orbit without requiring extra fuel to be brought up from Earth. (2003)

VASIMR is not the only new technology currently being researched. An old idea from Konstantin Tsiolkovsky has seen renewed interest. (Battersby, 2011). Sometime in the 1920's Tsiolkovsky proposed “a rocket with energy supplied by some external source [that] would be free to soar, unburdened by heavy fuel” (Battersby, 2011). Battersby (2011) goes on to say: “in 1972, American engineer Arthur Kantrowitz developed the idea much further, suggesting that a powerful laser beam sent from the ground could be used to zap a solid propellant on board the rocket, turning it into superheated plasma and providing a high-velocity exhaust.” In the 1980's and the 1990's two men separately came up with the idea of using microwaves instead of laser beams as a power source. According to Battersby (2001) both lasers and microwaves could drastically reduce the cost per kilogram of payload from tens of thousands of dollars to several hundred. These technologies are exciting futuristic ideas that could make space a popular tourist destination in the not too distant future.

There are many working on alternatives to chemical rockets but there are some at the Air Force who, instead of re-inventing the wheel are looking to improve upon chemical rocket's efficiency. One new idea is the Dual-Expander Aerospike Nozzle (DEAN). According to Hatsfield, Branam, Hall and Simmons (2011), “the DEAN engine, designed for high performance, saves engine weight and fuel, lends itself to manufacturing that uses today's technology, features robustness and tolerance of extensive ground testing and incorporates features that eliminate some catastrophic failure modes for upper-stage engines.” There are plenty of other ideas concerning ways to reach the stars but the few presented here show the most potential. The next part of this report is not concerned with reaching the stars, but rather reaching the clouds?

It is clear from the preceding information that all rockets are acted upon by the same four forces and are therefore similar. The similarities occur no matter the power: source or size of the rocket. The simplest rocket can be built using a film container filled with water and an Alka-seltzer tablet. The Alka-seltzer reacts with the water releasing gas. The film tube lid keeps the gas from escaping and eventually when the pressure is high enough the lid blows off releasing the gas and water which acts as a propellant and sends the film tube moving in the opposite direction. The film canister can be modified by adding a paper cone to the bottom and fins on the sides to improve aerodynamics. It could also be made longer by adding a paper tube to the bottom of the canister with a cone attached to it. This type of rocket is the stuff of school science fairs but amateur rocket pilots looking for something more exciting turn to chemically fueled rockets.

Commercially made paper model rockets and many homemade paper rockets use chemical propellants. The difference between a professionally designed paper rocket and a homemade paper rocket is not necessarily the materials used but rather their construction. The degree of difficulty between a beginners rocket and an advanced design, are a function of both
the complexity of the rocket and the size of the engine it uses. The complexity of the rocket design is based not only on the number parts used to build the rocket, but also possible second and third stages, as well as things like parachutes or electronics, like a mini-camera. This graduation from beginner to advanced also follows for amateur designs.

The commercially available model rockets that were investigated for this report primarily use solid fuel and vary in size. The information that came inside the package of Estes brand model rocket engines shows that they make engines which range from 0.625 to 40.0 Newton-seconds of total impulse and weigh between 0.83 to 40.0 grams. For amateur rocket enthusiasts these engines provide stability for transport and storage as well as ease of use. One obvious drawback is the fact that these engines produce thrust through combustion creating a fire hazard. However, they are the best engines for propelling a model rocket at high velocities and are therefore very exciting. This paper will now describe the construction of an ignition-less rocket created specifically for this project.

In order to minimize the danger present when dealing with fire and flammable compounds the decision was made to build a rocket that uses compressed air with or without water as fuel. Gary Jacobs created a website (www.waterrocketmanual.com) to sell his e-book dedicated to building water rockets and his instructions were used to complete the rocket. All of the ideas that follow come from Jacobs' e-book How to Build a Water Rocket and Launcher which is available at his website. A more detailed description will follow but for now a water rocket uses a plastic soda bottle under pressure. The bottle is released and the air/water mixture inside the bottle is allowed to escape through the opening propelling the bottle in the opposite direction.

The instructions received from Jacobs' website detailed a launch system composed of half-inch PVC pipe with an Ian Clark cable tie release system, and a polypropylene air supply line with an in-line pressure valve. The entire system is mounted to piece of wood which can be weighted down for stability. The cable tie release system is named after its inventor Ian Clark see illustration 3, the rest of the design is Jacobs'. His plans include instructions to modify two 20 oz. Coke bottles into a rocket as well as instructions to build the launch system. The launch system works with any bottle with the same diameter opening as the Coke bottle, like two liter bottles, or 24 oz. soda bottles. One may purchase the rest of the book with gives access to templates and advanced instruction on bottle modification and extras like parachutes as well as launch system modifications. The launch system instructions were modified slightly for this project to reduce materials cost and some guesses had to be made as the templates for cutting apart one of the soda bottles are not available in the free e-book.

The launch system is composed of half-inch PVC pipe assembled in a T shape with a launch tube extending perpendicular to the center of the vertical line in the T, see illustration 4. The original instructions called for an H configuration. The T lays flat and becomes the base
which is fastened to an approximately 2' by 1' board. The entire system is air tight except for the air inlet and the launch tube which seals to the bottle rocket with an o-ring. The air inlet is connected to a 30' long tube fitted with a pressure gauge and standard car tire valve at the far end.

The rocket is composed of two Coke bottles, a small section of a pool noodle as a cushioned nose cone and paper fins can be added to improve aerodynamics. Soda bottles are a perfect choice for use under pressure as they are designed to hold carbonated liquids, it is not recommended to try this with plain water bottles unless they are made of thick plastic and then only at low pressures. The first soda bottle is left intact and if it is punctured during construction it will no longer work as the main body. The second bottle is cut up and used to create a circular fin for the back of the rocket and the top of the rocket which the nose cone is attached to see illustrations 5 and 6. The top of the rocket is also made water tight so it can be filled adding weight to the front end of the vehicle and thereby raising the center of gravity. The weight at the front also causes the rocket to fall back to the ground nose cone first and reduces the chances that it will be damaged on impact.

Unfortunately there is not enough data to show the rocket equations with values that apply to the model that was built for this project. Fortunately, Jacobs includes a table of values which is based on simulation software in the e-book (see table 1, below.) The water rocket and launcher have performed marvelously on two separate occasions. The second test flight of the modified coke bottle rocket however ended with the circular fin coming apart from the main body of the rocket. Fortunately it only came unglued and can be easily repaired.

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Dry Weight</th>
<th>Propellant</th>
<th>Max. height</th>
<th>Max. speed</th>
<th>Max. acceleration</th>
<th>Total flight time</th>
</tr>
</thead>
<tbody>
<tr>
<td>p.s.i.</td>
<td>kg</td>
<td>m³</td>
<td>m</td>
<td>m/s</td>
<td>m/s²</td>
<td>sec.</td>
</tr>
<tr>
<td>60</td>
<td>0.063</td>
<td>1.90 x 10^-4</td>
<td>61.9</td>
<td>51.4</td>
<td>2381.4</td>
<td>7.2</td>
</tr>
<tr>
<td>80</td>
<td>0.072</td>
<td>1.81 x 10^-4</td>
<td>74.9</td>
<td>58.5</td>
<td>2930.2</td>
<td>7.9</td>
</tr>
<tr>
<td>100</td>
<td>0.079</td>
<td>1.84 x 10^-4</td>
<td>86.5</td>
<td>64.4</td>
<td>3136.0</td>
<td>8.5</td>
</tr>
<tr>
<td>120</td>
<td>0.087</td>
<td>1.79 x 10^-4</td>
<td>97.5</td>
<td>69.3</td>
<td>3714.2</td>
<td>9.0</td>
</tr>
</tbody>
</table>

*Table 1: Water Rocket Flight Spans.*
I can only imagine what Robert Goddard must have felt almost one hundred years ago when he sent his first rocket screaming toward the sky. The model I built did not go nearly as high as his first rockets did but nonetheless the feeling was incredible. My angst and anticipation during the weeks leading up to the test launch all became worth it when the rocket leaped from the launcher propelled only with water, air and human ingenuity.
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Cancer Treatments
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PHY 111 College Physics I
Course: 11738
T/TR 10:30-11:30
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Cancer Treatments

Globally, number of cancer deaths is projected to increase 45% from 2007 to 2030. Cancer (WHO are the...1). Cancer is one of the most urgent and menacing threat people all around the world face every day and have been for nearly all of human history. It is a frightening subject where most would rather look the other way, and with approximately 13% of all deaths in the world being caused by cancer alone, it is easy to see why (WHO, 1). However, the only way to beat cancer is to first understand it and where it comes from. Then, the focus can be shifted to realizing the different options available for treating cancer such as surgery, radiation therapy, chemotherapy, and many alternative treatments. Understanding the different options that exist to treat cancer is vital to solving the problem, and to do this, one must first understand cancer.

Cancer is commonly defined as the uncontrolled growth and spread of cells. However, these are not just any cells, cancer cells are normal cells that are damaged or mutated in such a way where they do not aid in any function of the body. When cells mutate, their DNA, which controls their behavior, is altered and can no longer function properly. These mutated cells will replicate themselves and clump together to form tumors. There are two main types of tumors: malignant, which are cancerous; and benign, which are not. Malignant tumors will grow and invade surrounding tissue, including vital organs, creating a serious problem (What is...American Cancer Institute,1). These will travel to different areas in the body, or metastasize through blood and lymph systems spreading the problem across the body and causing further harm to the individual. But benign tumors are unique in that they do not reproduce or spread to different parts of the body. These can be removed without risk of them returning.
Just as there are different types of tumors, there are different types of cancers. There are over 200 various types of cancer found throughout the body; however, these types can be put under five main categories: Carcinoma, Sarcoma, Leukemia, Lymphoma and myeloma, and central nervous system cancers (What is..National Cancer Institute,1). Carcinoma is a cancer found in the skin or tissues that line and cover internal organs. Sarcoma begins in bone, cartilage, fat, muscle, blood vessels, or other connective or supportive tissues. Leukemia is found in the blood from blood-forming tissues such as bone marrow. Lymphoma and myeloma start in the cells of the immune system, and central nervous system cancers are found in brain and spinal cord tissues. These types of cancers are unique and need to be treated differently, which is why so many forms of cancer treatment are available today.

Surgery is a major form of cancer treatment One of the most basic and oldest forms of cancer removal, this operation involves a surgeon who cuts into the body. This form of treatment is known as invasive because it requires entering into the body or body cavity and interrupting the body's normal processes. Advances in technology and surgery techniques have allowed surgeons to perform less invasive procedures where minimal cutting and damage to vital organs and tissues takes place and over the years several kinds of surgery have been developed. Each has a specific purpose in helping treat cancer from diagnosing what stage the cancer is to reconstructive surgery.

There is a number of surgery types used to treat cancer such as preventative, diagnostic, staging, curative, supportive, and restorative. The type of surgery used is unique to each patient's situation. For instance, preventative surgery is used if there is a high risk of future cancer. It is when a part of the body that poses a serious risk to grow cancer is removed such as pre-cancerous polyps which are removed from the colon (Surgery, 1). Diagnostic surgery is when a
biopsy is performed; a sample of tissue is taken and examined under a microscope to diagnose the type of cancer. This can be done with a needle, or with an incision in the skin. Staging surgery is done to find out how much and how far the cancer has spread. There is often a physical test, lab, and imaging tests all done to find the clinical stage of the cancer. Curative surgery is done when the cancer is confined to one spot in the body and can be completely removed and involves cutting into the skin and removing the cancerous tumor. Supportive surgery is surgery done in combination of other forms of treatment such as chemotherapy or radiation. Restorative surgery’s goal is to improve the way a person looks after surgery or to restore the function of a body part such as breast reconstruction after mastectomy. Each surgery is important and should be used with careful consideration to the patient’s needs.

While surgery has saved many lives, there is a measurable count of risk that comes with this kind of treatment. Every procedure or surgery poses a certain level of risk to the patients, but the benefits of surgery should outweigh the risks before any action is taken. Some concerns which are taken into consideration are: a patient’s overall health before going into surgery, the surgeon’s skill level, or the type of surgery being performed. For instance, small surgeries such as a biopsy do not require much risk at all. With small procedures such as the biopsy, the most common problems are pain at the point of incision, infection, or reactions to the drugs used to numb the site. However, larger procedures pose greater risk: the more complex the surgery, the greater the chance of complications. Some obstacles during surgery can include: excess bleeding during surgery, reactions to drugs used during surgery, damage to organs or blood vessels during surgery, and damage to other organs not near the site of surgery (What are..of surgery, 1). All these vicissitudes should be taken into consideration before the decision is made to perform surgery, but also the repercussions of surgery should be taken into account as well. Some
possible side-effects after surgery are: pain which can be eased with pain medicine, infections or sickness, internal or external bleeding: these complications occur if a vessel is not closed up or if a wound opens after surgery, blood clots if the patient doesn’t get up and move around after surgery, and constipation. These are all possible risks; however, every precaution is taken by doctors to prevent as many side-effects as possible.

Another form of treatment for cancer is radiation therapy which is unique in that it is non-invasive. This treatment which was first used in the late 1800s is the use of elementary or subatomic particles to destroy cancer cells. These particles are accelerated to high speeds so they pass through the body and destroy cancer cells on their way. There are three important types of radiation therapy including: photon, neutron, and proton. Each has unique properties that allow them to stop cancer from replicating.

Photon radiation is the oldest and the most inexpensive of these treatments. It is the use of electromagnetic radiation which is shot through the body (Smith, 2). These photons are the basic unit of radiation and can be used to knock out the electrons that orbit around the nucleus of cancer cells stopping the cancer cells from replicating. However because the electrons are knocked out of the cell, another electron can “drift” onto the cell; this allows the cell to grow once again causing the problem to return. Another negative is that, because of the nature of photons, they destroy healthy tissue along with cancerous tissue. This is especially dangerous when working with children, because radiation kills vital healthy cells responsible for development and cause serious deformities later in life. However, this form of cancer treatment is one of the most inexpensive forms of radiation treatment that exist. It is also non-invasive which means it does not require surgery to remove the cancer, thus removing all the risk that comes with having surgery.
Neutron therapy is the use of subatomic particles called neutrons which are also accelerated to extremely high speeds and shot through the body. These neutrons hit cancer cells, effectively destroying them by splitting their atoms apart ensuring they will never replicate again (Zyga, 1). Neutrons are stronger than photons and protons in their ability to destroy cancer; however, they cause more damage to healthy tissue as they pass through the body, whereas proton therapy destroys the cancer cells but does not pass through the body, leaving more healthy tissue intact.

Proton therapy is a newer treatment where the use of subatomic particles called protons which are accelerated to extremely high speeds and shot through the body. Protons are more effective than photons and require high energies to penetrate the body. However, once they hit a cancer cell they deposit all their energy at the site of the tumor, thus destroying and saving healthy tissue where other particles do not (Chui, 1). This is especially useful when treating patients with cancer that wrap around critical structures such as the eye or when treating children. It is the most expensive treatment among the radiation methods; however it is the best option when dealing with scenarios where saving healthy tissue is critical.

Another largely known type of cancer treatment is chemotherapy. This is a rather new form of cancer treatment beginning in the mid to late 1900s. It is the use of drugs and medicine to attack and destroy fast growing cancer cells found in the body. Chemotherapy was first used in the 1950s to help treat cancer, and now there are over 100 different types of drugs available (Questions., 1). These drugs are based on the type of cancer in the body and have been tested and proven to help destroy cancer cells.

Chemotherapy may be used for a number of reasons including: to help shrink a tumor before surgery or radiation, it may be used after surgery or radiation to destroy any remaining cancer
cells, to keep cancer from spreading to other parts of the body, to slow the cancer growth, and to

cure cancer but there are also certain possible side effects for those who choose chemotherapy

(Questions..1). One such side effect is that because chemotherapy kills all fast growing cells, not

just cancer cells, it can destroy healthy normal cells in the patient's body. This includes hair

follicles which are known to grow extremely fast making them vulnerable to attack from the

drugs that kill cancer. This is why chemo patients often suffer hair loss. Other side effects

include: nausea and vomiting, reduced blood count, mouth and skin changes, memory changes,

and emotional changes (What about..Effects 1). While not all people experience these side

effects when undergoing chemotherapy, they are something to be aware of.

While surgery, radiation, and chemotherapy are all major forms of cancer treatment, it is

also important to not forget alternative treatments. There is a broad range of treatments in this

category, but some examples include: hyperthermia, immunotherapy, and stem cell transplant

therapy. These new forms of treatment are still being developed but have shown great promise

for the future in the race against cancer.

Hyperthermia is the use of high temperatures to kill cancer cells. There are three types of

hyperthermia: local, whole body, and regional hyperthermia (Hyperthermia...1). Local

hyperthermia is when heat is used to destroy a small cluster of cancerous cells such as a tumor.

