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Interdisciplinary Applications of Chemistry through Engineering in Modern Medicine: CSI New Haven

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Introduction and Objectives

My goal is to develop a curriculum unit that is both educational and interesting. This will be an interdisciplinary curriculum that ties together the different scientific disciplines and shows how engineering in modern medicine contains a depth of chemistry that all the students will be able to analyze and understand. Following the completion of this unit, students will be able to:

· Identify characteristics that make different chemicals unique from each other.
· Use chemical spectra and other chemical assays to identify organic and inorganic chemicals that are classified as unknown at the initiation of the investigation.
· Identify chemicals as being basic or acidic based on their pH.
· Analyze both data and unknown samples to determine the outcome of the given scenario.
· Utilize and analyze data to formulate conclusions pertaining to the incident at hand.

The motivation for this curriculum unit is the increasingly growing interest into the field of forensic science. In developing the curriculum unit, a culmination of topics will be incorporated ranging from topics in biology to topics in physics. Furthermore, the fundamental application of forensic science in the curriculum unit is that it provides an interdisciplinary way to analyze crime scene evidence. Forensic science is the integration of science and the law. It may include such areas as firearms and toolmark identification, forensic psychiatry and profiling, unidentified document examination, criminal law, personal identification, and crime scene processing. The crime scene involves not only the location where the crime occurred but it may involve any connection that may lead to the solving of the crime. Forensic scientists work on properly maintaining the scene of the crime and collecting all related information pertaining to the crime scene. Forensic scientists must therefore be educated in all aspects of scientific discipline such as biology, chemistry, physics, and environmental science.

Chemistry is the study of matter and all the changes that it undergoes. It is the science that focuses on composition, structure, properties, and reactions of matter, all of which will be used to identify and characterize the crime scene. This curriculum will target ideas that will be cumulative in the sense that concepts learned throughout the year are then gathered and applied to the objectives of the curriculum unit.

Biology is the branch of science dealing with the study of life. [i] In this curriculum unit, concepts that will be related to Biology include, but not limited to, fingerprinting, DNA analysis, entomology, and genetics. In addition, biochemistry topics will be illustrated throughout the curriculum unit that gains relevance toward Biology science standards.

Physics (from the Greek physicos, meaning "natural") is the science of the natural world, which deals with the fundamental constituents of the universe, the forces they exert on one another, and the results of these forces. [ii] In this curriculum unit, projectile motion will be the main focus as relating physics to forensic science. As instructors facilitate in concept mastery through the lecturing of topics, they can determine the difficulty to which they will cover projectile motion (i.e. depth of calculations.)

As this is a unit geared toward the exposure of students to hands-on science techniques, the sector of forensic science that will be studied will be crime scene processing and personal identification. With these two aspects of forensic science, topics in chemistry, biology, and physics may be uncovered and analyzed in as much depth as foreseen by the teacher using the lessons.

Furthermore, pursuit of knowledge is one of the greatest attributes of human nature. The position of the teacher will be to facilitate in the techniques and allow students to derive questions from the task laid upon them. This is a chance for the students to work collaboratively and learn from each other. The class will be divided into different groups and each group will be required to do a PowerPoint© presentation at the end of the unit, illustrating the outcome of their research and the hard work that went into "cracking the case." In addition, students will compose a report detailing their methods and results obtained in the experiments. The report will be done to the specifications detailed in the Appendix.

Description of Unit

A new trend has developed where television shows are being geared toward forensic science, (i.e. CSI: New York, CSI: Miami, Numbers, Bones, etc.). As a teacher, I ask my students where their prospects for the future lie and many have indicated an interest in going for forensic science. Who am I to dismiss such an outstanding culmination of scientific inquiry? For this very reason, I have decided to focus the curriculum unit on the investigation of a crime that has taken place New Haven, CT. Through processes of inquiry and laboratory research, the students will be able to identify whether the crime was intentional or a mere freak accident. As a clarification, the unit is not based on any real events but on an "invented incident" that will provide a scenario to facilitate in the explanation and relation of topics.

