



## **Toxic Effects of Mercury, Alcohol, and Cannabis on Human Cellular Function**

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### **Introduction**

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All life, every organism, or any person moves, eats, reacts, and reproduces because of very small molecules or chemicals that move through the cell and the organism. Chemical reactions are the reason for every action by a living thing. Each of these processes can be explained, if not now, then later when our understanding becomes more complete. Gone are the days that we would say that we do not know why something happens, we might not completely understand the chemistry of every process of life, but we know there is a process to be discovered.

I still remember in the early 1980's when HIV started to appear and truly the general population did not know where it came from, how it was transmitted, or if you could get it from a handshake. The general population looked for extreme solutions, which fueled prejudice, isolation, and misunderstanding. Science understood that there had to be something there that was causing the disease, and followed systematic steps to identify the source, and to identify the molecules that would slow and stop it. It highlighted to me that certain chemical reactions need to be identified, demystified, and understood. If this could happen, life for everyone will be better, longer and safer.

When I heard about the seminar topic "How Drugs Work.", I joined most of my friends and colleagues with a raised eyebrow and smile thinking about recreational drugs. I began to explore the toxic effects of these substances and the negative repercussions for my students. I also began looking at other toxic substances surround my community, and found that there were common biological issues. The toxic substance needed a delivery system, a chemical process that would negatively affect the person, and a way for the body to heal itself and adjust to the chemical. But just as in the HIV story there also exists misinformation, mystery, and weird personal opinions on the substances. I feel that the best way to understand the chemical and societal issues is through a systematic and scientific process to identify and enlighten my students.

I will allow my students to evaluate the characteristics of four toxic substances: alcohol, tetrahydrocannabinol (THC), lead and mercury. We will look for their toxic effects on the cell, organs and human organism. They will focus on the chemical processes, but also the benefits, lasting health problems, and societal concerns for each of these toxins. In order to give each student a better understanding of the chemical processes, we will also conduct an extensive examination of how cells maintain an organism. We will examine the main components

of an organism and how the toxins inhibit the organism's functions.

Our current science curriculum focuses on hands-on experiments, observable scientific inquiry, and significant support for non-fiction scientific readings. The curriculum is light on a systematic understanding of cellular functions and cellular interdependence, so my unit should provide additional support in understanding of concepts from our state standards. Additionally my unit will support out current curriculum by maintaining focus on experiments, non-fiction scientific reading, reinforcing concepts of trade-offs, concentration, chemical reactions and molecular chemistry.

## Rationale

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This unit was written for my eighth grade science class at a neighborhood (non-selective enrollment), public elementary school (K-8) on the far southeast corner of Chicago. According to the 2011 Illinois School Report Card, the school population was 13.7% White, 9.3% Black, 74.9% Hispanic and 2.1% other; of this population 92.6% are considered low income, 26.6% are Limited-English-proficient students, 11.1% have Individual Education Plans. <sup>1</sup>

The geographic information of our community includes several major industrial factories, both functional and abandoned. The area also includes several well-used natural resources long frequented by outdoorsman and fishermen. There are a large proportion of residents who actively use the resources, without regard for the dangers of potential mercury pollution in fishes. Currently there are additional proposals in the community to add new industries, which may potentially release lead into the environment. I want to make the students more aware of these more personal issues surrounding their community.

I want to demystify the chemical reactions that occur from the use of both alcohol and cannabis, so the students better understand the near and long range consequences of their actions. I want to make the students aware of personal exposure to toxic chemicals and what can be done to mitigate the problems. There is some recreational drug use in our community and additionally some students have relatives that have experienced cancer, asthma, heart disease and related illnesses. I regularly field questions about why people lose their hair when they should be trying to get better from cancer treatment, but when the child with the question is asking about their relative, it is too hard to get into detail about cell structure and toxicity levels. I want my students to be armed with the information themselves, before the questions arise, so they can have a more informed understanding of how drugs work.

There also seems to be more misconception about the other toxic substances. There are many fishermen in the community. Lead and mercury contaminants have been regular problems since the times when steel mills, factories and waste dumps interspersed with two major lakes and natural marsh in the area. The Illinois Environmental Protection Agency regularly provides warnings about fish consumption, which are often ignored; many residents think that the fish is safe since they have not been sick yet. <sup>2</sup> A current issue is a potential cement factory permit being issued which would either provide additional pollutants or meaningful economic opportunity. <sup>3</sup> By giving my students information, they will be able to weight the trade-offs and understand the issues better.

## Background Information

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This section provides the information that the student will need to know before evaluating the toxicity of the substances. I want the student to know about the toxic substances and how they are administered, how they stay in the human system, and how they are cleansed from the system. I want the student to understand that all functions of an organism can be traced back to a chemical reaction, or set of chemical reactions, within the organism. I want the student to think: if something happens to a person, then I want to know what chemical reaction occurred to make that something happen.