This can be done either internally, where a small needle is inserted into the tumor, or externally,

where high energy electromagnetic waves from outside the body are aimed at a tumor. This is

often best for patients who cannot undergo the risks of surgery. Whole-body hyperthermia

involves raising the patient's body temperature for short periods of time. This helps raise the

patient's immune system for the next few hours after the procedure and is often employed in

conjunction with chemotherapy or other treatments. Regional hyperthermia involves the heating
of a hollow space within the body and is oftentimes used alongside chemotherapy or radiation treatments. Hyperthermia is a promising technique to help aid in treating cancer; however, it is largely experimental at this time and, thus, not commonly used.

Also known as biological therapy or biotherapy, immunotherapy is the use of one's own immune system to treat cancer. The immune system is meant to destroy foreign bodies that are seen as a threat, but cancer patients' immune systems do not recognize the cancer cells as foreign due to the similarity of cancer cells to normal cells. However, steps can be taken to help one's immune system recognize the threat of cancer and destroy it. That is what this therapy does by strengthening the immune system to work more effectively or through giving the patient man-made immune system components such as proteins to fight cancer (Immunotherapy, 1).

Stem cell transplant therapy is the use of adult stem cells to treat cancer. These are not to be confused with embryonic stem cells which are harvested from embryos. Adult stem cells are those taken from the blood or bone marrow of an adult individual and transplanted to the patient in need of cancer treatment. Adult stem cell transplanting is not a new idea. The first successful transplant occurred in 1968, and over 50,000 new transplants occur each year (What are stem...1). Adult stem cell transplant therapy is when stem cells from a healthy part of the individual or from a matching donor are transferred into the patient. Because of the nature of stem cells, they are capable of producing healthy cells in areas where the patient needs them. Sometimes these cells, if given from a donor, can find and destroy cancer cells better than the patient's own immune system cells ever could. However, there is always the risk that the transplant will be rejected if received from a donor. Despite this, stem cell therapy has been proven to be highly successful in ridding one's body of cancer cells and will probably continue to grow as a major form of cancer treatment in the future.
There are several benefits to choosing some treatments over others. Radiation therapy is non-invasive and painless and unlike surgery; it takes less recovery time than surgery or chemotherapy, most insurance companies are willing to pay for radiation therapy for their members, and it can be used alone or along with other types of cancer treatment. However, there are some drawbacks to this treatment as well. It is very expensive and is not effective for certain kinds of cancer that are not localized to one area such as leukemia. Chemotherapy is also non-invasive, however there can be several side effects. Stem cell therapy has the capability of performing on the same level as chemotherapy; however there is the risk of re-infecting the patient with their own cancer or a rejection of the donor stem cells. Overall the benefits and costs must be weighed appropriately when developing new treatments and perfecting the old in order to win the race against cancer.
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The Physics of Baseball
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Phy112
Dr. Durandet
Abstract

The mystery of the curveball has been a question in many peoples minds for a long time. How the spin of the ball and the speed affect the lateral deflection (curve) of the baseball was investigated. It was found that the curve of the ball is proportional to the spin and the square of the speed. Also the seam orientation of the baseball was not a big factor in determining the curve.

Introduction

Millions of people every year around the world enjoy watching baseball. There are many aspects to the sport that people like, the hitting, catching and of course, the pitching. Pitching in baseball is something that people enjoy watching but not many people know about the physics behind a ball in motion. Around the 1940's, a man by the name of Madden stirred up one of baseball's biggest debates, whether a ball curves or not? He wrote these words: "Now I'll tell you something, boy. No man alive, nor no man that ever lived, has ever thrown a curve ball. It can't be done."

Thus sparked the interests of many physicists and scientists who began to conduct experiments to see whether it really does curve or not.

One early experiment was done by Verwiebe and which he conducted a simple experiment consisting of wooden frames which has cotton thread screens on them. He placed them in a path from the pitching mound to the home plate and had pitches throw balls. The balls would go through the screens and he than constructed the trajectories through the hole in the screens, it was simple yet effective and he found that the ball has curves in the horizontal direction that were significant. For many years, people still argued about it and experiments were being done but in the present now, the scientific community agrees that the flight of a ball in the air does curve. The main content of this paper will look into how much does the spin and the speed effect the curve of a ball?

It is important to get the general idea of pitching, baseballs, and pitching techniques. Pitching in baseball is not simply to just throw the ball as fast you can. It requires a lot of dexterity and knowledge of the way the ball acts when thrown a certain way. In order for pitchers to be successful against their opponents, they needed to confuse the batter with different pitches, and the curve ball is very effective at doing its job. Also what a baseball is made out of, and how its made contributes to the way it behaves in the air as well.

The anatomy of a baseball is made up of three parts which are the core, shell, and the
stitches. The core is just a solid cork in the middle which does not contribute to the way the baseball acts in the air. There are 2 pieces to the shell which are made of cowhide. They are very smooth and the two pieces are put together with stitches which are the seams. If not for the stitches, the baseball would be smooth all around and would not be able to curve at all. The stitches are what give the uneven edges in the baseball and this is what makes the ball curve. The aerodynamics of a baseball are important to know to get a better understanding of how the ball curves. For example, if a pitch was thrown in a vacuum than only gravity would act on the ball, and the path could be predicted quite easily. But in the real world the ball is affected by the air and how it moves across the stitches on the baseball. “The drag exerted on a baseball by the air varies according to the ball’s velocity and the orientation of the stitches” so by changing the way the pitcher grips the ball when he throws it, can affect the curve significantly.

Discussion

There are many different types of pitches in baseball, but we will be looking at the curve ball in this discussion. There are many factors to look at in order to determine how the ball behaves the way it does in motion. Factors such as the seam orientation, the axis of rotation, revolutions per second, magnus force, and finally the spin and speed. The magnus force is the force that causes the curve movement of the baseball and is known as the Magnus effect. “The commonly accepted explanation is that a spinning object creates a whirlpool of rotating fluid about itself. On the side where the motion of the whirlpool is in the same direction as that of the direction of flow to which the object is exposed, the velocity will be increased. On the opposite side, where the directions are opposed, the velocity will be decreased. Then, according to Bernoulli’s principle, the pressure is lower on the side where the velocity is greater, and consequently there is an unbalanced force at right angles to the fluid flow. This is the Magnus effect.”

When an object such as a baseball is moving through the air, the surface of the ball interacts with a layer of air which is called the boundary layer which than creates a low pressure region behind the ball which slows the ball’s movement, and this is known as air resistance. This air resistance is applicable to any object moving in the air, however when there is a spin on the ball, this causes the boundary layer to separate at different points on the ball which makes the air flowing around the ball deflected. Here is a figure which demonstrates the point described.
A photograph was taken demonstrating this effect as well by Professor Brown in a low turbulence wind tunnel. In the picture, the wind is moving from right to left at 60ft/sec with smoke filaments to see the direction better and the ball was put stationary in the tunnel but spinning at 1000rpm's counter clockwise. You can see the the smoke filaments are crowding on the top of the ball which means it has an increased velocity at the top with a decrease in pressure which would deflect the ball upwards according the the Bernoulli principle. The Bernoulli principle states that the pressure is lower on the side that the velocity is greater. The wake of the ball which is the low pressure region which is the bottom of the ball has been deflected downward. So if there is a deflection downward there must be a corresponding deflection upward on the ball as well according to the conservation of momentum.

Some of the early attempts to measure spin and speed on the ball were actually done with an Air gun and not in wind tunnels. The ball was mounted onto a spinning tee which gave the ball its spin and than placed in front of an air gun. The air gun would shoot the ball and the spinning ball would be projected forward. In theory, it was figured that the speed of the ball could be measured by how far it traveled and how much is dropped vertically, and the spin was measured beforehand. However once the experiments were done, the results were not consistent with what would have been expected. They found that when the air gun hit the spinning ball, the spin was greatly reduced due to the impact from the projectile out of the gun. It was found that this new found trajectory matched closely to that of a ball that was hit by something, and not
pitched, so a new technique was sought after, wind tunnels.

The spin and speed of the ball were measured to see how it affects the deflection (curve). First the ball was dropped down through the wind tunnel which had a horizontal wind velocity which was known. To find the lateral deflection, "it was taken as one half of the measured spread of the two points of impact, with the ball spinning first clockwise and then reversed." The ball was rotated using a spinner that was belt driven and used a small DC motor so that the angular speed (rpm) of the ball could be measured beforehand. The ball was measured at different rotations and wind speeds. Looking at Table 1 we can see the the values of the lateral deflection and in all trials, it was the same was what would be expected in the Magnus effect. Also in the 4th column it lists the ratio of the deflections for each speed shown, and in the 5th column it shows the ratio of the speeds squared. When comparing both the 4th and 5th column together, it is apparent to see that the ratio of deflection (curve) is proportional to the ratio of the speed squared which means that the deflection is proportional to the square of the speed.

<table>
<thead>
<tr>
<th>Spin rpm</th>
<th>Speed ft/sec</th>
<th>Deflection inches</th>
<th>Ratio of deflections</th>
<th>Ratio of (speeds)^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200</td>
<td>125</td>
<td>17.8</td>
<td>1.52</td>
<td>1.56</td>
</tr>
<tr>
<td>100</td>
<td>11.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1200</td>
<td>150</td>
<td>26.0</td>
<td>1.46</td>
<td>1.44</td>
</tr>
<tr>
<td>125</td>
<td>17.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1200</td>
<td>150</td>
<td>26.0</td>
<td>2.22</td>
<td>2.25</td>
</tr>
<tr>
<td>100</td>
<td>11.7</td>
<td></td>
<td>1.92</td>
<td>1.77</td>
</tr>
<tr>
<td>1200</td>
<td>100</td>
<td>11.7</td>
<td>1.92</td>
<td>1.77</td>
</tr>
<tr>
<td>75</td>
<td>6.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1200</td>
<td>125</td>
<td>17.8</td>
<td>2.91</td>
<td>2.79</td>
</tr>
<tr>
<td>75</td>
<td>6.1</td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>150</td>
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<td>4.25</td>
<td>4.0</td>
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<td>75</td>
<td>6.1</td>
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<td></td>
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<tr>
<td>1800</td>
<td>125</td>
<td>25.8</td>
<td>1.47</td>
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<tr>
<td>100</td>
<td>17.3</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1800</td>
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<td>25.8</td>
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<tr>
<td>75</td>
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<td></td>
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<tr>
<td>1800</td>
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<td>17.5</td>
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</tr>
<tr>
<td>75</td>
<td>94</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In figure 3, the deflection of the ball vs the spin was graphed to get a better understanding of how the spin of the ball relates to the deflection. When the ball released from the top of the wind tunnel, it took 0.6 seconds to travel to the bottom of the 6ft tunnel so the graph represents the time interval of 0.6 seconds. The figures from table 1 were graphed and it shows that for the different spins, they almost all pass through the origin. So from the graph, it can be derived that the lateral deflection or the curve is directly proportionate to the spin.
So for the conclusion of the tests, it shows that the lateral deflection or the curve of the ball is in fact directly proportional to the spin and the square of the speed.

There is one more variable to look at when determining the lateral force on a rotating baseball. There are many grips to hold when throwing a baseball, and the different grips affect how the ball spins through the air. If the orientation of the seams differs when thrown, when the air hits the seams would it create a different lateral force on the baseball? As shown in the results above, Briggs did conclude that the lateral force is proportional to the spin and square of the speed. However a physicist, Igor Sikorsky had the same conclusion beforehand yet his predictions were way off than what Briggs predicted the deflection would be. So this begs the question on whether the orientation of the seams of the baseball when thrown affects the lateral force or not. Robert G Watts decided to test this question in 1985, and figure 4 shows the different seam orientations that were tested. Through the experiment conducted and the calculated values, it was measured that the lateral force on a curveball did not depend heavily on the orientation of the seams.
Conclusion

Due to the scientific advancements in today's technology, it can be recorded and proved that balls in fact do really curve. Scientists can come up with experimental apparatuses to test many different sorts of questions and through pooling many data from different experiments, the question of the curveball is no longer a mystery. The question of how the spin of the ball and the speed affect the curve was answered. It was found that the deflection of the ball was proportional to the spin and the square of the speed. Also the seam orientation of the ball was found to not be a big factor in determining the lateral force.
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Parabens: The Damaging Preservative

Found in Everything, From Food to Cosmetics

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Organic Chemistry 236

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Abstract:

Preservatives are found in almost everything that is bought today, from milk and cheese to mascara and mouthwash. One of the most common preservatives is the chemical compound known as a paraben. In the past couple of years, it has been discovered that this preservative can in fact be damaging to your body and is sometimes even linked as being a cancer-causing reagent.

What are Parabens?

The term ‘paraben’ is a derivative of the word para-hydroxybenzoic acid. (1) Parabens are part of the alkyl ester family attached to a benzene ring. They are used as preservatives in cosmetics, pharmaceuticals, and even some foods. The five main forms that are most commonly seen in these products are methylparaben, ethylparaben, propylparaben, butylparaben, and benzylparaben. Out of all five forms, methylparaben and ethylparaben are most frequent form found in these everyday items. In fact, besides water, they are the most common ingredient used in most cosmetics. (1) Most people believe them to be hard to find when looking at a label of a product, but they are actually quite easy to see, being clearly labeled as “-paraben.” It is an ingredient that can typically be found either in the middle or towards the end of the mass list. This is possibly done to “fool” the eye so people skip right over it when looking at the ingredient list.

History:

In 1924, a scientist by the name of T. Sabalitschka discovered the antimicrobial and preserving properties of parabens. (1) It was not until the 1930s, however, that parabens were first used as preservatives in products. (1) From here on out, parabens have been used because of the benefits they have in preserving cosmetics, pharmaceuticals, and industrial goods. They extend the life of the product anywhere from two days to two years. (2) Because of the extension that parabens have had on the shelf life of products, it usage has become widespread.

The US Environmental Protection Agency gave the usage of parabens to the GRAS list in 1995. The GRAS, or Generally Regarded as Safe, list first began by the FDA in 1958. (3) Generally, once a substance is added to this list, the FDA no longer attempts to evaluate any scientific information on these substances. However, with the concern brought to the attention of the government, first by the researchers and then by the public, the safety assessment of parabens was reopened in 2005 by the Cosmetic Ingredient Review (CIR). (4) This was about a year after the discovery of parabens in breast cancerous tumors. This study was published by the Journal of Applied Toxicology in the year 2004. In this study, twenty breast tumors were assessed, with nineteen of them having mass amounts of parabens associated with the tumor. As a result of this, the government considered it necessary to reassess how parabens affect the human body. However, after initial studies, it was found that “there is no reason for consumers to be concerned about the use of cosmetics containing parabens.” (3)
Chemistry:

Though there are several parabens that exist, there are five main structures that can be found as preservatives in ingredients today. These parabens are called methylparaben, ethylparaben, propylparaben, butylparaben, and benzylparaben, which can be shown in their molecular structure below, along with the IUPAC (International Union of Pure and Applied Chemistry) name.

Figure 1: Molecular Structure of Parabens

As can be seen in Figure 1, parabens are esters of the para-hydroxybenzoic acid family. (1) Each compound is made up of a hydroxyl attached to a benzene with a second ester substituent attached at the para position of the ring. The length of the second substituent affects the solubility of the chemical in human bodies. (1) The longer the length of the attachment, the greater solubility it will have in oil. If the chain is shorter, it will be more soluble in water. (1) Longer chains, because of their increased solubility in oil, tend to be more penetrable through the epidermis layer of the skin. This lipid solubility then affects the amount of parabens that
manufactures place inside of products. For example, methylparaben is the smallest chained paraben and is also one of the most common one used in cosmetics. (3) Since it has better solubility in water, for higher oil-based cosmetics, more methylparaben is inserted into the product so that the preservation of that particular item is still maintained. (1) This then increases the amount of parabens that are put into the human body, either topically or digestively.

Parabens were once thought to be minimally, if in no way absorbed by the body, but was instead, metabolized in the body’s liver and kidney and then excreted through urination. (1) Further research has been done to prove otherwise. Though parabens do not exist in their original form in a human’s blood and milk, there have been increased amounts of the para-hydroxybenzoic acid, the main component of parabens, existing in the body fluids in all humans that were tested. (1) Also, parabens have been found in several different types of tissue, and even found in cancerous tumors in the breast. This could be because parabens are xenoestrogens, meaning they are a synthetically made chemical compound that mimics the hormone estrogen in the body. Excess estrogen is one of the main causes of several issues in humans, including “diminished muscle mass, extra fat storage, and male gynecomastia (breast growth).” (5)

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**Estrogen Receptors Trigger Gene Activation**

![Diagram of Estrogen Receptors](image)

Specifically, when parabens behave like estrogen, they fill in the receptor found on an enzyme, which then sends off chemical signals to the body through neurotransmitters and glands. This then causes adjustments in the body to be done, as if the paraben were an actual estrogen hormone. (5)

In Figure 2, the picture is displaying how estrogen behaves in the body and can potential trigger gene activation. Normally, every cell has estrogen receptors in the nucleus alongside the DNA. (6) When no estrogen molecule is present, the estrogen receptor remains inactive. However, as soon as an estrogen molecule is present (or a xenoestrogen, which behaves like an estrogen), the estrogen receptor sends a signal to the DNA to make sure certain proteins in the cell are active. The proteins that become active vary, depending on the type of cell it is in. For example, in liver cells, estrogen directly results in the release of cholesterol into the blood stream, both good and bad. In breast tissue, the presence of estrogen causes breast cells to proliferate, creating more mammary gland (milk gland) cells. Proliferation also occurs in the uterus in the presence of estrogen. Cell proliferation in the breast and uterus typically happens to prepare a female to carry a child. (3)
As can be see, having estrogen is definitely needed in certain situations. However, if a body has too much estrogen, it becomes confused and creates more estrogenic cells in certain areas. This also happens in the presence of xenoestrogens, which is why having too much can potentially be hazardous.