In order to accomplish the task at hand, students will perform the following tasks:

Collect evidence and run the following tests either through internal procedures or requests for external laboratory assaying:

- pH determination--All acidic or alkaline chemicals carry a pH identity. By the measure of the pH, the student may determine how corrosive the chemical, if any, used would have been.
- Chromatography--This is the process of separating minute substances from solution through the use of their differences of migration rates through a slightly soluble solvent. In this curriculum unit the focus will be HPLC for its technology applications, but teachers may choose to perform paper chromatography as an introduction to the concept of migration.
- Percent Alcohol--through titrations and purification, the student will be able to determine the "blood alcohol level" and see if it the victim was a under the influence of alcohol.
- Skid mark calculations--the skid to stop formula may be utilized to determine the speed at which the person was going right as the determinant event occurred.
- DNA Analysis--DNA is the fingerprint of every human being. If left behind, DNA is a wonderful source of information that leads to the culprit. DNA analysis to be performed will be based on reports obtained from external requests and will solely be used as comparative analysis rather than complete utilization of the electrophoresis apparatus.
- Analysis of spectra--spectra can be obtained from such instruments as an UV/VIS, HNMR, Raman, as well as mass spec. These are useful in identifying the chemical in question.
- Introduction to entomology--study of bugs, which can help in aging a body based on the life cycle of the larvae.
- Determination of unknown--Unknowns will be used in different scenarios to have the students perform various techniques to identify the evidence.

Description of Methods:

pH Determination:

In terms of classifying chemicals there are many different categories that they can be broken down to. The chemical properties of chemicals are unique and this allows for identification. Even though chemicals can be differentiated between organics and inorganics, natural or synthetic, acids or bases; pH testing is a way to differentiate between acids and bases.

In its simplest form, acids are those chemicals that contain a hydrogen ion (H+) and when placed into water will dissociate into hydrogen ions and its complimentary anion (negative charged ion). A base, on the other hand, is a chemical that contains hydroxide ions (OH-) that when placed into water will dissociate into hydroxide ions and its complimentary cation (positively charged ion). The reaction of an acid coming in contact with a base is called a neutralization reaction where there is the formation of a salt and water as per the following equation:

$HX + YOH \rightarrow XY + H_2O$

When segregating the chemicals into the acid/base category, the pH of a solution is utilized. If a chemical has a pH lower than 7, then it is considered an acid; if the pH is greater than 7, then it is considered a base. A pH of seven is neutral and is that of water, the universal solvent.

The pH of a solution may be determined through the use of litmus paper, a pH indicator, or even a pH meter. Depending on the precision and accuracy of the result, different instruments may be used.

Chromatography:

HPLC:

The principle of HPLC involves a stationary and mobile phase under high pressure that acts to separate components of a sample mixture depending on their respective solubility for the mobile phase and affinity for the stationary phase. The most common type of HPLC is reverse phase chromatography, where the mobile phase is a polar mixture like water/methanol, and the stationary phase (analytical column) is a non-polar substrate typically octadecylsilane an 18 carbon molecule, bonded to the inside of a metal cylinder.

The mobile phase sweeps the sample mixture through the column where separations of the individual components occur according to polar/non-polar associations or chemical interactions between the chemicals in the mixture and the mobile/stationary phase. For instance, compounds of a sample mixture that are less polar will have a greater affinity for the stationary phase (remember like dissolves like) and will elute, or leave the column later in time. Compounds that are more polar relatively speaking will spend more time in the mobile phase and will be swept out of the column much faster.