### The Living Organism

Toxicity is the degree to which a substance can damage a living organism. It is important to make sure that there is a solid understanding of whether a substance is living or not. Many things have been called living but are not really alive. People say that the Constitution is a living document, that a stadium was alive with excitement, or that the river was alive. An organism exhibits the basic characteristics of living things including reproduction, cellular structure, response to stimuli, growth, adaptation, development, and use of energy and movement. <sup>4</sup>

Since all living things are comprised of cells there should also be an understanding that cells comprise tissue, while tissues group together to form organs, organs work together to form organ systems, and finally organ systems are grouped to create the complex organisms. Simpler organisms such as bacteria need to provide all of the characteristics of living things within their single cell: these are classified as prokaryotic cells. Most animals that my students will encounter (humans, dogs, cats) have organ systems and they are classified as eukaryotes. They are more complex and are able to do more things as far as eating, moving, and reacting than simple single cell organisms. How cells, tissue, organs, systems and the organism communicate with each other will be discussed later in this section.

### Parts of a Cell

The nucleus is the part of the cell that contains the genome, which provides the chemical codes for a cell to produce the chemicals needed for the cell to function. Deoxyribonucleic acid (DNA) is used to create ribonucleic acid (RNA) through the process of transcription. A part of the DNA uncoils and is used to make a duplicate of half the strand of DNA. Each nucleotide is paired with its complementary nucleotide (i.e. guanine and cytosine) only adenine will match with uracil in RNA, while it matches with thymine in DNA. Once this messenger RNA (mRNA) is transcribed it is released into the cytoplasm, which is the main body of the cell and is made of water and other chemicals. A ribosome uses the mRNA to translate the genetic code to produce different proteins which perform functions of the cell.

The cell gets its energy from glucose (sugar) and the process of respiration, which works to prepare enough energy for the cells to do their needed tasks. The cell uses the mitochondria to generate additional energy in the form of adenosine triphosphate (ATP), which are chemical forms of energy in units that the cell needs to perform particular tasks. The cell is surrounded by a semi-permeable membrane that protects the cell and limits how and what can enter the cell. The semi-permeability is an important issue because small molecules such as water and oxygen will diffuse through the cell membrane based on concentration levels on each side of the membrane, while larger molecules and substances (i.e. glucose, proteins, viruses, and toxins) will need some type of transport mechanism to enter the cell.

## Transporting Molecules around a Cell

Much of the movement of molecules throughout tissue and to a cell happens by diffusion of the molecules within the water of a cell and tissue. Diffusion is the random movement of particles in a solution. Over time molecules in a solution will keep moving and eventually have a uniformly distributed mixture of the molecules. If there are more of these molecules in one part of the water, it is said that it has a higher concentration of the molecule. Concentration is expressed as a fraction of the amount of a substance (the molecule) divided by the volume of all the fluid. Diffusion will always occur from the point of higher concentration and move to a point of lower concentration.

In discussing concentration, a gradient is a distribution of the substance in space. If you move with the gradient, this is the natural way that the substance will diffuse, always from the point of higher to lower concentration. If you move against the gradient, you are moving some of the substance from the point of lower concentration to higher. This will require additional energy to accomplish.

How larger molecules get into and out of the cell are a bit more complicated than through diffusion. Sometimes we will need to move substances against the gradient to create a surplus of that substance. We will need other methods to transport them.

Larger molecules will not be able to pass through the cell membrane. There will need to be additional methods to transport molecules including glucose and other molecules needed by the cell to survive and perform its needed functions. Glucose cannot enter the cell naturally, but requires facilitated transport using a transporter or a special protein on the surface of the membrane that creates a channel to allow glucose to pass through after the glucose attaches itself to the transporter. Glucose passes through the transporter from a solution of higher concentration to lower concentration. This is still a form of passive transport through the cell membrane. Glucose is the food for the cell and this is a way to get the food through the cell membrane. <sup>5</sup>

Other substances need assistance to cross the membrane. This assistance comes in the form of active transport and requires the use of energy in the form of ATP. Active transport can move a substance up the concentration gradient from low to high. A Na-K pump is an example of such a transporter. The pump will move sodium out of the cell and potassium into the cell to allow the cell to contain a higher concentration of potassium than in the fluid around that surrounds it. <sup>6</sup>

Co-transporters will carry pairs of substances into or out of a cell, while exchangers will replace one substance for another. A co-transporter example is Na/Glucose transporter where the glucose can pass when paired up with a sodium ion. Each of these will allow the transport because there is now a higher concentration of sodium in the cell. A sodium/calcium (Na-Ca) exchanger will have one ion of sodium cross the membrane while one ion of calcium will travel in the opposite direction. The cell uses the Na-K pump, and the ATP used to drive it, to move sodium out of the cell, and now the sodium allows the other substance to enter or leave by exploiting the gradient of sodium. <sup>7</sup>

Ion channels allow sodium, potassium, and other ions to flow through the membrane. With a sodium ion channel the structure of the channel will regulate the sodium ion entering the cell. The positively charged sodium ion will bind to the structure of the channel. Other types of channels are gated and require a substance or protein to come in contact with the channel. The shape of the protein will move into the channels to open the gate and allow transport across the membrane. The substance needed to affect the channel is called a ligand.