**Antimicrobial Ability and the Preservation Process:**

Widespread usage of parabens began in the 1930s as a way to preserve all sorts of products, including cosmetics and certain types of food. This helped products last from anywhere two days to two years longer. Because of this, the way products were manufactured changed permanently. Parabens are very good at preserving these products because they are an antimicrobial. They slow down, if not completely halt, the activity of yeasts, molds, and bacteria. (1) The antimicrobial ability changes along with the length of the alkyl chain. With the length of the chain increasing, the antimicrobial ability increases. (1) Though parabens are a good protectant against both fungi and bacteria, they are better at preventing fungal growth than bacterial growth. (1) Also, if an organism is Gram positive, it can fight against it even better. (1) Generally, to achieve a good antimicrobial ability in a wide range of products, a mixture of a few different types of parabens is used. This mixture is then combined with other sorts of preservatives, such as formaldehyde and phenoxyethanol, which helps in the preservation process for bacteria and fungi that are resistant to parabens. Overall, parabens work really well as preservatives, which is why they are used in thousands of products manufactured today.

**Negative Effects Caused by Parabens:**

In the past decade, the use of parabens has been linked to several health concerns. One thing that has recently been discovered is that there are people that are actually allergic to parabens. Though this is extremely rare, this presents a certain problem for these people to be able to use tons of cosmetics and consume certain types of foods that have parabens in them. The first case of this reaction occurred in the 1940s, when a woman discovered she was hypersensitive to the ethylparaben found in her antifungal cream. (1) Over the years, others have come forward, saying that they have had reactions to products applied topically. Many of these reactions occurred with facial cosmetics and even in some toys that contained gel-like substances. (1) The allergic reaction to parabens percentage rate increases in patients with leg ulcers, increasing from less than 0.5% in the average person to over 8% is patients with leg ulcers. (1) With products that are ingested, such as some foods and medications, reactions are even more rare but do occasionally happen. People that are hypersensitive paraben consumption have a tendency to have an eczematous eruption, which is a type of rash that is extremely itchy and dry, similar to the type of symptoms that occur with eczema. (1) Generally, people who are hypersensitive to parabens are more likely to be hypersensitive to topical application versus ingestion of products with parabens in them.

Parabens can also affect the endocrine system, which is a system of glands that secrete hormones into the body. The endocrine system includes several glandular parts, like the pituitary gland, the thyroid, the pancreas, and several more, all of which are responsible for the production, release, and balance of hormones in the body. Since parabens have the tendency to behave like estrogen, a hormone, it is considered an endocrine disruptor. (7) Not only do parabens affect estrogen
levels, however, they also affect testosterone and can lower the sperm count in males. (7) Overall, parabens definitely do affect the endocrine system, especially tissues that process estrogenic hormones.

One of the larger issues that has had more research done on it, is the affect that parabens have had on breast cancerous tumors. Several sources point to the research that was done in 2004 by Darbre on twenty women that had breast tumors. (4,8) Out of twenty women, all had some sort of paraben component to the tissue. Nineteen of the twenty actually had extremely high amounts of parabens, mainly methylparaben, which composed 62% of the total amount of parabens present in the tumor. (9) Since it can be seen that parabens do affect the mammary glands in a female, it can potentially affect her child too. Like with every mother who breast feeds, everything she eats tends to be transferred to her breast milk, which is then transmitted to the baby she is feeding. Baby immune systems are a lot less guarded than adults because they have yet had the opportunity to build up their microflora. So not only are young children getting parabens from lotions and soaps, they are also getting it from their mother’s milk. This means children are exposed to these parabens from birth and only build up the amount of parabens in their systems throughout their lives.

Naturally, not only do parabens affect humans, but because of the high use of them in almost all human manufactured products, they tend to get released into the environment after they are excreted through urine and feces. The Environmental Protection Agency (EPA) worries that, because of this, it will get released into the sewage systems, which in turn will affect fish in the local streams where sewage is dumped. (2) Already, fish have shown to contain traces of parabens in their tissue. (2)

On Figure 3, located below, the affect parabens have on certain health concerns and organ systems is shown, along with the how much research has been done to support the evidence that parabens affect these systems. As can be seen, the endocrine system is definitely affected by parabens and has strong research to prove that. With cancer and the immune system, parabens are shown to possibly affect these areas in the human body. (11)

**Figure 3: Table on Parabens and Their Effect on Certain Systems**

<table>
<thead>
<tr>
<th>Health Concern or Target Organ</th>
<th>Weight of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endocrine System</td>
<td>Strong</td>
</tr>
<tr>
<td>Cancer</td>
<td>Possible</td>
</tr>
<tr>
<td>Skin</td>
<td>Rare</td>
</tr>
<tr>
<td>Immune System</td>
<td>Possible</td>
</tr>
<tr>
<td>Sensory Organs</td>
<td>Limited</td>
</tr>
</tbody>
</table>

This table is a summarization from *Human Toxome Project- Environmental Working Group.*
How are parabens regulated in the US versus other countries?

A few countries have recognized the potential danger that parabens might have to humans. These countries are Australia, the United Kingdom, and the United States. In Australia, parabens are regulated by the government in some products, one of the most prominent being deodorant and other antiperspirants. These products are regulated by the National Industrial Chemicals Notification and Assessment Scheme (NICNAS), an agency within the Australian Government Department of Health and Ageing. Under the Trade Practices Act of 1974, product ingredients must be labeled in the order of the amounts that are in it. So this means that the highest occurring ingredient is listed first and the lowest occurring ingredient is listed last. The Australian government states that parabens are not to be used in deodorants and antiperspirants because these products are already basically self-preserving.

In the United Kingdom, where the original breast tumor study was done by Darbre in 2004, cosmetics are highly regulated. However, even with the study done, the UK government does not think there is enough research done to prove that parabens negatively affect the human body.

In the United States, the Food and Drug Agency regulates food items and medications but does not get involved in the regulation of cosmetics. The reason for this is the Federal Food, Drug, and Cosmetic Act, which makes it illegal for the government to get involved in anything cosmetic related, except for preventing coal-tar being used in hair dyes. Their main concern regarding cosmetics is the labeling and the contamination of products. The FDA regulates labeling to ensure that products are advertised correctly. The only time the FDA will get involved with cosmetics is if an item becomes spoiled or decomposes. This, in fact, makes manufacturers want to keep, if not increase, the amount of parabens contained within facial cosmetics because of their preserving properties.

Overall, not much regulation goes into maintaining levels of parabens in cosmetics, food, or industrial items. This is mainly impacted by the lack of research available on parabens, which has just started to be seriously looked into more so in the last decade or so. Since parabens are in everything, it is difficult to isolate them as being the cause of certain health concerns since everyone uses paraben-containing products. Though theories can be made that correlates cancer and other diseases to parabens, nothing has yet been proven completely by researchers.

What can be done to reduce impact that Parabens have?

One of the most necessary things that need to be done in order for parabens to be higher observed and regulated in products is for more research to occur. One of the research studies done was on how parabens affected breast tissue in human bodies, which was done by Darbre in 2004. However, there were a few things that were not looked into while he was doing this research. One of these things was that the research was only done with twenty women, a very small number to offer good results. Also, Darbre disregarded looking at healthy women that did not have cancerous tumors in their breasts to see if they had parabens in their breast tissue. Because of this, not much support has been offered to remove parabens from products. There is, however, a decent amount of research available that shows parabens definitely do affect the endocrine system in humans. Though parabens are still a large concern for a lot of holistic
Products with Parabens:

- Crest ProHealth mouthwash
- Dove body wash
- Almay Bright Eyes Mascara
- L’Oreal Feel Naturale Light Softening Powder
- Mayonnaise

Figure 4: Items Found in Personal Household

As far as what can be done personally, the best thing to do is for people to decide how concerned they are with the effects on them personally. Once this is done, if a person wishes to begin cutting out parabens from their personal products and foods, they can begin to recognize all the products that have parabens in them (examples in Figure 4). In Figure 5, there is a sample label of a product (ProHealth Mouthwash) that has parabens in it, with the paraben ingredients being circled. It is very easy to see what ingredients are parabens because they are clearly listed as “-paraben.”

Figure 5: Actual ProHealth Mouthwash Label with paraben ingredients circled.

Conclusion:

Though it is not clearly known what all parabens do in the human system, it can be hypothesized that parabens do have some effect on human bodies. To further discern what specifically parabens do, more research needs to be done. However, it can be seen, that parabens have been potentially affecting our systems since they were first used back in the 1930s. Many diseases and other health concerns have drastically increased in the past half century, which could be linked to the use of parabens as preservatives. The only thing that can be done at the moment, however, is to start using products that are paraben-free. Several cosmetic companies have started to become more aware of the possible affect that parabens have on the human system. To begin cutting out parabens, one can begin purchasing these products. Not only will it reduce the affect that parabens have on the endocrine system and hormones, but it will cut out the risks that are still unknown about parabens.

Recently, I have personally become aware of the dangers of parabens. Though it is sometimes difficult finding paraben-free products, it can be done if one just looks at the label. To me, eliminating parabens is necessary in order for people to live stronger and healthier lives. With all the correlations that have been found regarding parabens, I know I do not want to risk all the
things that parabens could potentially damage. Rather than increase possible risks, I do everything in my ability to be paraben-free. However, even in my own household, it is impossible to get completely away from parabens (Figures 4 and 5 were products found in my own household). I think this is in part caused by the fact that out of thousands of toiletries and cosmetics tested, only a few are completely paraben-free and regarded as safe to use. (13) Hopefully, with an increase of research, parabens will begin to be removed and regulated by governmental organizations.
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Carbon $^{14}$ Dating: what can and can’t it do?

Marilyn LaBash

04/17/2012
Carbon 14 dating is an important tool in the dating of scientific objects. First developed by Willard Libby in 1949, the natural presence and decay of 14C is exploited as an internal clock to tell the length of time since the test subject was alive. There are now a number of different methods to do this type of testing including Gas Proportional Counters (GPC), Liquid Scintillation Counters (LSC), and Accelerator Mass Spectrometry (AMS). Rigorous selection of samples and appropriate physical and chemical pretreatment are required before the subject can be tested. There are a number of complicating factors in the use of 14C dating, and therefore a complicated calibration curve must be utilized to produce the best results.

Earth's atmosphere is composed of a number of elements, the most abundant being nitrogen (78.084%), oxygen (20.9476%), argon (0.934%) and carbon dioxide (0.0314%). [1] The balance is made up of traces of other gases. The upper atmosphere is under constant bombardment from solar radiation. The collision between the atmosphere and the solar rays create secondary particles knocked off of the primary atoms. These excited protons regularly intersect with the abundant nitrogen molecules. This collision, under certain alignments, will knock a proton off the nitrogen, leaving it with 6 protons and 8 neutrons. This is no longer nitrogen, but is now an unstable molecule of carbon 14.

\[
^{14}\text{N} + \text{neutron} = ^{14}\text{C} + \text{proton} \text{ (lost)}
\]

These isotopes are continuously created, but make up far less than one percent of total carbon isotopes. One 14C can be found for every 1x10^{-16} 12C molecules [2].

Illustration 1: the development cycle of C14
The newly created carbons quickly pairs up with free oxygen molecules to create $^{14}$CO$_2$. The new molecule is evenly distributed throughout the rest of the CO$_2$ in the atmosphere. Photosynthetic uptake by plants during their respiration spreads a predictable ratio of $^{14}$C throughout all vegetable matter. When plants are consumed by animals, either directly by eating, or indirectly though the consumption of herbivores, $^{14}$C is dispersed though the animals tissues at the same ratio. When the plant or animal dies, all intake of new $^{14}$C ceases. At that moment in time, there is a fixed ratio of $^{12}$C to $^{14}$C, roughly at equilibrium with the ratio of the greater environment. While the $^{12}$C is a stable molecule and does not change, the $^{14}$C is an unstable molecule, which immediately begins to decay back to $^{14}$N.

$$^{14}\text{C} \rightarrow ^{14}\text{N} + \beta \text{ particle}$$

This decay continues at a predictable rate. [3] By use of a calibration curve the ratio of surviving $^{14}$C to $^{12}$C can give a statistical likelihood of the age of the sample. To calculate the age of the sample, the following formula can be used.

$$R = A \exp(-T/8033) \text{ or } T = -8033 \ln (R/A)$$

Where $R$ is the existing ratio of $^{14}$C/$^{12}$C, $A$ is the original ratio of $^{14}$C/$^{12}$C at moment of death, and $T$ is the time since death. [5]

![Curve of Knowns, Libby & Arnold 1949](image)

Willard Libby, winner of the 1960 Nobel Prize in Chemistry [4] for his discovery of $^{14}$C, initially calculated the half-life of $^{14}$C to be 5568 ± 30 years. This has since been recalculated at 5730 ± 40 years known as the Cambridge Curve. [6] The initial testing to confirm the Libby curve was done using samples of wood including a sample removed from an Egyptian tomb of a known date. [7] The dating was of the control specimens was known, to test the accuracy of Libby's method. Tree ring counting (dendrochronology) was another method used to calibrate the curve.
Subsequent studies found a disturbing difference between Libby's method and the known age of further samples. Further research uncovered the complications of varying $^{14}$C levels historically related to the last ice age and excess $^{14}$C produced with the dawning of the nuclear age. The rise of the industrial revolution also generated huge amounts of $^{12}$C without corresponding $^{14}$C production which further complicated the issue. Early attempts at regulation used a sample of wood from 1890 as the absolute radiocarbon standard. This was later supplemented by the use of National Institute of Standards and Technology's (NIST) developed standard of a specific lot of Oxalic Acid 1 from 1955 sugar beets (HOx1), and later replenished with HOx2 made in 1977 as the supply of HOx1 was exhausted. These standards provide a common reference for all laboratories to report their data. [9] All readings are now incomplete without taking the following into consideration: the Libby half life, use of HOx1 or HOx2 or another appropriate standard, a correction for the sample of the $^{14}$C/$^{12}$C level at the time in question and the use of standard errors to correct ages. [18] The age of a sample is then reported as Before Present (BP). 1950 AD is defined as zero BP, since measurements after this time entail a different ratio of carbon isotopes. Dates are usually reported with a margin of error ± 40 years. Calibration curves of up to 10,000 years BP are available for use based on the use of dendrochronology (Tree rings) and marine samples for up to 20,000 years BP.

There are a number of complicating factors in the use of radiocarbon dating. Large stores of older $^{14}$C are stored in the lower layers of the ocean and can give false readings to samples from a younger age. For this reason, it is less useful to use radiocarbon dating on ocean dwelling life forms and the animals which subsist on these as a primary diet. [19] The fluctuation in the earth's magnetic field has created some confusion and possible created some dates as too young. This has been addressed with the use of tree ring analysis of the bristle cone pine and other long lived trees. These and other calibration methods create a robust system for accurately dating objects between zero and 50,000 years BP, with less precision for older specimens. Some samples will never be able to be dated in this way due to site contamination by natural methods including digging animals and root intrusion. [20] A large point of entry for errors into radiocarbon dating lies in contamination during the collection and processing of samples. It is for this reason the selection and preparation of samples for dating is of critical importance.