The componentry of an HPLC system begins with the solvent reservoir; this is where the water and methanol are drawn into the system via a pump. Some systems may be of the 4º type and can utilize up to four different solvents to increase separation efficiency. The system can be programmed for isocratic elution or gradient elution depending on the requirements specified during method development regarding the types of components to be separated and their varying solubilities. Isocratic elution involves utilization of a single unchanging mobile phase over time, i.e., 90%H_2O/10% MeOH. Gradient elution involves altering the composition of the mobile phase over time, i.e., 70%H_2O/30% MeOH to 90%H_2O/10%MeOH. As mentioned, utilizing several different solvent concentrations to vary polarity over the course of a run could help separate individual components of a particular nature.

The solvent passes through an inline solvent filter to remove any impurities present in the sample loop where the sample is injected. The sample is carried by the mobile phase through a pre-column filter and then to the guard column that acts to remove any impurities to prevent contaminating the analytical column. The analytical column can be of many dimensions, i.e., 3cm x 3cm (length x inside diameter) and, as mentioned previously, contains the stationary phase where the separations of components occur. Separated compounds elute one by one and pass by a UV light source consisting of one wavelength that irradiates the sample. Compounds will interact and absorb the UV energy. The transmitted energy will pass through the sample and be collected on a photodiode array detector, which in combination with integrators and computer software produce an absorption peak on a chromatogram. The chromatogram has retention time on the x-axis, and absorption intensity on the y-axis.

Usual practice involves the chemist preparing a set of standards, or samples with varying concentrations of the compound of interest to serve as a calibration model, by which concentrations of unknown solutions may be determined. This is possible as the Beer Lambert law governs the absorption of UV radiation:

Absorbance = Concentration x molar absorptivity x path length.

The path length corresponds to the distance through the sample between the UV source and detector. This value is a constant for both unknown and standards, and therefore may be dropped from the equation to give:

Absorbance = Concentration x molar absorptivity

The molar absorptivity term is a constant for a specific molecule at a specific wavelength. The analysis wavelength for HPLC analysis typically remains constant throughout a run, and the compound of interest is assumed to be the same as the compound used to make the standard set. Therefore, the equation can be simplified conceptually to observe that absorbance is proportional to, or in other words, equal to the concentration. This relationship is linear, and therefore a linear regression may be fitted to the data to provide an equation of the form y= mx +b, whose y-value is Absorbance, x-value is concentration, and slope is the combined term molar absorptivity x path length.

So, the chemist may prepare and obtain absorbencies for standards according to a particular HPLC method. An HPLC method sets the parameters of mobile phase concentration, column type, run time, analysis wavelength, etc. The chemist will then proceed to analyze a solution of unknown concentration by the same method. The resulting standard linear model can be used to predict or extrapolate the concentration of the solution.

Percent Alcohol:

When probable cause exists in car accident investigation, police officers utilize breath-test instrumentations to correlate blood alcohol level to percent alcohol in the breath. According to Henry's Law, when a volatile substance is dissolved in a liquid and is brought to the equilibrium with air, there is a fixed ratio between the concentration of the volatile compound in air and is concentration in the liquid, and this ratio is constant for a given temperature. As applied experimentally, when alveolar air leaves the mouth at 34oC, the ratio of alcohol in the blood to alcohol in alveolar air is approximately 2,100 to 1. [iii] In cases involving drunk driving, the prosecution has to prove that the defendant's blood alcohol concentration (BAC) at the time of the offense is at or above a statutory concentration. In the majority of jurisdictions it is 0.10% [i.e., 0.1 gram of alcohol per 100 milliliters of blood]. In some jurisdictions, the BAC level may differ pending the jurisdiction's regulations. [iv]

As it pertains to the realm of this curriculum unit, a breathalyzer test is an inappropriate method of analyzing the blood alcohol concentration as the analysis will be made postmortem. Therefore, a sample of blood is required in order to determine the person's blood alcohol level at the time of the incident. The most widely used method for toxicologists involves Gas chromatography. Another method used is via the oxidation of alcohol to acetaldehyde. The reaction is carried out by utilizing the enzyme alcohol dehydrogenase and a coenzyme nicotin-amide-adenine dinucleotide (NAD). As the reaction proceeds, NAD is converted to NADH, the extent of conversion as measure using a spectrophotometer indicates the original concentration of alcohol. The latter method is used in hospital situations rather than in forensic science. (v)