Receptor-mediated endocytosis allows the cell to get special substances into the cell. Receptors appear on the surface of the cell membrane and when a substance fits into the receptor, and the receptor will bring the ligand into the cell. The receptors are either reused or are degraded within the cell.

All these transporters and receptors are scattered over the cell membrane. They will come in contact with either the substance that needs to cross the membrane, the ligand to open the channel or receptor, or the combination of both. The substances float around the cell in solution and the concentration gradient is the major factor in making sure that the substance is available to the cell. There needs to be enough of the molecules in the concentration to make sure that enough molecules enter the cell to produce the appropriate chemical reactions to allow the cell to function. <sup>8</sup>

### **System Communication**

Cells communicate with other cells, and other tissue, organs, systems, and organisms. They do this through chemicals. To communicate, a cell will generate a signal, in the form of a molecule such as a protein, and release it into the blood stream. The signaling molecule is carried to the receptor of another cell in another organ. This will "communicate" to the new cell what needs to be done. The first cell creates a chemical, and that chemical travels to another cell and causes a chemical reaction.

Types of cell that promotes a great deal of intercellular communication are neurons. They are responsible for controlling muscle movement, feeling of touch, and memory. A neuron cell has protrusions called dendrites that reach out and collect information from other neurons. The body of the neuron contains the nucleus and other organelles needed for the cell, and another long protrusion called an axon, which is responsible for the output signal needed to complete some process.

The signals created by the axon are chemicals. They are neurotransmitters which are released from the axon in response to signals received by receptors in the dendrites. These chemicals or ligands travel through a space called a synapse to receptors on another neuron to either continue the communication, or to a muscle neuron, which would cause the muscle to contract and potentially move a finger. <sup>9</sup>

We have discussed chemicals that cause cells to do certain things, either through crossing into the cell or affecting a reaction with a receptor on the face of the cell membrane. The chemical that causes the event is called a ligand. The process occurs because the chemical structure of the ligand will physically fit into the receptor. There are other chemicals whose shape and structure are similar enough to trigger the same reaction. These substances are called agonists. Agonists would trigger the same process, but might have different side effects from the original ligand. There are also chemicals that can block the receptor from receiving the ligand or agonist. They fit into the receptor and stop a chance for the process to occur. This kind of chemical is called an antagonist. Each of these chemicals offers potential to either enhance or stop any process that a cell needs to perform.

### **Hormones and the Endocrine System**

But the organism needs to be able to communicate on a larger scale. The organism needs to maintain itself and adjust to invaders, grow, or develop. Hormones are chemicals created by certain tissues in the body, which produce large amounts of chemicals for larger functions of the organism. There is not the direct cell-to-cell communication that we observed in the neurons, but a system-wide chemical throughout the body that attaches to similar receptors in each of the affected cells, which can change the composition and/or function of organs or organ systems.

There are basically two types of hormones, and their structure and composition determine how they impact the cell. Water-soluble hormones — including insulin, peptides and proteins — cannot cross the cell membrane, so they need a receptor of some type to enter or affect a cell. Fat-soluble hormones are able to pass through the cell membrane because they are fat based. They then bind to a hormone receptor within the cell and are able to proceed to the nucleus to interact with the DNA of the cell. These changes account for some of the system wide growth and development of the organism. <sup>10</sup> Typical fat soluble hormones are sex hormones and vitamin D. The first regulates sex drive and development, while the latter plays important roles in membrane growth.

The body of the organism is constantly trying to keep itself healthy and alive. When any invader or toxin enters the organism, mechanisms are engaged to combat whatever influence is trying to cause harm. The process of bringing the organism back to its normal state is called homeostasis. The endocrine system is an important regulatory system for maintaining homeostasis. When something goes wrong to the organism, the endocrine system goes to work to alert the needed organ to restore the organism to health. If the body starts to feel that the level of glucose (energy) begins to fall, the hypothalamus gets signals that the body is not processing enough energy it pumps out a chemical (hormone) that signals the pituitary gland to produce yet another hormone thyroid stimulating hormone, which affect the thyroid setting off another hormone telling all the cells to process more glucose to produce more energy. When the body produces enough energy the process stops, and if the organism overshoots the normal level an opposite response is triggered. <sup>11</sup>

Different hormones are created by different glands. The hypothalamus regulates the pituitary gland, which creates antidiuretic hormone, which regulates water balance by telling the kidney not to release water. The pituitary gland produces hormones that regulate growth, blood pressure, metabolism, pregnancy, lactation, childbirth, reproduction, and temperature along with water balancing. The thyroid gland regulates metabolism and calcium and phosphate in the blood. The adrenal glands produce compounds that can speed up the heart, store emergency glucose in the body, provide powerful anti-inflammatory effects, and produces noradrenaline and adrenaline, which aid the organism in emergency situations. The pancreas produces insulin and glucagon whose function is to regulate the consistent concentration of glucose in the blood. The testes produce testosterone in men, while the ovaries produce estrogen and progesterone in women. Each of the hormones is essential in developing the appropriate sexual characteristics of sexual organs, voice, hair, and sexual behavior. The pineal gland produces melatonin and plays an important role in restoring cells and the sleep cycle.