Not just any object is suitable for radiocarbon dating. Examples of specimens which can be dated include charcoal, wood, bone, peat, soil, ice cores, paper, resin, glues and wall paintings. All samples once identified as appropriate subjects next require two kinds of pretreatment regardless of which method of dating is chosen subsequently. The first pretreatment is the physical process. This includes removal of the object from the site it was discovered, scraping of the outer layers and removing any obvious contaminants. The outer surface is scraped and reduced in size to remove outer layers which would be the most likely area to have been contaminated by outside particulates. This reduction is one of the reasons which sample size is important in the selection of the method of dating used.
The second process for pretreatment is the use of chemical treatments to purify the sample. This step depends on which type of samples is being tested. Bone is a good example of a chemical pretreatment regimen. The sample would be crushed during the final step of the physical pretreatment. This increases the surface area which can be reached during the chemical process. The sample is washed repeatedly with cold dilute 0.5M hydrochloric acid (HCl) over 18 hours. This is to remove the hydroxyapatite component of the bone, which is more likely to suffer contamination. This isolates the collagen which will be dated. It is next washed with a solution of 0.1M sodium hydroxide (NaOH) for 30 minutes to remove any organic contaminates remaining. This is followed by another wash with 0.5M HCl for 1 hour. Each of these steps requires washes with ultra purified water between each step. This process creates a crude collagen which will be placed in a bath of pH 3 solution at 75°C for 20 hours. The resulting gelatin will be filtered and centrifuged to a small fraction of the gelatin suitable for testing. Samples other than bone have their own methods of preparation. Oxford University has created a useful set of standards for Pretreatment of AMS samples. [21]

Libby’s original work on carbon samples were from burning one ounce portions of the sample and counting the remaining 14C with a specially modified table surrounded by interconnected Geiger counters. This destroyed the sample, but did yield a close approximation of the time. [8] Shortly after Libby’s original work, Gas Proportional Counting (GPC) testing was developed. This was a marked improvement as it required a smaller sample to run the test. This method is still in use, but a more common form is Liquid Scintillation Counting (LSC). The newest method of determining 14C content is the use of Accelerator Mass Spectrometry (AMS). Each of these methods has benefits and drawbacks.

**Beta-minus Decay**

\[
\begin{align*}
\text{Carbon-14} & \rightarrow \beta^- + \text{Nitrogen-14} \\
6 \text{ protons} & \rightarrow 7 \text{ protons} \\
8 \text{ neutrons} & \rightarrow 7 \text{ neutrons} \\
\text{Antineutrino} & + \text{Electron}
\end{align*}
\]

Illustration C. Beta Decay.

Gas Proportional Counting and Liquid Scintillation Counting both count the beta particles given off as a result of the decay. In GPC, the sample is first converted to carbon dioxide gas, and placed into the chamber of the counter. The particles given off by the decay are then counted electronically. In LSC the sample must be converted to a liquid state, often benzene, after being pretreated to remove any potential contaminants which would give a false date. After the liquid state is achieved, a liquid scintillator is added to the vial. [10] A scintillator is a solute found in the scintillation fluid which is designed to show the presence of beta decay. [11][12] This is done with the presence of fluoros in the solution. As the beta particle decays off the 14C, it travels though the fluid. Due to the small amount of kinetic energy given off, it can travel only a short distance.
As the particle travels it encounters the fluors in the scintillation fluid. This energy is transferred to the fluor and raises it to an excited state. As the fluor returns to a ground state of energy, it gives off a photon of UV radiation. The fluor absorbs the photon, and glows briefly as it too returns to a ground state of excitation. This is the flash that the counter records. GPC and LSC are usually fairly cost effective and require in the neighborhood of 100mg of sample to test. This was a great improvement on over Libby's original method, but still calls for the destruction of a fairly significant amount of irreplaceable material. Sophisticated calculations and calibrations must be made on both methods to ensure reliable results.

The current gold standard of radiocarbon dating is the use of Accelerator Mass Spectrometry or AMS. Unlike GPC and LSC, AMS directly measures the amount of $^{14}$C in the sample, rather than counting beta emissions as they occur. This process is much faster than LSC and GPC, and uses sample sizes as small as one milligram. [13] This new smaller sample size means that objects previously considered too small to radiocarbon date are now possible, such as seeds, blood stains or teeth. The use of AMS also pushes back the time frame for the ages of samples theoretically to 100,000 years, although dating of more than 60,000 years are unusual. [14] With a half life of 5730 years, pushing dating past 12 half lives creates a problem with the standard deviations used to create dating curves. [15] The drawback for this method is that it is considerably more expensive than the GPC or LSC.

Illustration D. University of Arizona Accelerator Mass Spectrometer
Following the required pretreatment, the first step in AMS is to convert the sample to pure carbon (graphite) by combustion. The graphite is placed in the target wheel. Cesium sputtering though the target negatively charges the ions. They are then accelerated towards the positive target. They pass though a terminal which accelerates them to a high rate of speed. At this point, the ions pass though a chamber full of argon gas, known as the stripper. This knocks several electrons off the carbon ions and changes them to positive. The high rate of energy also makes it easy to separate the $^{14}$C ions from the other ions in the sample as the spread of the energy throughout the sample creates unique signatures for each. This is accomplished through the use of deflectors and magnets. The ions pass though a specially designed slit and hit the final target. The speed with which the ion was moving, along with the total energy with which it collides with the target identify the ion as $^{14}$C. [16, 17] At this point the total $^{14}$C amount in the sample is identified. This process runs in less than an hour compared to the multiday process required for the other two methods.

Regardless of the method chosen to date the sample, the result will be a raw date which must then be calibrated with known dates. As previously mentioned, these known dates include tree rings, corals and sediment from areas with annual deposits. The calibration curves must take into account the marine carbon reservoir effect, the effect of modern carbon based industry (the Seuss Effect), and the impact of nuclear testing (the DeVries Effect). Only when all of these may apply to a sample are taken into consideration may a final date be assigned, usually with the assistance of sophisticated computer analysis.

$^{14}$C dating is a complicated process which yields good results between BP 50 and 50,000 years, provided the rigorous samples selection and preparation process is followed, and appropriate calibration curves are utilized. It has been a useful tool in archeology, biology and environmental sciences to help generate and confirm timelines in research. Although there are several complicating factors in the use of $^{14}$C dating, and it must be prepared and tested with extreme care, the results are a boon for mankind and science.

As a student with a lifelong interest in prehistory and history, this felt like a great subject to me. I found the study of $^{14}$C dating to be fascinating and frustrating. It is clearly a valuable tool for dating appropriate samples. The process, which is a little over 50 years old, has undergone many improvements and adjustments. There is a group of citizens anxious to jump on any improperly run test, or even to misrepresent data from properly run tests to push their own religious based agenda. This creates a great deal of "noise" when attempting to research this subject. Many results of a search on this subject bring up a sizeable amount of this groups "research", often designed to mimic scientific journals, attempting to confuse this issue. On the bright side, this has an effect of improving critical thinking skills.

I find it ironic that just as Libby was identifying this useful tool, the world had just in the previous 60 or 70 years developed industries which prevented the modern dating of samples with this tool. One of the most important contributions Libby may have
made to mankind was not just his development of $^{14}$C dating, but the fact that this research has helped many others "stand on the shoulders of giants". $^{14}$C dating has definite limitations, but it has inspired the study and discovery that many other radioisotopes may be used with far longer time spans covered. Some useful isotopes for this expanded study include $^{232}$Th, $^{192}$Ir, $^{60}$Co, and $^{75}$Ga. [22] I am happy to live in a world where these tools and more are available to help study life, the universe and everything.
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Illustration
The Ins and Outs of MDMA
By: Austin Mach

Presented for: Dr. Mancini
Science Symposium
Organic Chemistry
Abstract

This paper is an in depth analysis of 3,4 methylene-dioxy-N-methylamphetamine. The different headings in clued the introduction, history, chemical information, methods of synthesis, effects, and a short personal statement at the end of the paper. Many illustrations accompany each section in order to get a good visualization of the information that is being presented in the section.

Introduction

3,4 Methylene-dioxy-N-methylamphetamine, more commonly known as its street names ecstasy, X, Adam, E, and Empathy, is a popular recreational drug due to the enhanced feelings of well being that the user experiences while under its influence. It is classified under the amphetamine family of drugs, meaning it is classified the same as speed. However, early on this drug was developed and used for all sorts of different reasons, ranging from dietary supplements to treatments for certain psychological disorders. Ecstasy has the ability to effect the body and mind in many different ways, all of which can be damaging and have long term adverse effects on living conditions. To understand how and why people put their well being in jeopardy to experience this moment of euphoria, it is first important to understand the history of this drug, as well as the way in which it chemically reacts within the body of a human person. This complex drug has a history shrouded in mystery, leaving one to wonder the same question asked of most pharmaceuticals, how could something intended to be used for good turn out to be so damaging and addictive to the users in the first place? Why has this drug run so rampant among young adults? And really are the serious side effects of continued use of 3,4 Methylene-dioxy-N-methylamphetamine?

History

Ecstasy has a long and lengthy history, dating back to about one hundred years ago. During this time, it has been used for all sorts of different reasons, ranging from health related to pleasure inducing. MDMA was first patented in 1913 (patent #274,350) by the German chemical company Merck.¹ Merck is the world’s oldest pharmaceutical and chemical company, dating back to 1668, when founder Friedrich Jacob Merck acquired the Angel Pharmacy.² The company, in fact, is still around and thriving to the very day. In, 1827, Emanuel Merck changed the company from a pharmaceutical trade into a research-based industrial company.³ Merck supposedly intended MDMA to be used as a dietary supplement, however no specific use was ever identified in the patent, so there is no actual hard evidence that this is in fact what the
product was designed to do. It is pure speculation, like much of the history of MDMA. It was even once believed that the UD Army tested MDMA as a truth serum in 1953, but no real evidence exists to support this account. However, Merck decided against marketing the drug and has hence forth had nothing to do with it, even though the company still holds the patent.

The man responsible for the modern day research of ecstasy is a man named Alexander Shulgin. Shulgin is known by some as the “Godfather of Ecstasy” because he is not only the first to do extensive research, but also believed to be one of the first human to have ever tried ecstasy as well. Shulgin earned his PhD in Biochemistry from the University of California Berkley. In the late 50s and early 60s he did post-doctorate work in psychiatry and pharmacology at U.C. San Francisco and worked briefly as research director at BioRad Laboratories before becoming a senior research chemist at Dow Chemical Co. Shulgin left Dow in 1965 to do independent consulting and teach public health at his alma mater University of California Berkley and San Francisco General Hospital. In 1967, he was introduced to the possibilities of MDMA by an undergrad at San Francisco State University at a time when very few people had tried MDMA. Shulgin did not invent the chemical, but instead by 1976 had invented a new synthesis process for the chemical which he introduced to a good friend of his, Leo Zeff, an Oakland psychologist who worked with psychedelics in his therapy practice. Since that time, Shulgin has synthesized and bioassayed (self-tested) hundreds of psychoactive chemicals, recording his work in five books and more than two hundred papers. He is a fixture in the field of psychedelic science, and in 2010 even won an award for lifetime achievement in psychedelic sciences.

MDMA is widely known to have been used to help treat psychiatric patients that had a hard time displaying emotions, or even married couples struggling to keep their relationship afloat. This movement came from the man that was one of Alexander Shulgin’s good friends, a man that he introduced to MDMA, Leo Zeff. Dr. Zeff believed heavily in the healing effects of psychedelic drugs. As a young man, Zeff was a Lieutenant Colonel in the U.S. Army. Later, after obtaining his PhD, he opened a private practice specializing in Jungian psychology. Eventually he discovered how effective psychedelics could be in helping heal his patients. When psychedelics were outlawed, Zeff went underground. When Zeff was about ready to shut down his practice in 1977 is when Alexander Shulgin turned him onto MDMA. It was at this point in time that Dr. Zeff decided against retiring and instead began traveling and introducing MDMA to other therapists throughout the world. It has
been speculated by one of his friends that Zeff was responsible for turning on around 4,000 other therapists to MDMA. Zeff is responsible for coining the term "Adam" for MDMA, as he felt that it stripped away the ego's defense mechanisms and returned the user to a primordial state of innocence. Dr. Leo Zeff continues to be known to this day as a pioneer in the use of psychedelic drugs as treatment of psychological disorders.

It wasn't until 1985 that ecstasy became more of a mainstream drug and started to receive massive media attention. Up until this point not many people had used it, and those who did used it primarily illegally in the rave scene, or as a psychedelic treatment for psychological disorders such as Dr. Leo Zeff had done. It was at this point in time that a group had formed together in order to sue the US Drug Enforcement Agency (DEA) in order to prevent them from making ecstasy illegal by placing it on Schedule I.

**Controlled substance drugs range from schedule 1 through schedule 5.** Schedule 1 substances are the most severe. Substances in this schedule have a high potential for abuse, have no currently accepted medical use in treatment in the United States, and there is a lack of accepted safety for use of the drug or other substance under medical supervision. Examples other than ecstasy include such drugs as marijuana and LSD. Schedule 2 controlled substances are the next below schedule 1 substances. Substances in this schedule have a high potential for abuse which may lead to severe psychological and physical dependence. Examples of schedule 2 substances are cocaine and methamphetamine. Schedule 3 controlled substances are not as severe as the first two. Substances in this schedule have a potential for abuse less than substances in schedules 1 or 2 and abuse may lead to moderate or low physical dependence or high psychological dependence. A couple of examples of schedule 3 controlled substances are ketamine and anabolic steroids. Schedule 4 controlled substances are the next step down in the drug hierarchy. Substances in this schedule have a low potential for abuse relative to substances in schedule 3. Examples of schedule 4 controlled substances include Xanax and Valium. Schedule 5 controlled substances are the lowest level of controlled substances. Substances in this schedule have a low potential for abuse relative to substances listed in schedule 4 and consist primarily of preparations containing limited quantities of certain narcotics. Examples in this final schedule include Robitussin AC and Phenergan.

The reason for the formation of this group was because the US Congress had passed a new law allowing the DEA to put an emergency ban on any drug that it thought might be a danger to the public. The very first time that this new law was used was on July 1, 1985 in order to place a ban on MDMA. There was a hearing held before a judge to try to decide the ultimate fate of MDMA. One side argued that there was sufficient data to show that the drug caused brain damage in rats, while the other side claimed that it was not the case for humans. In fact, they claimed it actually helped as a drug treatment during psychotherapy. The presiding judge after weighing the evidence, recommended that MDMA be placed on Schedule 3, which would have allowed it to be manufactured, used on prescription and subject to further research. However, the DEA decided to place MDMA permanently on Schedule I. Trial research began again for ecstasy in 1993 with approval from the Food and Drug Administration (FDA), which made it in fact the first psychoactive drug to be approved for human testing by the Food and Drug Administration.
**Chemical Information**

Ecstasy is a Schedule 1 controlled substance, meaning it is in the highest class of controlled substances in the United States, along with such drugs as marijuana and LSD, as stated earlier. Ecstasy is classified as a hallucinogenic stimulant, meaning it can cause both hallucinations as well as stimulate the brain, making it far more active. MDMA has a molecular formula of $C_{11}H_{15}NO_2$, meaning it is composed of eleven carbon atoms, fifteen hydrogen atoms, one nitrogen atom, and two oxygen atoms. The structure of MDMA contains a few methyl groups, an amine group, as well as a bicyclo group, one of which is a heterocycle. Below is a look at the chemical structure of MDMA, with the red atoms being oxygen, the blue atom being the nitrogen, the grey atoms being carbons, and the white atoms being hydrogens.

MDMA has a melting point of 147-153°C, meaning that it turns from a solid product into a liquid at this temperature. It also has a molecular weight of 193.25 g/mol. This molecular weight is obtained by adding up the molecular weights of all the oxygen, hydrogen, carbon, and nitrogen molecules in the compound. MDMA has an appearance that is a pure white, crystalline solid, that can be found in a variety of colors based on the way it had been produced and the types of dyes put into it. Another important point is that MDMA is a chiral molecule. This means that the mirror image of molecule is not superimposable upon the original molecule. This is due to the fact that one of its carbons is bound to four different groups. No amount of turning or bending the molecule will allow the two molecules to be congruent; bonds must be broken in order to create the other molecule. The $(R)$ enantiomer is more potent in vivo than the $(S)$ enantiomer, but MDMA is usually found as a racemic mixture, a 50-50 mixture of the two stereoisomers. Notice how the only difference between these two enantiomers is the different placement of the proton and the methyl group on the chiral carbon.

**Methods of Synthesis**

There are many methods that are used to synthesize MDMA. One popular method is to first synthesize 3,4-methylenedioxyphenyl-2-propanone, which is used for the basis in which to synthesize MDMA. To get MDP-2-P first a natural source of safrole is acquired. Safrole can be extracted from sassafras oil, nutmeg oil, or several other sources. The safrole is then easily
isomerized into isosafrole when heated with NaOH or KOH. The isosafrole is then oxidized into MDP-2-P (4-methylenedioxyphenyl-2-propanone). The synthesis of MDP-2-P from isosafrole will require the use of a vacuum pump to evaporate the solvent from the final product.\(^5\) Below is an illustration of the important compounds used in this synthesis.