Skid Mark Calculations:

In Forensic Science, many accidents produce skid marks. A skid mark is a mark left behind on the traveling surface by the tires of the car that have been locked in position, not rotating. In determining the speed of the car, there are many components that have an influence on the skid to stop formula: skid distance, drag factor for the road surface, and breaking efficiency of the vehicle. (vi)

The skid mark is created when the driver applies the brakes and locks the tires, once locked; the tires are not able to continue rotating, proceeding in motion. Steering is not possible once the tires are locked. When observing the skid mark, the beginning of the skid mark is called the skid speed. While analyzing the skid mark, it is possible to differentiate between rear tire skids versus front tire skids, where the rear tire skid mark is composed of a darkened center whereas the front skid marks are basically two thin outlines.

The average skid distance is obtained by analyzing all the skid marks present at the scene. When there are four skid marks, it is necessary to add up all the lengths and divide by four; the same is said for three. Furthermore, it is necessary to determine the drag factors by utilizing a vehicle that contains an accelerometer and chalk bumper guns. Professionals who have been formally trained are able to indicate the drag factor as per the performed test. Some of the examples of drag may be found in the appendix (See table 1).

The final component in analyzing the skid marks comes from the braking efficiency. When four skid marks are present, then the skid efficiency is 100%, or having a correlation of 1.00. When the rear tires are not working to their full potential then it is said that there is a lack of 40% in breaking efficiency for a 60% breaking efficiency, or a correlation of 0.60. Some cars are rear-wheel drive, and therefore, it can assume that the break efficiency is 30% for each front tire and 20% for each rear tire.

With all the components at hand, the following formula can be used to determine the velocity of the car:

$S = (30*D*f*n)*1/2$ (vii)

Where,

S = speed in miles per hour

30 = a constant used in the skid to stop equation

D = skid distance, in decimal feet and inches

f = drag factor for the road surface

n = Breaking efficiency as a percent

DNA Analysis:

Every human is unique and it has to do with macromolecules present in the nucleus of each cell called deoxyribonucleic acid. Deoxyribonucleic acid, DNA for short, encodes for genetic information responsible for all body functions, metabolism, and development. DNA contains building blocks called nucleotides that may contain one of four bases: adenine, cytosine, guanine, and thymine. In addition to one of the four bases, there exists a pentose (five-carbon) sugar and a phosphate

Animal (eukaryotic) cells contain double-stranded DNA that is linked using hydrogen bonding. The molecular conformation of DNA is in the form of double-helix. Each strand is differentiated as the leading or the lagging strand and is has to do with the process of replication as it occurs for each strand. The leading strand has a continuous replication process, whereas the lagging strand has a discontinuous replication through the development of Okasaki fragments.

In forensic science, DNA can be used as a fingerprinting mechanism that will place a culprit at the scene of the crime through the use of many methods such as Blood Typing, Restrictio Fragment Length Polymorphism (RFLP), PCR analysis, Y-Chromosome Analysis, Mitochondrial DNA Analysis, STR Analysis, and Agarose Gel Electrophoresis. This possibility of concisely placing a person at the scene of a crime has to do with the fact that only about one tenth of a single percent of person's DNA (about 3 million bases) differs from that of another [viii] . As an introduction to DNA Analysis, the focus will be to explain DNA Typing and PCR Analysis.

DNA Typing:

DNA Typing is done through the use of complimentary DNA markers that when combined to an unknown sample, will bind to specific regions and provide an image that can be later analyzed. When typing, if two DNA samples are similar in four or five regions, it can be deduced that the samples come from the sample individual [ix] . In order to increase the accuracy of the test, it would be possible to use more markers, but using more markers would also mean that more time and money would need to be invested into the assay. As with many tests, there has been no concrete evidence to invalidate the use of only four or five regions as a method of identification.