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Hormones play a critical role in the maintenance of a stable environment for the organism to function. Glands accept chemicals through receptors from other cells, organs, and other glands which trigger release of hormones to communicate, start or stop a process in another part of the body or the entire body as a whole. Hormones act as control and communication chemicals for the organism.

### **Organs that Remove Toxins from the Body**

There are many organs and systems that work together to protect from and eliminate toxins. Many organs can metabolize toxins in some way or form. Some organs work together to metabolize toxins in the organism.

The kidney will metabolize some toxins, and is very effective in excreting toxins in urine, especially water soluble toxins. The kidneys provide the major blood filtering organ and are effective in removing nitrogen based compounds from the blood, regulating acidity and water in the blood and blood pressure. The kidney also secretes hormones, which regulate vitamin D and production of red blood cells.

Human skin is the largest organ in the human body and is remarkably effective in protecting the body from many harmful substances. It is semi-permeable and does allow absorption of many substances. It also has characteristics of sensation, providing input to the body, excretion, providing waste removal from the body, and heat regulation, providing a regulated temperature for the body.

The digestive system has a great potential to let toxins into the body. Toxins can enter in food, water and other things ingested through the mouth and digestive tract. There are some safeguards that can prevent and eliminate potential chemical toxins in the digestive system. Enzymes and acids used to breakdown food into usable chemicals can also have a similar effect on toxins. Many ingested toxins are too large and not absorbed by the digestive system and are later excreted.

The liver is a main filtering organ in the body. Many other organs can metabolize toxins, but the liver is the most adept organ, especially with lipid soluble toxins. The liver is the source of many enzymes which metabolize lipid soluble and water soluble toxins. The metabolism happens in two phases. The liver is a major organ in processing alcohol. The liver produces alcohol dehydrogenase, which breaks down the alcohol into acetaldehyde, which is responsible for the hangover effect. <sup>13</sup> Pound for pound the liver can metabolize more toxins than any other organ. <sup>14</sup>

Since the body tries to return to homeostasis, the working of the hormones and the liver as a cleansing organ, the body will adjust to a person taking drugs. This leads to issues of addiction, tolerance and dependence. Once the body senses a toxic substance, the drug, the organs begin to send signals to try to fight the toxin, even if we enjoy the effect. The liver increases its metabolism of the toxin, so you will begin to need higher and higher doses to achieve the same effect. In the event that we begin to stop taking the toxin, the body is still expecting the amount that was being added, so naturally occurring substances that mimic the drug are not being produced, so the body feels a negative effect from the lack of its own chemicals. This is called withdrawal. Withdrawal and tolerance are major factors leading to the difficulty of people to stop taking drugs.

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## **Alcohol**

Alcohol is a drug that has a long history and strong cultural and social roots in our society. First evidence of alcohol dates back to about 5000BC and there is recorded history from Greeks, Romans, and medieval monasteries. <sup>16</sup> Alcohol is referenced twice in the United States constitution first in the 19<sup>th</sup> Amendment establishing prohibition, and then in the 21<sup>st</sup> Amendment abolishing prohibition. Most alcohol is consumed as a beverage, but it also can be ingested in food.

The correct chemical name of alcohol is ethanol (or ethyl alcohol) and it is a relatively small molecule. A standard drink contains eight grams of alcohol and this is considered one unit. Once inside the body it is metabolized with an enzyme called alcohol dehydrogenase (ADH) in either the stomach or liver. ADH can metabolize about one unit per hour, and if you drink any more that that you will increase the concentration of alcohol in your blood and you will feel the effects of alcohol. The effects are complex. It is a general depressant that has an inhibiting effect on several areas of the brain. The results may include talkative, restless, or aggressive behaviors, while it also may inhibit balance, memory, coordination and speech. At very high intakes breathing and heart rate may be affected. Alcohol has an effect on GABA receptors in the brain and this leads to a feeling of reduced stress and can also increase dopamine which can lead to euphoric feelings. <sup>17</sup>

