Teacher's Preparatory Guide

Title: The Case of the Patent Pending

Image Source: http://www.animationfactory.com

Purpose: The purpose of this investigation is twofold: 1) To use the skills of scientific inquiry to uncover the most likely perpetrator of a crime, and 2) To employ a paper diagnostics tool as a forensics device for chemically determining whodunit.

Time required: Two 50-minute class periods

Preparation Time
At least 24-hours prior to the student activity:

1. Cut and laminate "Cast" cards for each team of 4 students. Each team of students should be randomly assigned a character to play within their teams (Ocatavia Lister, Tony Wayler, Anna Lopez, and Detective Smart).
2. Photocopy enough copies of the student activity guide, crime scene scenario, wound chart, lead investigator report, and suspect organizational chart form for each student and group. Every student should be provided with a copy of the student activity guide and crime scene scenario and ONE cast card. ONLY the student playing the detective should be provided with the detective cast card, wound chart, lead investigator's report form, suspect organizational chart, and badge.

In-Class Time (Day 1)
At least 45-minutes of class time on Day 1 to distribute the crime scene scenario, assign roles, and to allow the detective to interview the suspects and complete the appropriate forms by the end of the class.

In-Class Time (Day 2)

1. At least 30-minutes for each group to present their prediction about the perpetrator of the crime with supporting evidence, to review laboratory safety procedures, and to use the paper diagnostic tool to confirm the identity of the perpetrator in each group.
2. At least 20-minutes on Day 2 for discussing the experimental results (i.e., discussion questions) and for proper cleanup of lab stations. Lab questions can be completed independently outside of class time.

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*Development and distribution funded by the **National Science Foundation through grants PHY-0117795 and EEC-0601939***

Level:
Techniques, materials, and equipment are appropriate for grades 8-10 life science and/or general science curricula.

Teacher Background:
Television dramatic series including Law and Order and CSI exhibit widespread appeal among high school students because of their close imitation of actual crime investigations. Fictional crime scene scenarios, therefore, can serve as effective instructional tools for engaging students in the process of scientific inquiry. This activity requires students to work in teams of 4 in order to solve a crime. Each member of the group is randomly assigned to play either one of three suspects or the detective. As the crime scene scenario is explored, students are challenged with determining who within the group is the most likely perpetrator.

Not only do students participate in this activity as cast members in the scenario, but they also have an opportunity to work collaboratively to determine if their powers of deduction, observation, and inquiry lead them to the correct identity of the culprit. This activity culminates in the testing of "unknown" liquid samples collected at the crime scene and at the suspects' home and/or place of work. Each sample will be tested for the presence of "cyanide" and "creatine" through a simulated chemical forensic analysis. Students will employ a novel paper diagnostics technique for determining the presence of "cyanide" and "creatine" in the samples provided. This only requires common laboratory material in small quantities. Note: The "cyanide" in this activity is really a .1M NaOH solution, and the "creatine" in this activity is really powdered LB Nutrient Broth.

Students should be familiar with the scientific method, proper lab safety protocols, and procedures for conducting scientific investigations.

Assessment:
Students will be assessed on their approach to solving the case. The teacher will collect the completed wound chart, lead investigator's report, suspect organizational chart, and one PowerPoint slide representing the group's conclusion. This PowerPoint slide must include one image and one paragraph identifying the culprit and an explanation substantiated by evidence about why the other suspects could not have committed the crime.