PCR Analysis:

PCR (polymerase chain reaction) is used to make millions of exact copies of DNA from a biological sample. A carefully developed process that incorporates heating and cooling allows for the denaturing of the DNA sample to produce single strands. As the single strands get exposed to an environment containing a forward and reverse primer, taq polymerase, and excess nucleotide bases, the DNA is in optimal conditions to produce hundreds to thousands and sometimes millions of identical replicas. DNA amplification with PCR allows DNA analysis on biological samples as small as an epidermal cell. The ability of PCR to amplify such tiny quantities of DNA enables even highly degraded samples to be analyzed. In the preparation of samples, aseptic techniques must be employed to maintain the viability of the sample as well as the validity of the test.

Analysis of Spectra:

H-NMR:

The principle of Nuclear Magnetic Resonance Spectroscopy relies profoundly on the spin, and hence magnetic moments of nuclei contained within the compound of interest.

When these nuclei are exposed to a strong external magnetic field energy levels will split, thereby creating an opportunity for the absorption of electromagnetic radiation in the radio-frequency (*rf*) region (4-600 MHz). Furthermore, the absorption of *rf* by the nuclei is influenced by it's molecular environment, (i.e., local electrons and neighboring nuclei) therefore, the resulting NMR spectra will be a representation of molecular structure. Note: Spectra are obtained using a suitable NMR spectrometer that either attenuates the *rf* or magnetic field strength in the presence of a rapidly spinning sample.

NMR spectra are displayed on an x-y plane, typically with field frequency (v) on the x-axis, and absorption intensity on the y-axis. Scanning an unknown compound will produce a spectrum with peaks occurring at various frequencies with varying absorption intensities. All spectra are gathered with respect to a tetramethylsilane (TMS) reference peak that is set to 0 Hz.

To interpret NMR spectra the chemist must be familiar with the concepts of **chemical shift** : small differences in absorption frequency due to the chemical group to which the nuclei is bonded, and **splitting** or **spin-spin coupling** : magnetic moment of nucleus interacting with another magnetic moment of immediately adjacent nuclei. Examining spectra in light of these two concepts will enable the deduction of the unknown compound's molecular structure.

Consider the compound ethanol H-O-CH2-CH3 The Hydrogen atom bonded to oxygen will experience electron withdrawal as a result of oxygen's high electronegativity, it is said to be least shielded with respect to the external magnetic field. The electrons circulating around the Hs of CH2 are the next most withdrawn while the Hs of CH3 are the least, and said to be most shielded. Lowly shielded nuclei will yield peaks at high frequencies (large **chemical shift-** up field), while highly shielded nuclei will yield peaks at low frequency (low **chemical shift** -down field, approaching the direction of TMS peak). Therefore peak positions serve as an indication of molecular environment or what atom is adjacent, as electronegative atoms like oxygen or fluorine within a compound will give spectra that contain peaks that are more shifted with respect to TMS as compared to compounds containing less electronegative atoms, i.e. carbon or phosphorous.

Next, in the examination of the spectrum the chemist will have to consider splitting. Because of the several possible spin-spin orientations in neighboring nuclei, a singular peak corresponding to an individual H atom will actually appear as several peaks. For instance, atomic spins of the two H atoms in CH2 may align in one direction either against or with the external magnetic field, thereby weakening the field or strengthening it, respectively. A weakening will give one peak at a larger shift, while the strengthening will give one peak at a lower shift. Furthermore, there are two orientations where spins are opposite and cancel having a net zero effect on the field. This peak will appear between the two other peaks producing a triplet. Note: this triplet will correspond to CH3, while CH2 will appear as a quartet corresponding to the net effect of CH3 on it.