It is the metabolized alcohol that produces the "hangover" feelings of nausea and vomiting. Alcohol and the hangover will also interfere with the sleep cycle and increasing fatigue. Women also have less ADH activity than men, so the effects of drinking on women are more pronounced. Apart from the individual effects of drinking, there are excessive and long-term effects. Binge drinking can lead to automobile accidents, violence, and even suicide. <sup>18</sup> Drinking and taking other drugs can have a serious cross effect. Mixing alcohol and barbiturates can lead to a lethal effect since each of the drugs work as depressants together. In the year 2002 10.7% of 12-17 year olds were classified as binge drinkers. Long term effects of excessive alcohol consumption include coronary disease, cancer, depression, liver cirrhosis and acute or chronic pancreatitis. <sup>19</sup>

## **Cannabis**

Cannabis, which goes by the Spanish name of marijuana, has a long history as well. Evidence of cannabis use has been found in the Far East, Middle East, Europe and the Americas. It was widely used for its medicinal properties in the 19<sup>th</sup> century and was even prescribed to Queen Victoria to alleviate menstrual cramps. <sup>20</sup> Cannabis has been an illegal drug in the United States for both distribution and possession since 1937. Cannabis is consumed in three main forms as hemp for rope or clothing, the dried flowers and tops are smoked as marijuana, and the resin form can be smoked or eaten in cakes and is known as hashish. <sup>21</sup>

Cannabis is considered a psychedelic drug in the same category as Ecstasy, Lysergic acid diethylamide (LSD), and certain hallucinogenic mushrooms (magic mushrooms). Smoked cannabis alters perception of time and space while relaxing the user fairly quickly. Cannabis that is ingested can take longer to enter the blood. Some side effects in higher doses include anxiety, paranoia, and excessive hunger and thirst. There are also some medical properties of cannabis including lowering eye blood pressure as a treatment for glaucoma, pain and muscle spasticity in multiple sclerosis, nausea in chemotherapy cancer patients, and increases appetite in AIDS patients. These characteristics have led to calls for legalization for medical marijuana. <sup>22</sup>

Typically the effects of smoked cannabis will dissipate within two to four hours of ceasing use, but long term cognitive effects can last up to seven days after use. <sup>23</sup> The most active ingredient in cannabis is tetrahydrocannabinol (THC). THC is metabolized in the liver and usually will leave the blood in about 1 day, but since it is stored in fatty tissues, it can be detected in urine for about two weeks after a single use. Since THC can be accumulated, regular and heavy users might be detected 45-90 days after discontinuing use. Cannabis smoke also contains 50-70 percent more carcinogenic substances than tobacco, but since there is less consumption, this is no conclusive evidence of a cancer causing effect. <sup>24</sup>

Since its criminalization in 1937, many people have sought to decriminalize marijuana possession and distribution, both from a libertarian and medical perspective. There are the same arguments that brought about repeal of prohibition. That it is a relatively safe drug that creates criminals of people that otherwise could be a part of society and reduce the burden on a strained jail system. Others say that cannabis is a gateway drug that has high social and economic costs to society. Many people were concerned with the focus on cannabis criminalization as a way to racially criminalize the black community, where cannabis consumption was higher, especially among musicians of the "Jazz Age". <sup>25</sup> Medicinal values of cannabis (eye blood pressure, nausea prevention and appetite improvement) are often touted, but stories of medical marijuana abuses where prescription are written upon entry to clinics work against arguments for legalization or medical prescription uses.



## Lead

Lead is a dark gray, soft, heavy metal and an element with symbol Pb. Because of its malleability and low smelting temperature it has been used for thousands of years. There are many records and remnants of lead from Roman times. It is not a naturally occurring substance, but is a large by-product of silver and copper ore processing. Lead is still used in manufacturing today of batteries, lead glass, electrodes, soldering, ceramic glazes, lead shields, an additive to certain metals, and some traditional homeopathic medicine. Former uses include paint, gasoline additive, bullets, hot metal typesetting, makeup and plumbing. <sup>26 27</sup>

Lead toxicity develops due to repeated exposure to lead and it builds up in the body. The most common source of lead poisoning in children occurs from exposure to and ingestion of dust from lead paint. Lead poisoning can affect mental and physical growth and development, and in very high doses can cause death. Lead toxicity in adults can lead to hearing and vision problems, hypertension, reproductive problems, nerve disorders, and muscle and joint pain. For pregnant women, lead can lead to miscarriage, premature and low birth weight babies, and decreased learning, development and growth in born children. In children, lead can be responsible for brain damage, slow growth, hearing problems, anemia, headaches and hyperactivity disorders. <sup>28</sup>

Most lead is removed from the body through urine and feces. It is absorbed into the blood through the intestines, but quickly finds its way into soft tissue and bones. <sup>29</sup> After exposure lead gets into the blood quickly, but within one day the concentration will drop by half and only a trace remains after six days. <sup>30</sup> Once in the cells of the organism it has a tendency to stay in the cells. There is typically an increase in the body lead burden which is the excess lead that body retains over what it excretes. <sup>31</sup> Lead poisoning is a major concern for young children, because of the developmental concerns. Tests for blood lead level are regularly done, because of the concern for repeated exposure. The main treatment is removal of the source of the exposure. In cases of high exposure, chelation therapy can be administered. In chelation therapy, an agent is introduced which binds to the lead in the blood and allows it to be excreted into the urine. Chelation therapy should be done under medical supervision, because the agent can also remove essential metal and minerals that the body may need.