Once MDP-2-P has been synthesized, there are six different routes that can be used in order to synthesize MDMA. These six routes include sodium cyanoborohydride, aluminum amalgam, sodium borohydride, Raney nickel catalysis, Leukart reaction via N-formyl-MDA, and Leukart reaction via N-methyl-N-formyl-MDA. The first route, involving sodium cyanoborohydride, is usually the most commonly used route for this method because the other five have some unwanted risk or side effect involved in them. The aluminum amalgam synthesis is often used but has a slightly higher risk of failure and is not as versatile. The Raney Ni synthesis is more dangerous and requires special equipment to be done right (although this scheme is used in a significant number of clandestine labs). The sodium borohydride requires harsher conditions for the chemicals than sodium cyanoborohydride or aluminum amalgam and produces lower yields. The Leukart reaction is 2-step with lower yields and requires chemical apparatus.\(^6\)

Another popular method for the synthesis of MDMA is a synthesis starting from the compound benzo[1,3]dioxol-5-yl-acetic acid that yields MDMA and several other byproducts along with it. The reaction for this synthesis will be covered slightly more in-depth, with an illustrated reaction at the end in order to visualize what is actually taking place during the synthesis. First, you use benzo[1,3]dioxol-5-yl-acetic acid as the staring material, and react this compound with Ac₂O and NaOAc. This reaction will yield both an intermediate and a byproduct, with diarylaceton as the byproduct and 2-benzo[1,3]dioxol-5-yl-1-methy-ethyamine as the intermediate. The next step is to react this mixture with formamide and HCOOH. This reaction causes the 2-benzo[1,3]dioxol-5-yl-1-methy-ethyamine to form N-(2-benzo[1,3]dioxol-5-yl-1-
methy-ethyl)-formamide, as well as he dialyacetone byproduct to form into N-formyl-1,3-bis (3,4-methylene dioxyphenyl)-prop-2-y1-amine. You can also react the intermediate 2-benzo[1,3]dioxol-5-yl-1-methy-ethylamine with HCOOH and N-methylformamide to form another intermediate, N-(2-benzo[1,3]dioxol-5-yl-1-methy-ethyl)-N-methyl-formamide that through a hydrolysis reaction will form MDMA. During this hydrolysis reaction, the byproduct N-formyl-1,3-bis (3,4-methylene dioxyphenyl)-prop-2-y1-amine is turned into 1,3-bis (3,4-methylene dioxyphenyl)-2-propanamine, which is the end of this byproduct reaction. The intermediate N-(2-benzo[1,3]dioxol-5-yl-1-methy-ethyl)-formamide can be reduced using LiAlH₄ to also form MDMA.⁹

These two methods shown for the synthesis of MDMA are two of the more common methods for synthesizing the drug. As stated earlier, there are many ways in which to synthesize MDMA, too many to try to go into much detail regarding them. It is important to know that although MDMA has been approved for human testing by the Food and Drug Administration, it is illegal to synthesize by the common public due to the drug’s Schedule 1 classification.

**Effects**

Depending on who is asked, many people in today’s society will give their own unique answer when asked to describe how they feel about ecstasy. When asking someone who goes clubbing or to raves on a consistent basis, they would probably sing praises of this particular drug. When asking a regular blue collar worker, the given response would probably be the complete opposite. Although it has been shown that some doctors support the drug and wish to develop it, the general consensus amongst them is a negative view of the drug as well. The reason for this general negative overview of MDMA is not without reason. It is because of the severe short-term and long-term effects of this particular drug.
The desired effects of drug users taking MDMA kick in about an hour or so after the drug is orally ingested. These effects include feelings of mental stimulation, emotional warmth, empathy toward others, a general sense of well being, and decreased anxiety. In addition, users report enhanced sensory perception as a hallmark of the MDMA experience. A major target of ecstasy in your brain is the serotonin pathways. Serotonin is a neurotransmitter that is synthesized, stored, and released by specific neurons in this pathway. It is involved in the regulation of several processes within the brain, including mood, emotions, aggression, sleep, appetite, anxiety, memory, and perceptions. Here is a diagram pointing out the different regions of the brain being effected by MDMA, and what each of these regions that are being effected control. Many of the psychological effects of ecstasy are due to its actions within the limbic system (the amygdala, in red, and hippocampus, in blue, especially). The ability of ecstasy to produce mild stimulation is due to its actions in another part of the limbic system -- the basal ganglia (in purple). It is here where ecstasy's effects on the dopamine system may be important. The heightened perceptions involve the actions of ecstasy in the neocortex (in yellow). Ecstasy can also reduce the appetite, because it acts in the hypothalamus (in green), which controls feeding behavior. However, not all short term effects of MDMA are of the desirable sort. A few psychological effects of MDMA are agitation, clouded thinking, anxiety, and disturbed behavior. Users of MDMA also show signs of physical side effects as well. MDMA can produce a variety of adverse health effects, including nausea, chills, sweating, involuntary teeth clenching, muscle cramping, and blurred vision. There is also the possibility of overdosing on MDMA. There are many symptoms of an ecstasy overdose, including problems urinating or sweating. The most serious symptom of an MDMA overdose is overheating--when the body enters a state of hyperthermia, various organs and tissues can be damaged very easily. The inability to sweat is a precursor to this.

Effects of ecstasy are not limited to the short term. There are also long term, perhaps permanent side effects to the drug as well. As stated earlier, the major pathway associated with the use of MDMA is the serotonin pathways. When people use ecstasy repeatedly or long term, there may be changes in their brain chemistry that suggest that the serotonin neurons are damaged. One major clue is that serotonin itself and its metabolites are diminished in the brains of animals treated with ecstasy. In the animals tested, the serotonin levels in the brain two weeks after the introduction of MDMA was down to virtually zero. Even after seven years, when the animals have not taken the drug at all since the initial test, the serotonin levels have only recovered to about half of what they originally were before the introduction of MDMA into the system. This is a disturbing discovery because of all of the important functions of serotonin. These functions include such things as the regulation of mood, appetite, sleep, muscle contraction, and some cognitive functions including memory and learning. Serotonin is also in
blood platelets where it helps to regulate homeostasis and blood clotting. Out of all of these side effects of diminished serotonin levels, verbal and visual memory impairment is the most prominent among people who have used MDMA repeatedly. These long term effects are not just limited to the brain, MDMA also affects many of the other systems of the body as well. Dramatic increase in heart rate, leading to serious complications for people with cardiovascular disease can be one of the more serious long term effects of MDMA use as well. However, the most serious issue according to most people is the high risk of brain damage associated with extended use of MDMA. Brain damage is directly related to amount and frequency of usage. Brain damage is a serious issue that affects many frequent users of MDMA. It is irreversible and will debilitate the person for the rest of their life.

**Personal Statement**

The reason in which I decided to write this paper is because as a young college student I have been able to see firsthand the effects that drugs have on people. Not only have peers of mine been affected, but family members as well. The reason for choosing MDMA is because of the controversial background associated with the drug. As someone that is going to be going into a professional pharmacy program, I feel like it is my duty to get a better understanding of certain drugs that may or may not be used for medicinal purposes. I personally find the ins and outs of such drugs as MDMA to be fascinating and look forward to one day having a better understanding of the workings of such drugs.
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Pesticides: Organic vs. Inorganic
Ashley Maes
Organic Chemistry
April 20, 2012
Dr. Mancini
ABSTRACT
Enclosed, this paper is a review of the differences between pesticides used in the growing of inorganic and organic crops, along with the advantages and disadvantages of both type of the consumption of these crops. It will also discuss what pesticides do and how they affect the human body. The usage of pesticides has opened up discussions and has caused many controversial opinions along with more stringent regulations on the use of pesticides and how they have had effect by human consumption that is discussed.

BACKGROUND ON PESTICIDES
Pesticides have been used for a long time in the past, and in modern society. Elemental sulfur was used by ancient Sumerians to protect their crops along with medieval farmers. Scientists experimented with chemicals ranging from arsenic to lead on common crops. They have been used for decades by many different cultures in growing their crops to keep them free from agricultural pests. Pesticides are a common chemical used to control insects in crops grown throughout the world as well as for livestock feed. There are four major types of pesticides used today to aid the growth of agriculture: insecticides, herbicides, rodenticides, and fungicides. Of these types, insecticides are the most commonly applied pesticides used every year. Pesticides can either be natural or synthetic in all four of these categories and are used in different crop growing when it comes to inorganic or organic crops. Today, more than 20,000 pesticides are registered with the Environmental Protection Agency (EPA).

WHAT PESTICIDES DO
With the many types of pesticides used today it can be confusing to know what they do and why they are used in farm fields. Pesticides are used to control and/or eliminate pests in agricultural growth and livestock. Between the four major types used they all have different functions and are made from different chemicals. Insecticides are used to kill insects; they are usually made up of harmful chemicals that will kill the insect before it can destroy the crops being grown. Hericides are used to kill weeds; it is one of the most commonly used because weeds are the most prevalent problem farmer’s face in their crop seasons. These herbicides will kill the weeds and help prevent them from growing back while not damaging any of the crops. Rodenticides are used to control the rodent population trying to eat the crops. The last major pesticide used is fungicides. They control the growth of fungi, mold and mildew populations. Fungi, mold and mildew in themselves can be dangerous if the levels get to high and can also seriously destroy crops being grown so they need to be killed off to prevent even more damage and problems.

PESTICIDE REGULATIONS
Pesticides are regulated by the EPA under two federal statutes; the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food, Drug, and Cosmetic Act (FFDCA). FIFRA authorizes the EPA to review and register pesticides for specified uses. This federal statute is where they check to make sure the pesticides are licensed, regulate them with their use and disposal, and to suspend or cancel the use of pesticides. The FFDCA is responsible for authorizing the EPA to set residue levels and tolerances in pesticides for food and livestock feed. These statutes are very important in maintaining healthy levels of pesticides used and making sure they are as low in toxicity levels as possible.
ADVANTAGES OF USING PESTICIDES
The use of pesticides has many advantages with how much output in crop growing there is in this country. The biggest advantage is quantity. Because the demand for food is going up and goes up every year, it is imperative that farmer's keep up on the demand. By use of the pesticides they are able to retain more seasonal crops with less being damaged by unwanted guests. They require low labor input and allow large areas to be treated quickly and efficiently 3. Another advantage of pesticides is control of weeds growing through the crops. This is a very labor intensive job in keeping weeds from growing throughout the crops and it helps keep the nutrients to go to the crops instead of the weeds that would take all the nutrients from the soil. Last is keeping bugs and insects under control. Without farm chemicals the treatment of spiders, cockroaches, etc in houses; fleas on pets, etc, would be most difficult 3.

DISADVANTAGES OF USING PESTICIDES
Pesticides can have huge impacts not only in the ground, but also in the consumption of the crops and livestock that are taken in by the consumers. Studies link pesticide exposure to cancer, birth defects, stillbirth, infertility, and damage to the brain and nervous system 4. Researchers have also studied levels of pesticides in individuals and they have high levels in their bodies. One of the most used pesticides is known as organophosphate pesticides. These are mostly insecticides and they affect the nervous system by disrupting the enzyme that regulates acetylcholine, a neurotransmitter 5. They are used because they have similar effects on insects as they do on humans and this gives the farmers an upper hand to control them. Another common type of pesticide used is called carbamate pesticides. These also affect the nervous system by disrupting the enzymes. Below are the structures for these two types of pesticides.

![General Structure of organophosphate pesticide](image1)

![Carbamate pesticide](image2)

In the body thousand of enzymes are at work and they allow the cells to carry out chemical reactions very fast. Enzymes work like a lock and key mechanism. There is an active site on the
enzyme and only specific substrates fit into that active site for it to work. Below is a diagram of a typical reaction of Acetylcholine in the active site of Acetylcholinesterase. It illustrates the way acetylcholine should lock into acetylcholinesterase when functioning properly.

![Diagram of Acetylcholinesterase Reaction](image)

The organophosphate and carbamate pesticides work on the active sites on this enzyme of acetylcholinesterase, they blocks it so that acetylcholine can’t attach to make the enzyme function properly. When it does this it acts as a nerve agent and causes nerve damage.

WHAT IS ORGANIC
Organic produce has become very popular over the years as people have become more aware of what they are putting into their bodies. When people think of organic fruits and vegetables they think that they are pesticide free and chemical free but unfortunately that is not true. In fact, under the laws of most states, organic farmers are allowed to use a wide variety of sprays and powders on their crops. So what is organic? To be labeled as organic, products can only be sprayed from natural sources, not synthetically manufactured products. The equipment used to spray these natural sources must also be free from those synthetic sprays. The biggest mistake was to think that these natural sprays are harmless for the consumers. “This is a case where everyone (consumers, farmers, researchers) made the same, dangerous mistake. We assumed that "natural" chemicals were automatically better and safer than synthetic materials, and we were wrong. It's important that we be more prudent in our acceptance of "natural" as being innocuous and harmless” . When these natural sprays were tested in a laboratory it was discovered that around half of them were carcinogenic. Substances and exposures that can lead to cancer are called carcinogens. Some carcinogens do not affect DNA directly, but lead to cancer in other ways. For example, they may cause cells to divide at a faster than normal rate, which could increase the chances that DNA changes will occur . Below is a table of some known carcinogens that have been found in natural sprays used in organic crop growing.
<table>
<thead>
<tr>
<th><strong>2,4-D</strong></th>
<th><strong>MCPA</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>2,4-dichlorophenoxyacetic acid</td>
<td>4-chloro-2-methylphenoxyacetic acid</td>
</tr>
</tbody>
</table>
| \[
\text{Cl} - \text{O.CH}_2\text{CO}_2\text{H}
\] | \[
\text{Cl} - \text{O.CH}_2\text{CO}_2\text{H}
\] |
| **Dichlorprop (2,4-DF)** | **Mecoprop (MCPP)** |
| 2-(2,4-dichlorophenoxy) propionic acid | \[
\alpha-(4-chloro-2-methylphenoxy) propionic acid
\] |
| \[
\text{Cl} - \text{O.CH}_2\text{CO}_2\text{H}
\] | \[
\text{Cl} - \text{O.CH}_2\text{CO}_2\text{H}
\] |
| **Fenoprop (Silvex, 2,4,5-TP)** | **2,4,5-T** |
| 2-(2,4,5-trichlorophenoxy) propionic acid | 2,4,5-trichlorophenoxyacetic acid |
| \[
\text{Cl} - \text{O.CH}_2\text{CO}_2\text{H}
\] | \[
\text{Cl} - \text{O.CH}_2\text{CO}_2\text{H}
\] |

**Structure of 2,4-dichlorophenoxyacetic acid (2,4-D) and chemically-related herbicides.**

Although some of these carcinogens are found in the natural sprays the levels of them are much lower than other harmful chemicals that are found in the synthetic sprays used on inorganic crops. In organic crop growing, farmers also do rigorous work compared to inorganic crop farmers. They spend more time on their land setting traps for different wildlife to protect the crops then use additional chemicals that would normally harm this wildlife. They also have taken steps to protect the environment by not polluting the air with additional chemicals that can be inhaled by neighbors.

**ORGANIC COSTING MORE**

With much more care and maintenance going into the growth of organic crops the price that reaches consumers can be a noticeable difference. Consumers may pay a price premium of up to 30% for organically grown foods. This is because the cost for farmers to grow organic crops cost them more money. They must pay to have their land inspected yearly as well as to have...
these reports submitted. They must also pay for soil testing as well as certification requirements. With all of their overhead costs going up, the price is passed down to buyers of their produce.

DISADVANTAGES OF GOING ORGANIC
The biggest disadvantage of going organic is by far the price. While eating healthier for many people is an important part in their lives, the price they pay at the stores for their food can start to have an impact on whether or not they can afford to live a life of healthier eating. The next disadvantage to consumers is starting to feel like they are buying a product that costs more but not getting what they were told they were getting. When people think of organic food they think of it not only being chemical free and hormone free but also pesticide free. Once they do the research on it they realize that pesticides are still used and even though they are considered natural over synthetic they can still be harmful to the body when consumed.

WHAT IS INORGANIC
Inorganic crops are what are common and mostly purchased in stores today. These are crops that are grown in fields across the country and throughout the world that are regularly treated using various types of pesticides. These pesticides are used to keep unwanted pests, weeds, rodents and fungi away. Inorganic grown crops are not as heavily regulated than that of organic grown crops, and the regulations are not as stringent. The pesticides used in this conventional way of growing crops are known as synthetic sprays and can contain harmful chemicals that can have adverse effects on the human body. These pesticides are known to cause cancer, and are most prevalent in causing nervous damage. They may contain chemicals such as organophosphate and carbamate that cause nerve disorders, as well as carcinogens that can cause cancer.

DISADVANTAGE OF GOING INORGANIC
There are many disadvantages of consuming inorganic produce. The first is the chemicals that make up the pesticides. While these pesticides help farmers grow their crops and help yield a larger crop season, they can have severe side effects on the consumers. When testing was done researchers found most people carried high levels of these pesticides in their bodies and children between the ages of six and eleven carried four times the acceptable level of pesticides in their system. With these high levels, physicians are seeing a higher increase in both adults and children with disorders that they feel may be coming from the food they eat. Cancer is occurring more often than ever before and many researchers believe it could be due to the produce we eat. In a few sections above a variety of carcinogens were listed that are in natural sprays, these carcinogens are also found to be in synthetic sprays. Below is a picture of how a carcinogen can affect one of your cells during replication. (Table)
HOW ANEUPLOIDY COULD CAUSE CANCER

Abnormal chromosome numbers in a cell create conditions that lead to further chromosome damage and disarray. With each new generation,

1. Because of a random accident or damage by carcinogens to chromosomes or mitotic machinery, a dividing cell distributes its chromosomes unevenly between two daughter cells, leaving both aneuploid.