NMR spectral interpretation is very important, however with the proliferation of large chemical reference libraries; this task is facilitated by comparison of an unknown compound to a reference standard.

Raman:

Raman spectroscopy is a technique that provides information, both qualitative and quantitative, on molecular media via inelastic scattering of monochromatic radiation. The wavelength of the scattered radiation is shifted from that of the incident radiation, in fact, these shifts correspond to the same type of quantized vibrational changes that are associated with infrared absorption. For this reason Raman and IR spectra of identical compounds appear very similar in structure and tend to share scattering/absorption bands. Therefore Raman spectroscopy is an ideal candidate for chemical identification and quantification techniques, particularly in aqueous media where IR and NIR techniques are predisposed to complication in gathering practicable data.

Raman spectrometers use a powerful laser source to irradiate a sample of interest. The radiation scatters back from the chemical in the sample at various wavelengths corresponding to the natural frequencies of the molecule. The detector collects the scattered radiation and via a series of computer algorithms, converts the signal into a spectrum much like that seen in IR or UV spectroscopy. Since the observed frequencies correspond to the molecular structure, the chemist may consult a table of known frequencies and eventually deduce the structure or something close to the structure of the compound of interest. Alternatively, the chemist may compare the spectrum against a library of reference standards. This is very similar to the investigative process that a chemist would use when employing FTIR. However, Raman is a very expensive alternative for identification purposes, but it does have another advantage.

Raman spectroscopy can be utilized as a tool for quantitative analysis because molecules elicit a particular Raman shift whose intensity is directly proportional to concentration, via a variant of the Beer-Lambert equation:

I = KVCI0, where,

I is the Intensity of the Raman Band, K is a constant for each band, C is the concentration, and I0 is the intensity of the laser. Much akin to Beer's law and quantitative UV methods (reference HPLC section), this fundamental relationship enables the prediction of chemical concentration in situ.

Raman techniques offer a practical advantage over preparative spectroscopic techniques as simple fiber optics and hand-held probes can be used in the field to obtain spectra of many types of substances without laboratory preparation. Furthermore, Raman probes may be inserted into a solution or solid sample and quantitative information about the component of interest may be obtained with the aid of powerful software and without involved preparative methods.

Entomology:

Forensic Entomology is the use of the insects, and their arthropod relatives that inhabit decomposing remains to aid legal investigations. The broad field of forensic entomology is commonly broken down into three general areas: medicolegal, urban, and stored product pests. For purposes of this curriculum unit and those examples that have been portrayed in forensic science shows, the medicolegal area will be the general focus of review. The medicolegal section focuses on the criminal component of the legal system and deals with the necrophagous (or carrion) feeding insects that typically infest human remains. (x)

Insects not only aid in the analysis of the crime scene but they may also hinder the investigation. For that reason, trained entomologists are required to assist in the investigation so as to analyze the possible track through pooled and spattered blood, and the feeding and defecation of possible areas where evidence may be obtained from. Therefore it is important to recognize and properly document the natural artifacts that may occur from the presence, feeding, and defecation of roaches, flies, and fleas.

Determination of Unknown:

When samples are obtained from a crime scene, many tests are run because the sample does not come pre-labeled. Therefore, in identifying unknown substances present in a fabric, hair, urine, or other inanimate sample, many tests can be utilized for identification of unknowns. Some samples can be identified using many of the testing that has been discussed in this overview.

Background Information

What is Forensic Science?

As portrayed by the very popular television shows crime scene investigators do not exist. On the contrary, there are criminalists, crime scene analysts, document examiners, evidence custodians, firearms specialists, firearms/toolmark examiners, and photo technicians. The job titles and/or the description of their jobs, varies from jurisdiction to jurisdiction. [xi]

The Collection of Evidence:

There is a difference between the "scenes of the crime" as compared to the "crime scene." The scene of the crime is the location where the crime took place, whereas the crime scene is the investigatory realm that forensic scientists establish to obtain relevant information to solve the crime. A "crime scene" is not only the actual location of the crime--it is also the staging and planning areas, the paths of flight to and from the primary scene, and the paths between the primary and secondary scenes. [xii]

The first responder has many responsibilities that range from turning the "scene of the crime" into a secured "crime scene" by maintaining its legitimacy to finalizing the documentation. In preparing the crime scene for evidence collection, the first responder must maintain the integrity of the scene by closing it off to the public or anyone outside of the investigative forces.