We will focus on how lead is introduced into the environment. Lead is put into soil, dust and air through use of lead in gasoline, paint, pesticides, industrial production (incinerators, factories, and coal burning power plants) and natural occurrences (volcanoes). We will look at trade-offs made by society to limit uses of lead in gasoline, paint, and coal burning power plants. We will look at costs to the environment and costs to consumers to determine what will be the best for our community, based on proposed projects being discussed. <sup>32</sup>

## Mercury

Mercury, also known as quicksilver, is a metal in liquid form with the element symbol Hg. Mercury exists in either an inorganic or organic form depending on the substances to which it binds. It has been found in ink of Chinese emperors 3000 years ago, and in Egyptian tombs acting either as a preservative or a kind of spiritual substance. Mercury was used in ointments and in mercuric nitrate which was used to treat the fur in hats, which gave rise to Alice in Wonderland's Mad Hatter, since people in the profession had higher incidence of mental problems. Mercurochrome and Thimerosal have been used in medicine as an antiseptic and an additive to vaccine, and mercury in amalgam fillings have a very long dental history. But the largest source for mercury is from methylmercury in fish and other animals. <sup>33</sup>

Organic mercury toxicity develops due to repeated exposure to mercury and it builds up in the body. Inorganic mercury is toxic at much lower levels, but these are not usually fatal because inorganic mercury is poorly absorbed in the gastrointestinal tract. Death by ingesting quicksilver from a thermometer is rare <sup>34</sup> , and the health risks from amalgam fillings are either low or inconclusive. <sup>35</sup>

I will focus on methyl- and ethylmercury compounds found in fish and game as being the more significant health problem of mercury. Both these compounds impact the central nervous system and ethyl- compounds damage the kidneys. Mercury vapor is released into the atmosphere by both natural (volcanoes) and man-made sources (coal burning plants and municipal incinerators). It lands in the water and soil and is ingested by fish and wildlife and accumulates in their muscles and fat cells. <sup>36</sup> Much of the danger of methylmercury in fish comes from fishermen doubting or ignoring warnings and guidelines regarding consumption. Some misconceptions included knowing the safe spots to catch the fish, being able to recognize polluted fish, and being able to remove the pollutant. Another big concern is that interviewed anglers did not read the government warnings about safe consumption levels. <sup>37</sup>

I will discuss with my students the issues surrounding mercury contamination in the community and how mercury contamination enters the environment and organisms. The concentrations of mercury particulate in the Grand Calumet River and Indiana Harbor Region averages 1.3 nanograms per liter, but registered as high as 17.2 nanograms per liter in certain areas of the region. Mercury in the water comes from source point discharge (industrial or municipal discharge), or atmospheric deposition (coal fired power plants, waste incinerators, forest fires, and volcanoes). Organic mercury is deposited in lakes and streams where natural convection forces circulate the mercury and it is ingested by fish and wildlife. Mercury has been detected in all fish samples since 1983, and has prompted state officials to issue warning and guidelines of fish consumption in these areas. <sup>38</sup>

## Strategies

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I am designing this unit to supplement my regular 8<sup>th</sup> grade science units on physical chemistry, concentration and toxicity. My intention is to reinforce the concept that chemicals are the source and reason for all cellular and functions of organisms. I want them to understand this is also true of the human organism. As additional preparation for this unit, I will support a framework for non-fiction reading with anchor charts and lessons on how to read non-fiction material. Additionally our school is focusing on collaboration in the classroom. Too often we ask our students to work in groups, but we do not give them the training and expectations of their behavior in those groups. Our school is focusing attention through teacher lead study groups, classroom lessons, and collaboration practice and activities as part of our regular activities.

The beginning of the unit will reinforce basic cellular concepts, while focusing on how chemical reactions provide functions in human biology. I will do this with a series of individual units on the major topics listed in the background information. I envision the individual units to begin with a short explanation of the topics followed by activities, which support those units. There will be assessments after several units and some of the activities will also act as assessments. Special care will be given to building vocabulary and understanding of the concepts taught. Among the activities there will be included reading source documents on daily lessons and preparing sharing activities from the readings (Think-pair-share). The goal will be to build a better

understanding of the taught concepts, but also how to read non-fiction and gather, share and retain information from the readings. To facilitate understanding at this level our class will include KWL charts (Know-Want to know-Learn), Guided Reciprocal Peer Questioning and Structured Learning Group team Roles.