Materials:
- 7g or 1 ½ tsp Powdered Nutrient Broth
- 6 microtubes or small container for samples
- 50mL .1M NaOH solution
- Permanent marker
- 25mL Apple Juice
- Transparent Tape
- 1 box of Q-Tips®
- Protective Gloves
- Plastic sandwich bags
  - 6 for Day 1 Cast Cards
  - 6 for Day 2 Forensic Analysis
- Biuret Reagent
- Scrapbooking Paper punch
- Universal Indicator
- Chromatography paper (Whatman)
- 50mL beaker or microtube rack for holding suspect samples

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At Teacher Workstation (for a class of 24 students/6 groups of 4 students)

Prior to Day 1

Copy 24 of the following:

- Crime scenario: *The Case of the Patent Pending*
- Student Activity Guide

Copy 6 of the following:

- Lead Investigator's Report
- Suspect Organizational Chart
- Wound Chart

Prepare 6 sets of the following:

- Laminated Suspect Cast Cards (Images on each cast card may be changed to incorporate pictures of individuals that are familiar to the students)
- 1 Police badge

Prior to Day 2

Prepare "Suspect" Stock Solutions for 6 groups of 4

Note: You may choose to change the ingredients in these recipes, as long as the test results are conserved.

Victim:
Add ½ tsp. of Powdered Nutrient broth to 25 mL of .1M NaOH
Aliquot 1mL of this solution to 6 microtubes labled "Victim"

Octavia:
Aliquot 1mL of distilled water to 6 microtubes labeled "Octavia"

Anna:
Add ½ tsp. of Powdered Nutrient broth to 25mL Coke®
Aliquot 1mL of this solution to 6 microtubes labeled "Anna"

Tony (same as Victim, therefore the culprit):
Add ½ tsp. of Powdered Nutrient broth to 25 mL of .1M NaOH
Aliquot 1mL of this solution to 6 microtubes labeled "Tony"

Make 24 cutout leaflets using a scrapbook hole punch

Use a Q-Tip® to load a drop of reagent to two leaflets on the cutout

Note: *One reagent should be universal indicator to detect the presence of an acid or a base with an obvious color change and the second should be Biuret Reagent used to detect the presence of protein in solution.*

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At Student Workstations/Supplied in Plastic Bag on Day 2

In each plastic bag:
4 prelabeled microtubes containing corresponding "Suspect" Stock Solutions
4 Q-Tips® (2 Q-Tips® cut in half)
4 chromatography cutouts pre-treated with Biuret and Universal Indicator
Transparent tape

At each Student Workstation:
50mL beaker for holding the microtubes
Forceps for handling treated paper cutouts
Protective gloves for handling treated paper cutouts
1 permanent marker
Goggles
Aprons

Advance Preparation For:

Day 1:

1. The first day activity will require laminated Cast Cards and Police Badge for each group of 4 as well as copies of the following for each student group: Lead Investigator's Report, Suspect Organizational Chart, and Wound Chart.
2. In addition, copy a sufficient number of the following for each student: Student Activity Guide and The Case of the Patent Pending.

Day 2:

1. Wear gloves to prepare the following.
2. Prior to the second day of the activity, the chromatography cutouts (paper diagnostics) must be fabricated. Use a scrapbooking paper punch to punch out 4 paper cutouts per group. For a class of 24 students this equates to 24 paper cutouts.
3. Insert one end of a Q-Tip® into a sample of Universal Indicator. Place the Q-Tip® directly on one leaflet of the paper cutout until it appears on the paper (it should appear as a yellowish color). Repeat this for all 24 cutouts.
4. Insert the other end of the Q-Tip® into a sample of Biuret Reagent. Place the Q-Tip® directly on the leaflet directly opposite of the one containing Universal Indicator. The Biuret Reagent should appear on the leaflet as a light blue/purple color. Repeat this for all 24 cutouts.
5. Prepare plastic bags of materials for each group.

Safety Information

(NOTE: Refer to www.flinnsci.com/Documents/miscPDFs/SafetyContract.pdf for a copy of the specific lab safety contract used with this investigation).

a. Always wear your safety goggles and lab coat when working in the laboratory;
b. Food and/or drink are not permitted in the lab area;
c. Wash all glassware thoroughly in order to eliminate cross contamination;
d. Always dispose of liquid chemicals in properly labeled receptacles; and
e. Prior to exiting the lab area, utilize proper hand washing techniques.