Description of Incident

An abstract of the crime reads as follows: On a mid-spring afternoon, a woman was driving through a trail on East Rock Park. While driving, her car veered off the trail and plummeted to the bottom of the cliff. As a result, the woman was found dead in her car. Reasons for the occurrence are still under investigation. As it stands, this may or may not have been an accident. Therefore, your lab will conduct the necessary tests in order to determine the nature of this incident. The tests performed will determine the cause of death, if there was foul-play, and how the car veered.

All necessary personnel reported the scene and were able to obtain evidence that were taken to the forensic laboratory for further investigation. As for the evidence obtained, the following consists of the list of evidence. Fingerprints

1. A cup containing an unknown liquid substance.
2. Hair and blood samples
3. Larvae found on the body of the deceased woman.
4. Data referring to the skid marks left by the projectile car.
5. Impressions of footprints nearby the car.

Ready, Set, Go!!!!

The curriculum unit is geared toward the understanding of science through the integration of Chemistry, Biology, and Physics while studying the outcome of an unfortunate incident. The teacher's responsibility is to create six scenarios that pose different outcomes for students to investigate, making sure that at least one of the scenarios does not involve foul-play. In formulating the activities that go beyond the ones introduced in this unit, teachers need to make sure to incorporate at least one topic from each of the aforementioned concepts. It is fair to say that not schools have the same resources, for that reason; there is a form in the appendix for external laboratory requests. For example, in order to obtain specific readings on the composition of a soiled piece of fabric, students might need to have the samples submitted for HPLC testing. Teachers have access to chemical spectra and may provide the completed spectra for student analysis. This still gives students the ability to have skills gained from practicing the skills without having to run all the tests in-house.

Objective:

Activities and Concept Correlation:

(table available in print form)

Teacher Manual

In completing this unit, the following needs to be completed:

- Students must create either a college brochure or a career bulletin. There must be an even split for each assignment and students may not duplicate careers or colleges.
- Students must complete minimally one activity for each discipline.
- Students must formulate conclusions about the scenario based on the gathered information.
- Students must present their conclusions using a PowerPoint© format. Additionally, they must compile a final report specifying their thought process in gathering and analyzing the information.

Reading List

Teacher Resources

Books

Christian, Gary D. *Analytical Chemistry* , 5th ed. New York: John Wiley & Sons, Inc., 1994.

Genge, N.E. *The Forensic Casebook.*

Hewitt, Paul G, John Suchocki, and Leslie A. Hewitt. *Conceptual Physical Science--Explorations.* New York: Addison Wiley, 2003.

Websites

http://dictionary.reference.com/search?q=trajectory - This website provides general definitions that may be used in defining concepts and terms.

http://www.forensicdna.com/ - Provides a description about what forensic science is as well as the different sectors of it. It also provides information about careers in forensic science.

http://www.fbi.gov/hq/lab/handbook/intro.htm - This website provides information on the FBI's *Hanbook of Forensic Services.* It illustrates the methods of collecting, preserving, packaging, and shipping evidence and to describe the forensic examinations performed by the FBI's Laboratory Division and Investigative Technology Division.

http://www.aafs.org/?section_id=resources&page_id=choosing_a_career - This is the website for the American Academy of Forensic Science. It provides information on choosing the aforementioned career and the steps that are needed to go through prior to pursuing this endeavor.

http://www.scientific.org/tutorials/articles/gcms.html -Provides information about GC/MS a very important technique used to analyze and identify samples obtained in a crime scene.