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Important parts of the unit include source reading of the content area. I will include articles on the background units from periodicals and the internet. Our school has made a commitment to non-fiction content area reading. Our middle school teachers participated in a study group looking at the book "Subjects Matter - Every Teacher's Guide to Content-Area Reading" by Harvey Daniels and Stephanie Harvey. We have looked at strategies for our students to help them read non-fiction books such as pre-reading headings, examining captions, pictures and graphs, and asking questions as you read. We additionally support our students with anchor charts, mini-lessons and inquiry circles that reinforce good practices in reading non-fiction. This year we will be focusing on collaboration in the classroom, also with anchor charts and mini-lessons, so the group work is important in supporting the inquiry circles. Items included here will include group roles, responsibilities, and practice of opening lines to facilitate communication.

One of the reasons for group projects in the unit is to use students with multiple learning styles to be able to show an understanding of the concepts using learning styles where they are more comfortable. Students that are artistic, vocal, or possess other ways of communication can demonstrate mastery of the material. The groups will need to focus on all the students in the group and collaborate, because seldom do students possess all the talents needed for both presentations. The students should be exposed to cognitive, psychomotor, and affective learning. Remembering and understanding are supported by increased vocabulary and functional understanding of cell structure and function. They will be analyzing and applying information from cell function to larger issues of addiction and toxicity. Finally students will need to be creative in preparing non-standard presentations and demonstrations. My intention is to provide the rigor from using the higher order thinking skills, and allow students to demonstrate it in their most appropriate learning style, while they collaborate and work together.

## Activities

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Initially I will use short presentations and activities for understanding of cellular processes and toxic effects. I will create short presentations for each of the units in the background knowledge sections listed earlier. Every teacher knows what information their students possess coming into the class. Everyone might not need to introduce or review these concepts, and each individual teacher should examine if all or more might be needed to discuss toxic effects to organisms of the three toxins listed above. This program is designed for my science class which meets every day Monday - Friday for a fifty minute period.

### Introduction

This unit will last about two class periods (50 minutes each) and have the objective of reviewing a basic understanding of living things and how they fit on a continuum from very small to very large organisms and systems.

Examples include using KWL charts to determine what students consider as living things. I will continue with

examples of things that were clearly living, and other things that had some of the characteristics of living organisms. We will then follow up with groups to establish a more comprehensive list of the characteristics of living organisms. For the unit on hierarchy of living parts, I will invite the students to order cells, tissue, organs, etc. by using set diagrams of 12-13 concentric circles. The students should start with atoms, molecules and move into cells, and tissue, and conclude with ecosystems and the world. This will reinforce the organism as part of a smaller and larger world. There will be an article that students will round robin read from Britannica Kids. <sup>40</sup>

## **The Cell**

This unit will last two to three days and its objective will include basic identification of cell parts and function with special emphasis placed on chemical functions occurring within the cell.

Working with cells structure and organelles, we will examine a two and three dimensional representation of a cell and students learn about the parts and develop a two dimensional representation for an assessment. The 3-D aspect of the model will include characteristics such as DNA in the nucleus that demonstrate knowledge on function of the organelles and the cell.

## **Movement of Molecules in Tissue and the Cell**

This unit will last three days and its objective will be to review concentration and look at diffusion. There will also be examples of different kinds of intra-cellular and extra-cellular molecular movement. We will examine differences between passive and active transport, and receptors in the surface of cells.

We will look at diffusion. We will review previous lessons on concentration and creating a serial dilution. We will examine the math for each step of the serial dilution, and follow up with selective mixture of the solutions and calculation of new solution composition. We will also focus on changes in appearance in each step in the serial dilution. In examination of passive and active transport, the students will design a shape for a cell receptor and design a ligand and potential drug to replace the ligand and provide a different function for the receptor.

## **Cell Communication**

This unit will last two days and its objective will include communication with neurons and muscle cells. We will also combine information from the previous unit about receptors to explain re-uptake transporters and effects of ligands on these transporters. We will use this information to help introduce the concept of tolerance of a drug and withdrawal symptoms.

I will cover neuron communication. We will cover the chemical and physical properties of a chain of neurons communicating a signal. We will then create a type of "telephone" game to pass messages through the chain. We will begin with a linear communication chain, where one student passes the message to another students, then we will create a two dimensional model of nerve tissue and create thresholds to witness a signal going through, but using alternate paths for the communication. We will add blockers to the process to see if the message still gets through. Finally we will increase the amount of blockers to determine if increase dosage will improve the outcome. We will use cards to act as neurotransmitters and blockers to help with the simulation.

## **Filtering Toxins Out**

This unit will take about two days and review previous lessons on filtration to introduce and identify the main

organs in the body responsible for cleaning toxins out of the body.

I will review previous lessons on filtration, and filtration with a binding agent to simulate organ processes of the kidney and liver where the binding agent is similar to an enzyme and allows the better processing of toxic material. We will also discuss where in the body these filtering mechanisms are and how they work to eliminate toxins from the body. We will conclude the unit with diagrams of liver, kidneys, skin and stomach to label characteristics needed for each function of each organ.