2. Most resulting cells are not viable and die, but a surviving cell may continue proliferating. Low aneuploidy in its offspring begins to compromise their internal functioning, but they are not yet multiplying excessively.

Substances labeled as carcinogens may have different levels of cancer-causing potential. Some may cause cancer only after prolonged, high levels of exposure.

TO GO ORGANIC OR INORGANIC

Choosing to go organic or inorganic is a personal choice. There are pros and cons to both types of these crops being grown. While natural sprays do not contain as many chemicals as synthetic sprays they still have their own downfalls. As a consumer of any produce they must do research to understand what they are putting into their bodies and decide what the best choice is for them. Below is a chart that focuses just on the sales of corn and how consumers are choosing to spend their money.

Historical Organic and Conventional Corn Prices

Source: USDA Market News
While organic corn has been on the rise these past couple of years only time will tell and
determine how far consumers will choose to go with the two options they have in buying there
produce.

PERSONAL STATEMENT
I chose to do this topic because it has become a big consumer, environmental and health debate
for decades. Along with many consumers, I want to make better choices in nutritional value for
my family to eat healthier. I studied the major differences between going organic or staying with
conventional produce. I believe that organic produce is a better choice than conventional, while
natural sprays still have their problems it is still a better choice overall that synthetic sprays. As a
person you are going to encounter chemicals throughout your life and can always be exposed to
hazards and I want to help reduce those that I am exposed to on a daily basis.
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Scientists experimented with chemicals ranging from arsenic to lead on common crops.


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Testosterone Replacement Therapy

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ABSTRACT

Testosterone replacement therapy is most often used to correct the symptoms of male hypogonadism, a condition in which a man’s body makes very little testosterone. Hypogonadism can begin during fetal development, before puberty or during adulthood. Signs and symptoms depend on when the condition develops. The symptoms of hypogonadism in adult men, the advantages and disadvantages of different treatment options are discussed, as well as, diagnosis, drug interactions, side effects, and how hormone replacement therapy contributes to the quality of life for those who take it.

INTRODUCTION AND BACKGROUND

Testosterone is a sex hormone that is produced in the testes, although it’s also produced in small amounts in women’s ovaries and adrenal system. The amount of testosterone synthesized is regulated by the hypothalamic-pituitary—gonadal (HPG) axis, which is an interaction between the hypothalamus, anterior pituitary gland, and gonads. When testosterone levels are low, gonadotropin-releasing hormone (GnRH) is released by the hypothalamus which in turn stimulates the pituitary gland to release follicle-stimulating hormone (FSH) and luteinizing hormone (LH). These later two hormones stimulate the testis to synthesize testosterone. Finally, increasing levels of testosterone through a negative feedback loop, act on the hypothalamus and pituitary to inhibit the release of GnRH and FSH/LH respectively.¹

Testosterone is responsible for the physical differences between men and women such as body hair, large muscles, strong bones, or a deep voice in the case of males. During puberty, testosterone initiates the maturation of the male reproductive organs and the appearance of secondary sex characteristics and sex drive. In addition, testosterone is necessary for normal sperm production and maintains the reproductive organs in their mature functional state in adult males. As men get older, the testicular ‘machinery’ that makes testosterone gradually becomes less effective, and testosterone levels start to fall. This results in weakened accessory sex organs.¹ This situation is easily remediated by testosterone replacement therapy. This form of therapy is possible today thanks to Adolf Butenandt and Leopold Ruzicka who were able to synthesize testosterone in 1935.²

STRUCTURAL FORMULA

It’s important to note the minor difference between testosterone and estradiol, which is responsible for the sexual characteristics of females. The key structural differences are that testosterone has a methyl group on carbon 19 and a carbonyl on carbon 3, whereas, estradiol lacks the methyl group and the carbonyl on those same carbons and instead has an aromatic ring. “In mammals, testosterone is converted to estradiol in the female’s ovaries, where enzymes remove carbon 19 and two hydrogen atoms to give the aromatic ring.”³ This simple chemical arrangement of carbon rings makes a distinct difference in the development of males.
SIGNS AND SYMPTOMS

Men who fail to produce normal levels of testosterone in their bodies suffer from a condition called hypogonadism. Some of the symptoms of having hypogonadism are "lowered sex drive, infertility, and impotence, a loss of body and facial hair, and osteoporosis." Other symptoms may include, "decrease in muscle mass, with an increase in body fat, changes in cholesterol levels, decrease in hemoglobin and possibly mild anemia." Additionally, increased fatigue; sleep apnea, diminished strength, cognitive impairment, and a depressive mood are attributed to having low testosterone levels. Not all of these signs and symptoms need to be present for a diagnosis. Risk factors for hypogonadism include: "Kallmann syndrome (an abnormal development of the hypothalamus), Cryptorchidism (undescended testicles as an infant), mumps infection affecting the testicles, testicular or pituitary tumors, Klinefelter syndrome (an abnormality of the sex chromosomes, X and Y, also known as XXY males), or previous chemotherapy or radiation therapy." These symptoms can be alleviated by hormone replacement therapy, which involves consumption of additional androgenic hormones which take the place of those no longer produced by the body.

TESTS AND DIAGNOSIS

A blood test indicates the level of testosterone produced in the body. There’s a wide range of what is considered to be a “normal” testosterone level. According to the Endocrine Society the blood concentration testosterone levels in healthy adult men range anywhere from 300-1000 ng/dl. Therefore, testosterone levels below 300 ng/dl are considered low, but doctors don’t always agree on a number. Aside from the blood test, the doctor will perform a physical exam to assess whether muscle mass or size of testes is consistent with the patient’s age. A decrease in the production of sperm or the production of testosterone leads to a diagnosis of hypogonadism. There are two basic types of hypogonadism: primary which is the result of testicular failure due to Klinefelter’s syndrome, chemotherapy or radiation treatment, toxic damage from alcohol, or hemochromatosis (too much iron in the body) or secondary. Secondary
hypogonadism indicates a problem in the hypothalamus or the pituitary gland. These are parts of the brain that signal the testicle to produce testosterone.

The table below illustrates the main causes of adult growth hormone deficiency.

<table>
<thead>
<tr>
<th>Aetiology</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pituitary adenomas + their treatment by surgery and/or radiotherapy</td>
<td>75</td>
</tr>
<tr>
<td>Other tumours of the sellar region (craniopharyngioma, meningioma, chordoma, etc.) + their treatment</td>
<td>10</td>
</tr>
<tr>
<td>Congenital GH deficiency (idiopathic, genetic, isolated CHD or multiple hormone deficiency)</td>
<td>5-10</td>
</tr>
<tr>
<td>Inflammatory, infectious or vascular pituitary diseases</td>
<td>2-3</td>
</tr>
<tr>
<td>Cranial or cervical trauma (TBI), subarachnoid haemorrhage</td>
<td>1-2</td>
</tr>
<tr>
<td>History of cerebral irradiation for cancer (malignant blood disease, cerebral tumour)</td>
<td>1-2</td>
</tr>
<tr>
<td>Unknown</td>
<td>2-3</td>
</tr>
</tbody>
</table>

**TREATMENT OPTIONS**

Such unpleasant symptoms will undoubtedly make any man seek treatment. Common treatment options are injections, patches, topical gels, and pills.

IM (intramuscular) testosterone is an injection in a muscle and the oldest form of treatment. It's less expensive than gels and ideal for cost-conscious consumers. Patients often
have positive responses initially and then experience a return of symptoms before it is time for their next injection, creating “a roller coaster effect” as blood testosterone levels peak and then return to baseline. This roller coaster effect translates into wide swings in mood and well-being, which is disconcerting and upsetting to both patients and their partners. Patients can avoid this effect to some extent by giving weekly injections, but it becomes very inconvenient for patients to go to the doctor’s office that often.

Transdermal patches offer another option. This topical treatment helps maintain an even and constant level of testosterone in the blood; a daily transdermal patch is available in 2.5 mg and 5 mg dosages. The patches can be slightly less expensive than gels and are covered by most insurance carriers. Transdermal testosterone therapy is available both as scrotal and non-scrotal patches. However, the scrotal patch is not appealing due to inconvenience such as their inability to remain in place and the need for frequent shaving of the scrotal skin. Patches do cause dermatitis (swollen, reddened and itchy skin) in about 40% of users, thus their use is somewhat limited.

Transdermal gels are a convenient means of administering testosterone, although some patients have trouble absorbing it. The gel is applied thinly on the skin normally once a day and dries quickly. It is the most commonly used testosterone preparation in the United States. AndroGel® and Testim® are the names of the topical gels containing testosterone. “They are manufactured differently and are used in slightly different ways. AndroGel can be applied anywhere on the shoulders, upper arms, or abdomen, whereas, Testim can be applied on the shoulders or upper arms, but not on the abdomen.” As the gel dries, the body absorbs testosterone through the skin. It’s important to wait a few hours before taking a shower to make sure the gel is absorbed completely on the skin. “Testosterone gel comes in single use tubes and packets and a multiple use pump. The pump releases a specific amount of testosterone gel each time the top is pressed.” Their key disadvantage is cost, even with insurance and coupon cards, it’s relatively expensive. Without a coupon card, it can easily cost several hundred dollars, thus it’s not accessible for everyone. Another disadvantage is that it can be transferred through skin-to-skin contact, making children and women vulnerable to exposure.

Pills can also be taken but are strongly discouraged because they cause liver problems, raise cholesterol levels, and increase the risk of heart disease. “Older forms of oral testosterone are alkylated at the 17-carbon position, which are not considered safe for long-term use.” Therefore, oral administration of testosterone is currently only safely accomplished by the use of testosterone undecanoate (TU), which is commercially available in many countries but not in the United States.” Due to the risk of liver problems, it’s often advisable to monitor liver function prior to onset of therapy and on a yearly basis during treatment. The buccal tablets such as Striant®, are placed above the incisor tooth on either side of the mouth and slowly release testosterone over 12 hours, after which they have to be replaced. Some of the side effects are dry mouth and toothache. Some patients find the buccal tablet uncomfortable and report concern about the tablet shifting in the mouth while talking.
## DOSAGE AND ADMINISTRATION

### Comparison of Forms of Testosterone Therapy

<table>
<thead>
<tr>
<th>Formulation and Regimen</th>
<th>Regimen</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testosterone enanthate (Deltatestyl) and testosterone cypionate (Depot-testosterone) injections</td>
<td>200 mg every 2-4 weeks (testosterone enanthate); 100 or 200 mg every 2-4 weeks (testosterone cypionate)</td>
<td>Relatively inexpensive</td>
<td>Peaks and valleys in blood testosterone levels; frequent office visits for injections</td>
</tr>
<tr>
<td>Scrotal testosterone patch (Testoderm)</td>
<td>One 6 mg patch/day</td>
<td>May be less irritating to skin than non-scrotal patches</td>
<td>Scrotum must be shaved in order for patch to adhere to skin</td>
</tr>
<tr>
<td>Non-scrotal testosterone patch (Testoderm TTS and Androderm)</td>
<td>One or two patches/day, depending on strength (2.5-5mg/patch)</td>
<td>Ease of application; mimics normal daily rise and fall of testosterone</td>
<td>May need two patches a day; can cause skin irritation</td>
</tr>
<tr>
<td>Testosterone gels (AndroGel and Testim)</td>
<td>5-10 mg/day</td>
<td>Ease of application; generally well tolerated by skin</td>
<td>Not all patients absorb it well; potential to transfer to others through skin-to-skin contact soon after application; relatively expensive</td>
</tr>
<tr>
<td>Methyltestosterone (Testred) and fluoxymesterone (Halotestin) pills</td>
<td>Not recommended</td>
<td>None</td>
<td>Can cause liver toxicity</td>
</tr>
<tr>
<td>Buccal testosterone (Striant)</td>
<td>30 mg tablet twice a day; applied to gums</td>
<td>More effective at raising testosterone levels than skin patches</td>
<td>May cause gum or mouth irritation, pain, and tenderness; bitter taste</td>
</tr>
<tr>
<td>Injectable testosterone undecanoate (Nebido/Aveed)</td>
<td>1,000 mg to start; 1,000 mg at 6 weeks; 1,000 mg every 12 weeks thereafter</td>
<td>Needs to be administered only four times a year</td>
<td>Under FDA review and not currently available in the United States</td>
</tr>
</tbody>
</table>

## DRUG INTERACTIONS

Patients who take any of the aforementioned medications should be aware of the drug to drug interaction associated with hormone replacement therapy. “A clinically relevant drug-drug interaction (DDI) occurs when the effectiveness or toxicity of one medication is altered by the administration of another medicine.” 12 For this reason, patients should tell their doctor or pharmacists about any prescriptions and nonprescription medications, vitamins, nutritional supplements, and herbal products they are currently taking before considering hormone replacement therapy. Some common drug to drug interactions include: anticoagulants (blood thinners), such as warfarin (Coumadin), fluticasone (Flovent), triamcinolone (Azmacort), insulin
Humalin, Humalog, Novolin), methylprednisolone (Medrol), prednisone (Deltasone),
propranolol (Inderal), and steroid creams, lotions or ointments. 10

SIDE EFFECTS

In general, hormone replacement therapy is safe. However, it is associated with some side
effects, including: acne or oily skin, sleep apnea (a sleep disorder that results in frequent night
time awakenings and daytime sleepiness), fluid retention, and gynecomastia (breast enlargement)
and is loosely associated with prostate cancer based on an article written in the 1940's. The
theory that testosterone may stimulate the growth of prostate cancer originates from 1941. It was
reported that marked reductions in testosterone following castration or oestrogen treatment
resulted in regression of metastatic prostate cancer. “The thinking became that if lowering
testosterone makes prostate cancer disappear, then raising it must make prostate cancer grow.” 9
Several long-term studies thereafter have failed to prove this theory. As mentioned before,
abnormal liver function (if taken orally) is another side effect. Administration to children is not
recommended and rarely diagnosed because it may stunt growth since it may cause premature
closure of the epiphyses. Furthermore, women who take this medication are at risk of
virilization, such as facial hair and deepening of the voice. 13 The side effects have to be taken
into consideration to determine if the benefits from the treatment far out-weigh the adverse
reactions.

QUALITY OF LIFE

Trying to reverse the signs of aging is not a new phenomenon. In the mid-19th century, a
number of scientists were making new discoveries related to the endocrine system and its
function. Brown-Sequard’s claims of increasing his physical strength and mental ability were
due to injecting himself with testicle extract from dogs and guinea pigs. 2 His claims resulted in
an increase of scientific research about what the testes produce and how they affect the human
body. 2 By the end of the 19th century, doctors were selling Brown-Sequard’s fluid to preserve
the “fountain of youth.” 2 Thereafter, clinical studies have investigated the effects of hormone
therapy.

While many side effects have been associated with hormone replacement therapy;
beneficial effects have been linked to it as well. The benefits are enticing; “improvement in
energy level, lean body mass, strength, and bone mineral density, an improvement in libido and a
sense of well-being.” 14 In one study, “the abdominal circumference and the waist/hip ratio
decreased with treatment, while muscle strength increases in parallel with the gain in lean mass.
Exact figures of androgen sales in the United States are not accurate because a significant
percentage of hormone sales belong to the black market for the purpose of bodybuilding. In a
world full of intense competition, and the pursuit to look better than others, people will do any
means necessary to improve themselves physically. For this reason, men with a desire for large
muscles are prone to abuse testosterone use. Based on the popularity of this drug in the black
market, it is believed that aside from building more muscle; men seek testosterone replacement therapy for the sole purpose of increasing their sex drive. The repercussions of long term use without actually needing it are still unclear. Living in a society obsessed with reversing the effects of aging may lead men to seek this treatment despite not needing the therapy.

CONCLUSION

"The U.S. Food and Drug Administration (FDA) have estimated that 4 to 5 million American men may suffer from hypogonadism, but only 5% are currently treated." In some cases, men avoid talking to their doctor about the possibility of testosterone deficiency due to embarrassment about the symptoms they may be experiencing. After an accurate diagnosis of low testosterone levels or hypogonadism has been determined by the physician and accepted by the patient, hormone replacement therapy can be initiated. The benefits of hormone replacement therapy include, improved body composition, bone density, and cardiovascular health. Other benefits attributed to this type of therapy are a sense of well-being and an increased libido.

Hormonal therapy may be initiated for a variety of reasons, and treatment is normally life-long. Monitoring these patients is also a lifetime commitment and is a shared responsibility that cannot be taken lightly. The physician must emphasize to the patient the need for periodic evaluations and the patient must agree to comply with these requirements. The physician's evaluation should include an assessment of the clinical response and monitoring must be tailored to the indications and individual needs of the patient.