http://www.virtualmuseum.ca/Exhibitions/Myst/en/index.html - Provides and interactive game in solving crimes using deductive reasoning and the skills in forensic science.

http://www.pbs.org/wgbh/nova/sheppard/analyze.html - This site offered by PBS offers an interactive and online based DNA fingerprinting activity.

http://www.fiu.edu/~mccordb/Manualv7.2.doc - Laboratory resources can be obtained in order to perform forensic science experiments in the classroom.

http://www.scafo.org/library/110501.html - Article on chemical dating for latent fingerprints.

http://www.rit.edu/~pac8612/electro/E_Sim.html - This is a simulation of electropheresis.

http://phys.educ.ksu.edu/vqm/ - Online interactive models of spectroscopy.

http://www.mtholyoke.edu/~mlyount/MySites/ForensicSpectroscopy/ForensicApps.html - This site provides information on applications for detecting alcohol, dugs, fibers, and paint using IR.

www.chemfinder.com - This site provides information about chemical and physical properties of compounds.

http://home.earthlink.net/~thekeither/Forensic/forsone.htm - This website provides a really good overview of what forensic science is to the nonscientific person. It uses layman's terms in order to facilitate the conceptualization of forensic science.

http://en.wikipedia.org/wiki/Forensic_science

http://webbook.nist.gov/chemistry/name-ser.html - Obtain chemical information for all chemicals including IR, NMR, Mass Spec information to place on reports for external laboratory assays.

http://www.harristechnical.com/articles/skidmarks.pdf#search='skid%20marks - This article provides information on skid marks.

http://www.ornl.gov/sci/techresources/Human_Genome/elsi/forensics.shtml -

http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=500652 - Blood Alcohol Reading

Appendix

Lesson Plans

Activity 1

This activity is geared toward the immersion of students into the concepts of careers and education for forensic scientists. The teacher should be the facilitator in getting the students to use library and internet resources to research on either the types of careers there are for those with a forensic science background or create a "college brochure" indicating the education requirements to pursue a career in forensic science.

Outcome: students should choose between writing a bulletin about a position in forensic science or a college brochure.

Requirements: For the career bulletin, students must include a description of the career, the job requirements (skills and knowledge), and minimum education and experience requirement, as well as salary range. For the college brochure, students are required to include the college information, the different types of specializations, any entry requirements for the program, average tuition (if available), and course descriptions for a chosen specialization.

Activity 2

This activity is geared toward the introduction of calculations and analysis of the skid to stop calculations. Students must create a standard curve with random speeds so that it may be using in estimating the person's speed for the scenario provided.

Outcome: students should develop five graphs on Excel© for each of the different surfaces provided in table 1 of the appendix. In using this, make sure to determine the line of best fit for the data points. When given the length of the skid mark, students will then be able to estimate the speed at which the car was going before it came to a stop. Remember, if there were skid marks, it means that the person had a reaction and were still conscious; if there were no skid marks, the person was not conscious and may not have had a reaction.

Activity 3

This activity works as an introduction to fingerprinting through the use of an interactive website. Students will understand the process of uniqueness prior to delving into the topic and utilizing provided DNA fingerprints to identify the culprit.

Requirements: Students must be given access to the internet in order to complete this activity. They will be provided with a partner and together they must solve the mystery at hand. Students will visit the website provided by PBS and complete the assignment. Once the assignment has been completed, students are required to print out the confirmation page. (www.pbs.org/wgbh/nova/sheppard/analyze.html)

Activity 4

This activity introduces students to the differences in pH for household products. Students will be given a sampling of different products ranging from cleaning solutions to juices in their refrigerators.

Outcome: Students will be able to differentiate between basic and acidic pH and determine what types of products are either acidic or basic

Forms and Handouts:

Table 1: Drag Factors for a Given Road Surface

(table available in print form)

Notes

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