### **Introductions of the Toxins**

This unit will take about a week. The objective will be to provide students with basic facts about the function and toxicity of the four substances (alcohol, cannabis, lead and mercury).

I will return to KWL charts for study of our four main toxins. We will keep track of what the students know or think they know, what they want to know, and at the conclusion of the unit, they will list what they have learned. We will begin these charts as we introduce each of the four toxins, alcohol, cannabis, lead and mercury. We will look at these substances as trade-offs. We will examine the benefits, dangers and abuses of each substance in preparation of the larger unit. There will be opportunity to watch and discuss video on addiction and drug costs from various sources (National Geographic, Youtube -see bibliography for examples). We will also use jigsaw strategies to read several articles and report to the class about the findings. We will have groups of students read parts of the same article and report to the group. They in turn will report a summary of the article to the class. This will allow several points of view on the topics to be introduced and discussed. We will record some of the findings into the KWL charts to be included in items that we have learned.

### **Project**

This part of the unit will begin with the introduction of the toxins and continue for about four days after the completion of the Toxin Introduction. This will allow students sufficient time to access outside sources and computer time. The last two days will be used for presentations. The objective of the project is to provide for differentiated evaluation of the students' understanding of the material, while presenting information to fellow students about different toxins and their issues.

While I complete introductions on the background material, I will allow the students to select their own inquiry circle group. My class size is about 30 students, so this will naturally allow for seven to eight groups of four. The way the groups select each other is that I will prepare eight to ten articles on alcohol, cannabis, lead and mercury, each of the students is allowed one minute to browse the article, and after they browse the ten articles they will vote on choices one to three. I will then organize the groups by their choices. I have used this method in the past and it has proved successful. This will be the structure for group inquiry projects on different perspectives of alcohol, cannabis, lead and mercury. The questions will surround pro and con for alcohol and cannabis, but focus more on cost and benefit of lead and mercury, which are both industrial products and toxins.

The groups will be responsible for two presentations. One presentation will be five to seven minutes, while the other will be one to three minutes. One presentation will need to be informative focusing on the article, and on other source material that will be researched to support or refute the position of the article chosen. The students will need to research at least 5 additional sources to support their position, and will need a color presentation board to assist in the oral presentation. The other presentation will need to be artistic in nature.

They will need to perform a skit, a poem, an artistic (drawing), or song. The groups will select which length of time they will present. The better presentations will participate at our school science assembly or if the timing does not allow that at a regular school assembly after this unit is completed.

## Assessments

Assessments of these units will vary. In some activities I will assess the worksheet or assignment for effort and participation. Others will require an exit slip that will demonstrate understanding of an important concept. There will be vocabulary practice, where the students will write sentences using multiple words in a sentence to demonstrate understanding of the words in addition to remembering which will be evaluated with a quiz. Each of the presentations will be graded on content, presentation style, participation, preparation of display materials and behavior during the presentation. I have had success with giving each student a presentation worksheet, which helps them list and organize sources, but also a place for me to record participation in groups. Participation points are issued through periodic observation of the students and interviews with other group members. If a student loses his/her sheet they forfeit participation points.

I plan on implementing this unit for my 8<sup>th</sup> grade class the first week in January, right after winter break. I think this will help review concepts introduced earlier in the year on concentration, chemical reactions, and diffusion. I feel that this unit supports the Illinois State Standards and it will provide practice in reading non-fiction scientific sources, so it will prepare my students for testing in March. I am confident that support for the non-fiction sources and a more rigorous overview of cell and chemical functions will offer a bridge for my school in implementing the Common Core State Standards.

## Appendix A - Bibliography

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## Appendix B - Standards

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Our school district is currently changing the standards for our curriculum. We are transitioning from the Illinois State Standards to the Common Core Instructional Standards over the next two years. I feel that this unit that I am preparing is an excellent bridge between these standards.

The Illinois Standards that I will include in this unit include 11A.3.e-f Report and display the process and results of a scientific investigation , 12.A.3a Explain how cells function as "building blocks" of organisms and describe the requirements for cells to live., 12.B.3b Compare and assess features of organisms for their adaptive, competitive and survival potential (e.g., appendages, reproductive rates, camouflage, defensive structures)., 13.B.3a Identify and explain ways that scientific knowledge and economics drive technological development., and 13.B.3f Apply classroom-developed criteria to determine the effects of policies on local science and technology issues.

From the Common Core we would cover RST.6-8.1. Cite specific textual evidence to support analysis of science and technical texts., RST.6-8.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics., RST.6-8.7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table)., and RST.6-8.10. By the end of grade 8, read and comprehend science/technical texts in the grades 6-8 text complexity band independently and proficiently. Specifically the non fiction reading component of the lesson plans will support RST.6-0.10.

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