The first time I came across a prescription for testosterone, I was amazed at the retail cost without insurance. Androgel® retails for approximately $400.00 and Testim® for about $385.00. The cost and popularity sparked my interest to research the reasons behind taking this drug. The therapeutic goal of this medication is not to raise testosterone levels so high that men become hyper muscular, or as a formula of eternal youth; but rather this treatment's purpose is to restore normal testosterone levels, providing a higher quality of life for those with a deficiency.
Bibliography


Mercury, Deadly Beauty

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Organic Chemistry 236

Prepared By
Megan Murad
April 17, 2012
Abstract

Mercury is an element that can be found in nearly everything even though it is not found as a stand-alone element. This liquid metal is used in Compact Fluorescent Light Bulbs, face creams, High Fructose Corn Syrup, and even vaccines. This element has multiple forms, some more toxic than others. Mercury can be found everywhere in the environment, including the land, air, and water. Having this type of exposure is not only detrimental to the health of the people, but it is also detrimental to the health of the environment.

Background

Mercury appears in the 80th position on the periodic table. It has an atomic weight of 200.59 amu. Mercury is not found freely in the environment. It is usually attached to Sulfur, forming the mineral, cinnabar, which is a mineral. (1) When this metal is at room temperature it is in a liquid phase; it is the only one that can do that. The high surface tension that the metal experiences causes it to have a low viscosity therefore, making the droplets look round. (2) Mercury is an odorless, shiny silver-white metal. (2,4) The chemical symbol for Mercury is Hg, which is for the Greek word hydragyrum, which means liquid silver. (1,2) Since the metal is a liquid at room temperature, it evaporates easily. In 1500 B.C. Mercury was found in Egyptian Tombs, this made Mercury one of the first metals to be mined. The element is considered a neurotoxin, which is why if someone is exposed to a lot of Mercury, it can cause them to become poisoned, which in turn can open a person up to a series of medical problems or even death. (2)

Amalgams

An amalgam is a mixture of Mercury and another metal. (5) It is used for many things such as batteries, extracts gold from ores, and used in silver tooth fillings. (1) The one metal that Mercury does not bond to form an alloy with is iron, which is why it can be transferred in iron flasks. (2) Dry cell batteries, which contain zinc, are usually in cars and they are easily removable. The batteries contained a mercuric-oxide electrode. The
problem arose with these removable batteries because people were removing these batteries, which contained the electrode and they were disposing of them like they would any other battery. Getting rid of the batteries in an unsafe way is harmful to the environment and human health. The mercuric-oxide electrode is unhealthy for everyone. (6) Miners used Mercury to extract gold from the mines that they were trying to retrieve gold from. When the mines were broken down with water cannons, which were used in hydraulic mining, the various deposits of sand or gravel were broken which caused the gold particles to combined with the liquid element to form an amalgam. A consequence for using the element to extract the gold from the mines was that there was a certain percentage of the metal lost each gold season, which in turn caused the sediments to become contaminated with Mercury. The amounts of the element at the mining sites today show that the method to extract the gold has affected the land and environment, which then can affect human health. (7) One of the most amalgams that were used is mercury, silver, and various other minerals. This combination is used to make silver fillings, which are used to treat decaying teeth. The filling made with a predetermined amount of mercury, which is then added to the tooth to prevent the decay. Having an amalgam filling is rarely harmful. The only time that the fear of being exposed to mercury can occur is when the filling is being put in, taken out, or while someone is chewing. (8,9) Amalgams are used to prevent tooth decay because they do not break easily and they are cheaper to have put in. (10) These mercury vapors can be absorbed through inhalation or ingestion. If the exposure was high, it could cause brain and kidney damage. The FDA and the CDC consider these fillings to be safe and claim that they do not have many problems with them, except for the rare occurrences. (8,9) The people who could have a health risks on their hands with amalgam fillings are women who are pregnant, because it can affect their fetus, and children who are under the age of six, because their little bodies can cause them to have health effects. (10) The exposure to amalgam that people have because of their fillings is similar to what other people get exposed to from the environment. (11) There are still skeptics out there who believe that even the slightest amount of mercury entering the human body is detrimental to the learning abilities of children. A study was performed, over a seven year stretch, on children varying from ages eight to ten years old, where half of the children were given amalgam fillings and the other half were given a composite filling, which contains plastic resin and either quartz or glass filler. The results showed that the children with the amalgam fillings had higher mercury out put in the urine of the children. Even though the
urine output was high, there was no change in the IQ of the children. David Kennedy believes that the mercury fillings are actually harmful. He noticed that the urine excreting the mercury was at its all time high two years after the fillings were put in, and when the numbers started declining, he believes that the kidneys had received some damage, which caused the output of the mercury to leave the body efficiently. (12)

Found in Everyday Items

Mercury can be found in everyday items. Items such as light fixtures, thermometers, and even cosmetics can be made with it. Compact Fluorescent Light Bulbs contain a small amount of mercury in them. They have about four milligrams of mercury in an encapsulated tube, compared to having 500 milligrams in an older thermometer. The mercury is actually beneficial to the light bulb; it causes it to become a proficient light source. The liquid silver does not cause harm when the bulb is intact or if it is being used. Manufacturers have decreased the amount of mercury used in a light bulb by about twenty percent, while others have decreased the amount of mercury used to as low as one milligram per light bulb. Before there were Compact Fluorescent Light (CFL) Bulbs, there were Incandescent light bulbs. The CFL Bulbs were being phased in while the Incandescent Bulbs were being phased out. It turns out using the Incandescent Bulbs added more mercury into the environment than the CFL Bulbs do. The only time the CFL bulbs release mercury is when the bulb is being used, but the mercury is contained in the glass outer shell that is surrounding the encapsulated mercury. Another way mercury is released by the CFL bulbs is when it is disposed of in a landfill, which includes the assumption that the bulb had been broken, causing the mercury to leak out. The total amount of mercury that is expelled from a CFL bulb is 1.6 mg compared to the amount released from the incandescent bulb, which is 5.5 mg. (13)

Mercury thermometers are glass tubes that are filled with the silver metal and it has a temperature scale going up the side of it. They are easily identifiable due to the silver bulb at the bottom of the thermometer. The element then starts to expand or contract due to the temperature in the atmosphere. Mercury thermometers can be used to take temperatures of everything, which includes body temperature, the temperature of vapors and liquids. (14)

Mercury is also popping up in skin care products. These products are placed directly on the skin allowing the mercury to get into the body through absorption. The specific products being affected are skin-lighteners and anti-aging creams. This can also affect adolescents who use the creams as an anti-acne treatment. Product like these are not manufactured in the United States, they are manufactured internationally and then sold illegally in the States. Another reason there is a problem with these skin-care items is because the FDA does not allow mercury in their cosmetics and drugs, unless there is an exception, which these items are not a part of. (15)
Mercury in the Environment

When mercury is introduced into the environment, it can be done in one or two ways: through an oxidation-reduction or methylation-demethylation. Oxidation is an important mechanism for elemental mercury (Hg⁰). Hg⁰ can vaporize easily, which can then be taken up into winds for about a year and then it can deposit itself on land or water. Comparatively reactive mercury (Hg²⁺) is usually in the wind for about two weeks because of its solubility with water. When Hg⁰ is converted to Hg²⁺ it can rapidly take in snow, rain, or small particles and then it is re-deposited into the environment. In the Arctic, Hg⁰ is converted to Hg²⁺ rather quickly, which is known as mercury depletion. This phenomenon happens at the end of the dark polar winters. When the spring sun starts to shine, Hg⁰ changes photo-chemically to Hg²⁺. This reaction happens with either the release of bromine or chlorine. The levels of mercury deplete, because it is deposited on the snow and the icy surface. A side effect of mercury depletion is that scientists still do not know if the Hg⁰ is being converted to Hg²⁺ or if it is being turned into methyl mercury, causing the animals and plants to suffer.

When Hg⁰ or Hg²⁺ gains a methyl group causes the element to undergo methylation. When the Hg²⁺ undergoes methylation, it creates the highly toxic and bio-accumulative compounds, called methyl mercury (MeHg⁺). These compounds increase in living tissue and slowly make it up the food chain, eventually leading up to humans. Methyl mercury is ingested when fish is being eaten. This highly toxic compound of the liquid silver is what causes the poisonings to occur. (16)

Conceptual Biogeochemical Mercury Cycle

Figure 3: Biogeochemical Mercury Cycle (16)
Food

Mercury can be found in certain foods. Methyl mercury can be found in fish and it can also be found in High Fructose Corn Syrup (HFCS). Fish and shellfish are important to a person’s diet. It contains a lot of Omega-3 fatty acids; it is a good source of protein, and other important nutrients. Seafood has such an amazing nutritional benefit; it should be incorporated in everyone’s diet. Almost all fish and shellfish contain mercury. Other sea animals have more mercury than others. The types of seafood that would be okay to eat are catfish, shrimp, and salmon. Since the amount of methyl mercury in the certain fish is too high, it is recommended that certain fishes, such as shark, albacore tuna, swordfish, and tilefish are not consumed by someone who is either pregnant or who is a young child. Methyl mercury can break across the blood placenta barrier. The amount of MeHg in this system can cause children and pregnant women to have mercury poisoning issues. (17)

Mercury has been recently traced back to HFCS. HFCS has replaced a sweetener in many processed products. Tests were performed on the HFCS, which showed that the artificial sweetener, which is in 55 of the leading selling brands, has mercury in it. Children and adolescents have an increased amount of HFCS consumed; their consumption is about an 80 percent above average. A reason why the product is becoming contaminated with mercury is because they still use mercury-cell technology. (18) Having 55 leading brand names tested and having one-third of those products have HFCS with mercury appear in them is a shock. When making HFCS, it is made with caustic soda; this soda is what contaminated the sweetener. Not only do people have to watch out for the consumption of eating HFCS, it is also upon the avoid list because of the possible mercury contamination. Some foods that have mercury in them are Quaker Oatmeal to Go, Jack Daniel’s Barbecue Sauce (Heinz), Hershey’s Chocolate Syrup, Kraft Original Barbecue Sauce, Nutri-Grain Strawberry Cereal Bars, and many more. (19)

Table 1: This is part of a table that shows the amount of mercury found in food with HFCS in it. (19)

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Total Mercury</th>
<th>Limit of Mercury (ppt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quaker Oatmeal to Go,</td>
<td>350</td>
<td>80</td>
</tr>
<tr>
<td>Jack Daniel’s Barbecue Sauce (Heinz),</td>
<td>300</td>
<td>100</td>
</tr>
<tr>
<td>Hershey’s Chocolate Syrup</td>
<td>257</td>
<td>50</td>
</tr>
<tr>
<td>Kraft Original Barbecue Sauce</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>Nutri-Grain Strawberry Cereal Bars</td>
<td>180</td>
<td>80</td>
</tr>
</tbody>
</table>
**Reaction in the Body**

This element is a neurotoxin and it is highly destructive. The nervous system is greatly sensitive to mercury. Having some exposure to mercury can cause renal or neurological damage. The damage to the kidneys and brains are extremely drastic. There are a variety of symptoms that suddenly come to light when someone has been exposed to too much of the metal. These symptoms are personality changes, tremors, vision changes, deafness, loss of coordination and sensation, and there are difficulties with memory. If a woman is pregnant and she is ingesting or inhaling items that tend to have mercury in them, the element can pass to the fetus and cause irreversible harm. This irreversible harm can cause growth problems or it can even terminate the pregnancy. Children who are exposed to mercury vapors can give children stomach, lung and intestinal damage. When methyl mercury is being brought to the body in any way, whether it is through inhalation, ingestion, and having it seep through the skin, it all causes the same damage. (20, 21)

**Proper Handling**

Cleaning up mercury is very similar for whatever the type of spill or issue it is. When cleaning the mercury up, pick everything up that had the element on it or in it, so it is to be placed in a tight sealed plastic bag that it then thrown away in an outdoor facility as to not inhale the fumes that mercury gives off. When physically cleaning the mercury up, gloves need to be worn and each piece of mercury needs to be found as to not to put people’s health at risk. (13,14,15)

The clean up process is very through. The clean up requires every breathing individual in the house to leave the room for a period of time, because of the fumes that could be emitted from the fall. Then someone needs to come in and pick up all of the large pieces of glass carefully and then they need to start picking the pieces of mercury and seal it in a tightly sealed container. Dispose of the items in the trash to make sure the mercury and its fragments are not in-door to cause poisoning from the fumes. (13)

Cleaning up a thermometer break needs extra care when being done. The person who is going to be cleaning up the mercury needs to be extra careful, they need to wear gloves, pick everything up with care, pick up the visible mercury and then go searching and make sure none of the mercury made it to any other area of the room. The clean up for mercury is so intense because it is a highly toxic chemical. (14)

Reading labels and making sure that the word mercury or any word resembling mercury should stopped being used right away. People need to wash their face and hands right away if they are being exposed to the element. If the product being used does have mercury in it, seal it in an airtight container or have it be sealed in a plastic bag. Once the item has been properly stored then it can be discarded, away from the inside of your house. (15)
# Vaccines and Thimerosal

Thimerosal is preservative in vaccines that contain mercury. (22) It is used as a preservative to prevent the growth of bacteria and fungi in the vaccine tube. (23) The use of Thimerosal in the vaccines kills most of the pathogens that it comes in contact with. Thimerosal is about 50% its weight in mercury. When Thimerosal chemically breaks down, it becomes ethyl mercury and thiosalicylate. (24) No current health problems have not been linked to vaccines yet, other than having a red, itchy bump at the injection spot. In July of 1999, the American Academy of Pediatrics, Public Health Service and the people who make the vaccine, agreed together that the amount of Thimerosal should become very limited or it should be non-existent at all. (22)

<table>
<thead>
<tr>
<th>Vaccine</th>
<th>Tradename (Manufacturer)</th>
<th>Thimerosal Status Concentration** (Mercury)</th>
<th>Approval Date for Thimerosal Free or Thimerosal / Preservative Free (Trace Thimerosal)*** Formulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTaP</td>
<td>Infanrix (GlaxoSmithKline Biologicals)</td>
<td>Free</td>
<td>Never contained more than a trace of thimerosal, approval date for thimerosal-free formulation 9/29/2000</td>
</tr>
<tr>
<td></td>
<td>Daptacel (Sanofi Pasteur, Ltd)</td>
<td>Free</td>
<td>Never contained Thimerosal</td>
</tr>
<tr>
<td></td>
<td>Tripedia (Sanofi Pasteur, Inc)</td>
<td>Trace(≤0.3 µg Hg/0.5mL dose)</td>
<td>03/07/01</td>
</tr>
<tr>
<td>DTaP-HepB-IPV</td>
<td>Pediarix (GlaxoSmithKline Biologicals)</td>
<td>Free</td>
<td>Never contained more than a Trace of Thimerosal, approval date for thimerosal-free formulation 1/29/2007</td>
</tr>
<tr>
<td>DTaP-IPV/Hib</td>
<td>Pentacel (sanofi pasteur Ltd.)</td>
<td>Free</td>
<td>Approved June 20, 2008, never contained thimerosal</td>
</tr>
<tr>
<td>DTaP-IPV</td>
<td>KINRIX (Glaxo SmithKline Biologicals)</td>
<td>Free</td>
<td>Approved October 8, 2009, never contained thimerosal</td>
</tr>
<tr>
<td>Pneumococcal conjugate</td>
<td>Prevnar (Wyeth Pharmaceuticals Inc)</td>
<td>Free</td>
<td>Never contained Thimerosal</td>
</tr>
<tr>
<td></td>
<td>Prevnar 13 (Wyeth Pharmaceuticals Inc.)</td>
<td>Free</td>
<td>Approved February 24, 2010, never contained thimerosal</td>
</tr>
<tr>
<td>Inactivated Poliovirus</td>
<td>IPOL (Sanofi Pasteur, SA)</td>
<td>Free</td>
<td>Never contained Thimerosal</td>
</tr>
<tr>
<td>Varicella (chicken pox)</td>
<td>Varivax (Merck &amp; Co., Inc)</td>
<td>Free</td>
<td>Never contained Thimerosal</td>
</tr>
<tr>
<td>Mumps, measles, and rubella</td>
<td>M-M-R-II (Merck &amp; Co., Inc)</td>
<td>Free</td>
<td>Never contained Thimerosal</td>
</tr>
<tr>
<td>Mumps, measles, rubella and varicella</td>
<td>ProQuad (Merck &amp; Co., Inc.)</td>
<td>Free</td>
<td>Approved September 6, 2005, never contained thimerosal</td>
</tr>
<tr>
<td>Heptatitis A</td>
<td>Havrix (GlaxoSmithKline Biologicals)</td>
<td>Free</td>
<td>Never contained thimerosal</td>
</tr>
<tr>
<td>Vaccination Type</td>
<td>Name</td>
<td>Price</td>
<td>Thimerosal Information</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>------------------------------------------------</td>
<td>-------</td>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Hepatitis B</strong></td>
<td>Vaqta (Merck &amp; Co., Inc.)</td>
<td>Free</td>
<td>Never contained thimerosal</td>
</tr>
<tr>
<td></td>
<td>Recombivax HB (Merck &amp; Co., Inc)</td>
<td>Free</td>
<td>08/27/99</td>
</tr>
<tr>
<td></td>
<td>Engerix B (GlaxoSmithKline Biologicals)</td>
<td>Free</td>
<td>03/28/00, approval date for thimerosal-free formulation 1/30/2007</td>
</tr>
<tr>
<td><strong>Haemophilus influenzae type b conjugate (Hib)</strong></td>
<td>ActHIB (Sanofi Pasteur, SA)</td>
<td>Free</td>
<td>Never contained Thimerosal</td>
</tr>
<tr>
<td></td>
<td>OmniHIB (GlaxoSmithKline)</td>
<td>Free</td>
<td>Approval date for thimerosal free formulation 09/99</td>
</tr>
<tr>
<td></td>
<td>PedvaxHIB (Merck &amp; Co, Inc)</td>
<td>Free</td>
<td>Approved August 19, 2009, never contained thimerosal</td>
</tr>
<tr>
<td></td>
<td>HIBERIX (GlaxoSmithKline Biologicals)</td>
<td>Free</td>
<td>Approved August 19, 2009, never contained thimerosal</td>
</tr>
<tr>
<td><strong>Hib/Hepatitis B combination</strong></td>
<td>Convax (Merck &amp; Co, Inc)</td>
<td>Free</td>
<td>Never contained Thimerosal</td>
</tr>
<tr>
<td><strong>Seasonal Trivalent Influenza</strong></td>
<td>Fluzone (multi-dose presentation) (Sanofi Pasteur, Inc)</td>
<td>0.01% (12.5 µg/0.25 mL dose, 25 µg/0.5 mL dose)</td>
<td>12/23/2004</td>
</tr>
<tr>
<td></td>
<td>Fluzone (single-dose presentation) (Sanofi Pasteur, Inc)</td>
<td>Free</td>
<td>12/23/2004</td>
</tr>
<tr>
<td></td>
<td>Fluvirin (multi-dose presentation) (Novartis Vaccines and Diagnostics Ltd)</td>
<td>0.01% (25 µg/0.5 mL dose)</td>
<td>09/28/01</td>
</tr>
<tr>
<td></td>
<td>Fluvirin (single dose presentation) (Novartis Vaccines and Diagnostics Ltd) (Preservative Free)</td>
<td>Trace (&lt;1ug Hg/0.5mL dose)</td>
<td>09/28/01</td>
</tr>
<tr>
<td></td>
<td>Fiularix (single-dose presentation) (GlaxoSmithKline Biologicals)</td>
<td>Free</td>
<td>Approved 10/19/09, never contained thimerosal</td>
</tr>
<tr>
<td></td>
<td>Afluria (multi-dose presentation) (CSL Limited)</td>
<td>0.01% (24.5 µg/0.5 mL dose)</td>
<td>Approved 11/10/09, never contained thimerosal</td>
</tr>
<tr>
<td></td>
<td>Afluria (single-dose presentation) (CSL Limited)</td>
<td>Free</td>
<td>Approved 11/10/09, never contained thimerosal</td>
</tr>
<tr>
<td><strong>Seasonal Influenza, live</strong></td>
<td>FluMist (Medimmune Vaccines, Inc)</td>
<td>Free</td>
<td>Never contained Thimerosal</td>
</tr>
<tr>
<td><strong>Rotavirus</strong></td>
<td>RotaTeq (Merck and Co., Inc.)</td>
<td>Free</td>
<td>Approved February 3, 2008, never contained thimerosal</td>
</tr>
<tr>
<td></td>
<td>Rotarix (GlaxoSmithKline Biologicals)</td>
<td>Free</td>
<td>Approved April 3, 2008, never contained thimerosal</td>
</tr>
</tbody>
</table>

Table 2: Shows an up to date vaccines and the amount of thimerosal in them (25)
Exposure and Cure

There are many ways to be exposed to mercury because it is in the land, air, and water. A common way to become exposed to mercury vapors is through the dental fillings, the amalgams. When it is being put into the tooth or even being taken out of the tooth, it is releasing vapor, if it is bitten down on it the wrong way through chewing, it can release a mercury vapor as well. The amount of mercury released through dental amalgams ranges from three-17 grams per day. The inhalation of this small amount of vapor does not necessarily mean it is harmful to someone’s health. Mercury is even used in some religious practices, causing the people who are apart of those practices to expose themselves. The religions that practice with mercury are Voodoo, Santeria, Palo Mayombe, and Espiritismo. Products around the home like the CFL Bulbs, mercury thermometers, and barometers could have mercury in them. The items just listed are not a threat unless the glass is broken or damaged. People can be exposed to mercury with the jobs they work. A very common way that people are exposed to mercury is through fish and shellfish that have a very high content of methyl mercury, which is very toxic. This form of mercury is readily entered into the human body through the gastrointestinal tract. Mercury can enter the human body through inhalation, ingestion, or even from skin to product contact. Metallic mercury, even if taken by the spoonful, does not affect the human body, but when someone breathes in vapors, it is a cause for concern, up to 80 percent of the mercury inhaled is very detrimental to the body, because it goes straight from the lungs to the venous system. (20)

Ways to limit the exposure to mercury is to not have children play with the liquid silver, which can decrease the amount of mercury that the children are exposed to. Children think the liquid metal is fun to play with, and their little bodies are highly susceptible to become exposed to toxic levels of the liquid silver. If there happens to be a mercury spill, people need to pick it up carefully and they have to make sure every drop is out from the inside of their house. People should not eat the shellfish or fish that is on the high mercury list, because methyl mercury, as stated earlier, is highly toxic. (20)

A cure for mercury poisoning is to have a mercury chelation performed to remove excess metals from the body. The chelation is a mixture of cilantro and chlorella, which removes the toxins and the heavy metals, such as mercury, from someone’s system. Cilantro is used because it changes the intracellular electric charges on the metals in the body, which causes them to be transferred into a neutral state and makes it easier to become flushed out of the body easier. When the metals need to be removed from the body is when the chlorella comes into the picture. Chlorella has the ability to absorb heavy metals, such as mercury, and remove them from the body. Once this 42-day cleanse is complete, it should be repeated every three to four months, unless there are outside factors such as amalgam fillings or the consumption of fish high in mercury, which causes the chelation to be performed every two months as advised so there will not be an excess of mercury affecting the internal organ system. Do not do the detox everyday, because believe it or not, the body needs some heavy metals. (25)
Conclusion

I believe that mercury should not be used in anything that can affect the environment or the health of people everywhere. Mistakes made when the miners were looking for gold are affecting us now. Certain fishes can not be eaten, or they have to be avoided in general because of the high content of mercury that is contained within them, because of the sediments, that infected the water, which in turn infected the fish. Face creams, such as anti-aging products, have mercury in them, which is a problem, because nothing is sacred anymore. I know I do not want nervous system, neurological, or renal damage because of mistakes that people made years ago.

There is no point in having mercury in the vaccines used to immunize children and infants today. That mercury affects their little bodies, it might not be proven, but there has to be some damage done to the body in a subliminal way. Life is already hard enough, why add the effects of mercury poisoning to it? But it does make sense as to why mercury is still used today, because people have fascinations with items that are deadly beauties.
Bibliography:
10. http://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/DentalProducts/DentalAmalgam/ucm171094.htm#2
15. http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm294849
3D Printing

Afan Nwambuonwo

April 18, 2012

PHY112

Casey Durandet
Abstract

Printing has not only played an important role in humanity’s history but has also revolutionized the concept of transformative technologies with the development of 3D techniques. Today, 3D printing has the potential to move many fields, particularly medicine, into an unseem future where doctors could potentially request a needed organ and a computer could “print” the part allowing physical models to demonstrate and illustrate mechanical concepts. This paper discusses the developmental history of this emerging technology; the intricacies of how it works; and the benefits that this innovation provides.

Introduction

Ted Levitt, a pioneer on market globalization once said “Just as energy is the basis of life itself and ideas the source of innovation, so is innovation the vital spark of all human change, improvement and progress”. He was not wrong. Hand in hand, innovation and technology have progressively changed the course of human history. From the very beginning of discovering how to make a fire in the 770,000BC for basic human survival, to the invention of windmills as an energy source in the 1000AC, to the discovery of electromagnetism in the 1830s from which the electric generator, motor and relay were developed opening the gates of innovation and moving humanity to an era of ipads and Apple stores. The 2000s brought a new generation of innovation and technology, moving our and future generations to a more efficient, rapid, and self-sufficient era while re-defining our future.

3D Printing technologies is one example of this new era; a breakthrough idea that could change the future of medicine. 3D printing techniques can be used to create human organs as well as the blood vessels that would connect them to a recipient and could one day, solve the problem of organ donor shortages. This paper discusses the developmental history of this revolutionary emerging technology, from its early stages in the early 1980s until today; the intricacies of how it works together with its past and current methodologies; and the benefits of this technology.

History

From the beginning of times until today, printing has evolved taking various forms throughout history: from woodblock prints, the printing press, lithography, rotary press, screen printing during the 1900s to photocopying, laser printing in the 1960s to dot matrix printing, inkjet printing to the modern day 3D printers and printing, taking a long stroll in the development of printing techniques and technologies.

Charles Hull, born on May 12, 1939, was the founder of 3D Systems in 1984, developing the idea of 3D printing. Hull, served as inventor of over 60 patents in the fields of ion optics and rapid prototyping in the United States. In his patent for the “Apparatus for Production of Three-Dimensional Objects by stereolithography”, issued on March 11, 1986, he defined stereolithography as a method and equipment for making solid objects by successively “printing” thin
layers of the ultraviolet curable material one on top of the other. Originally called Stereolithography, this technique was in parallel development with Fused Deposition Modeling (FDM), invented in 1988 by Scott Crump, the founder of Stratasys (today, one of the leading corporations that sells products used in the aerospace, defense, automotive, medical, business & industrial equipment, education, architecture, and consumer-products fields). In 1993 the Massachusetts Institute of Technology (MIT) contributed to the advancement of this field by patenting “3 Dimensional Printing techniques” based on modifications to 2D printers, which was then licensed to Z Corporation for development of their 3D printers. In 1996 Z Corp released, as a major advancement, their 3D printers by Z Corp, Stratasys, and 3D Systems. At this point in time, the use and idea of a 3D printer nomenclature became more prevalent and known worldwide. Over the next decade, this revolutionary and innovative printer technology made great advances in respect to resolution and software capabilities, concluding in 2005 with the launch of the Spectrum Z510, the first high definition color printer in the market. The following year, in England, a breakthrough open source printing project, named Re-prap, was created. This project was capable of re-manufacturing various plastic parts; roughly 50% of itself. From 2008 to 2010, the industry developed a few improved models, one with larger capabilities than the other, such as self-replication techniques. In early 2011, a Dutch printer manufacturer created a faster model raising the average travel rate to 250mm/second, and later that year a fashion manufacturer jumped on the boat of 3D printing developing the first 3D printed bikini. Following the notorious 3D clothing item, the University of Brunel and application developer Delcam invented the first 3D chocolate printer.

As the technology expanded impacting many fields, scientists and researchers are using 3D printing today to create bone-like material that paired with actual bone could revolutionize not only the organ donor scarce but also could move medicine to a new frontier.

How does it work?

3D printing, also known as additive manufacturing is a prototyping process whereby a real object is created from a 3D design. 3D printing is actually a subset of Additive Manufacturing and it has been defined as the “process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies.” Although various 3D printing technologies exist, they all operate under the same principles: CAD software used to slice a digital object into layers as thin as 10 microns; the 2D pattern of each layer is transmitted to a 3D printer that extrudes, sprays, or spreads raw material onto a flat, horizontal platform; the material is cured, laser sintered, fused or bound by UV light, lasers or electron beams. The process repeats itself until the object is fully formed.
The generalized steps of Additive Manufacturing are shown below.

Additive manufacturing process begins with computer-aided design (CAD) software used to create a 3D model of the object. This 3D model can also be obtained using a scan of an existing object. Specialized software slices this model into cross-sectional layers, creating a computer file that is sent to the additive manufacturing machine then creates the object by forming each layer via the selective placement of material. This process is similar to an inkjet printer going back over and over the page, adding layers of material on top of each other until the original works are 3D objects.

There are a few technologies capable of 3D printing such as FDM (Fused Deposition Modeling) or Fused Filament Fabrication, SLS (Selective Laser Sintering) and SLA (Stereolithography). Fused Filament Fabrication involves extruding thermoplastic or wax material through heated nozzles to create a part’s cross sections. Filament feedstock is guided by a roller into a liquefier that is heated to a temperature above the filament’s melting point. The material is then able to flow freely through the nozzle. When the material reaches the substrate, it cools and hardens. Once the layer is finished, the build platform is lowered one layer-thickness by the Z-stage and deposition of the next layer begins. Stereolithography involves the use of ultraviolet laser to harden a photosensitive polymer. While Laser Sintering uses a laser to selectively melt metal or polymeric powder into the desired 3D replica.
An example of a Fused Filament Fabrication Process is shown below.
Today with the help of recent developments in 3D printing technology, an increasing amount of materials are being used simultaneously. Below is a picture of a typical 3D printer.

In short, 3D printing works by stacking differently shaped layers of matter on top of each other to create the desired object. The thinner the layers, the more complex the objects can be. Using high powered lasers, new advancements allow scientists to work on a molecular level.

**Innovations**

On a study conducted at Washington State University (WSU) researchers used a 3D printer to create a bone-like material and structure that could be used in orthopedic procedures, dental work and to deliver medicine for treating osteoporosis. Paired with actual bone, it acts as a scaffold for new bone to grow on which ultimately dissolves with no apparent ill effects. One of the main findings is on the type of paper, which with the addition of silicon and zinc more than doubles the strength of the main material, calcium phosphate. As an added innovation, researchers at Washington State University also spent time optimizing a commercially available ProMetal 3D printer designed to make metal objects.
The printer works by having an inkjet spray and a plastic binder over a bed of powder in layers of 20 microns, about half the width of a human hair. Following a computer’s directions, it creates a channeled cylinder the size of a pencil eraser. After just a week in a medium with immature human bone cells, the scaffold was supporting a network of new bone cells. However, artificial bone scaffolds would enable doctors to repair defects or injuries without taking a bone graph from elsewhere in the patient’s body or using a synthetic mesh material that can have negative long-term effects. Produced using a 3D inkjet printer, and a bone-like ceramic, it harmlessly dissolves as new bone grows around it. This method has been tested in small animal models where the bone grows over them with success. Susmita Bose, WDS’s lead bone printer, reported that this methodology has also been tested with human bone cells finding that bone will grow over them successfully as well.9

As this technology continued to develop over the past few years, researchers have been focusing their efforts on improving techniques to produce biological materials like organs with 3D printers. The prospect of transplanting 3D-printed organs into living patients rose when a team of German researchers announced in September of 2011 that they had perfected a method to print blood vessels as well. It is of inherent nature that the human body wants to reject artificial materials, but with controlled chemistry, scientists can better replicate human cellular makeup and also embed drugs that help the body accept the transplants. While the material differs for organs, the bone-like powder used to print scaffolds is very similar to actual bone.

Pros and Cons

The advantages of 3D printing are numerous. As a result of additive manufacturing processes, complex geometries impossible to fabricate by any other means are possible. Additive manufacturing offers the maximum geometrical freedom in engineering design thereby creating new opportunities for design in industries as diverse as aerospace, automotive and bio-engineering. Another advantage of additive manufacturing is that it is possible to create functional parts without the need for assembly, saving both production time and cost. Finally, additive manufacturing processes are inherently “green”. Since material is added layer by layer, only the material needed for the part is used for production. There is virtually little or no waste compared to traditional subtractive manufacturing. With the use of local materials that are more appropriate for local consumption, recycled materials could be used.

There are limitations to 3D printing just like any other manufacturing processes. Additive manufacturing processes are limited for mass production purposes. These additive-manufacturing processes will continue to grow in speed but it is highly unlikely they would be able to create parts as fast as molding technologies. Instead, this process would be more appropriate for custom parts. Finally, there is a great need for better material to use in printing and greater uniformity in production quality.
Conclusion
It is truly remarkable not only how much innovation has affected the growth of technology but also how far society has come from the times when man discovered how to make a fire. It is an understatement to say that transformative technologies have moved society forward. I would not be surprised if we start seeing 3D printers in hospitals in the near future. When a doctor needs a particular organ, he would send a CT scan to a specialist who would generate a computer-aided design (CAD) file that would provide the 3D printer with detailed instructions for printing the part. A surgeon would implant the transplant, and hope that the patient would make a speedy, easy recovery. How difficult is it to imitate nature?
BIBLIOGRAPHY