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Directions for the Activity

The following directions apply to one class of 24 students or 6 groups. Increase or decrease the amount of materials according to your class size and/or the number of classes participating in the activity.

At least 2 days prior to Day 1 activity

Prepare Group Cast Cards and Copies

1. Copy and laminate 6 copies of the Cast Cards provided, or incorporate images of people with whom your students are familiar to spark interest.
2. Insert laminated Cast Cards into 6 sandwich bags labeled Group 1 to Group 6. Each bag should contain a card for Anna, Octavia, Tony, the Detective, and the police badge.
3. Make 6 copies of the Lead Investigator Report, Wound Chart, and Suspect Organizational Chart.
4. Make the appropriate number of copies for a classroom set of the Crime Scenario: The Case of the Patent Pending and the Student Activity Guide.

At least 2 days prior to Day 2 activity

Prepare Paper Cutouts (Paper Diagnostic Tool)

1. Cut 24 paper cutouts using the scrapbooking paper punch.

2. Using a Q-Tip®, apply Universal Indicator and Biuret Reagent samples to each of the paper cutouts. Allow treated cutouts to dry overnight.

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3. Prepare bags for "Chemical Forensic Analysis." Prepare one bag for each group of 4 students to include 4 pre-treated paper cutouts, 4 Q-Tip® halves, one roll of transparent tape, and 4 microtubes (or similar container) labeled A (Anna), T (Tony), O (Octavia), and V (Victim) for suspect/victim samples.

Student Workstation (9/2008)

Day 1
Making Predictions

1. After defining scientific facts as "data gathered through the five senses" and inferences as "logical interpretations based on data and prior knowledge," present the crime scenario and present the task for the period.
2. Divide your students into groups of 4 and randomly assign each student a role to play. Once the roles have been determined, provide each student group with the sandwich bag of laminated cast cards. Allow students to read the contents on the back of each card to ensure that the interviews are carried out efficiently.
3. Provide the Detective with copies of the "Lead Investigator Report," "Wound Chart," and the "Suspect Organizational Chart."
4. The Detective's task is to conduct interviews for gathering data about each suspect before the end of the class period. Students playing the role of the suspects should answer questions based on the content of their cast card. Students may approach the instructor for additional information which you may choose to supply.
5. Once the interviews have been conducted, the group must decide, based on the evidence (facts) collected, which suspect is the most likely culprit and why (making inferences). This is accomplished by completing the "Suspect Organizational Chart – Predictions."
6. Allow all student groups to present their predictions and encourage other student groups to challenge those predictions.
7. Collect and staple the "Lead Investigator's Report," "Wound Chart," and "Predictions Table" from each group. Check that all interview synopses consist of facts only, and all motives are written as inferences.

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Day 2

Testing the Prediction Using Chemical Forensic Analysis

1. Student lab stations should be setup prior to class time. Each station should be equipped with the suspect samples, Q-Tips®, treated paper cutouts (forensic analysis tool), transparent tape, forceps, protective gloves, a paper towel, permanent marker, and Predictions Chart from the previous class period.
2. The suspect/victim samples can be prepared the day before, and paper cutouts can be treated the night before as well. **NOTE:** Results are more consistent when the paper cutouts are treated the morning of the activity compared to treated paper cutouts that have been treated 24-48 hours in advance. Use different Q-Tips® to dab the Universal Indicator and the Biuret reagent on the paper cutout leaflets. Allow them to dry before placing them in the sandwich bags with the other student supplies.
3. Students should report to their assigned group and lab station for this portion for the activity.
4. Review the student group predictions from the previous day and record those predictions on the board.
5. Review the activity protocol and safety precautions before proceeding. Emphasize the importance of avoiding cross-contamination of Q-Tips® and performing the "Forensic Analysis" on a paper towel to avoid contamination from the workstation.
6. When students have applied the Q-Tip® sample from each suspect/victim to the paper diagnostic device (forensic analysis tool), they should be instructed to tape their paper devices to the appropriate square in the "Suspect Organizational Chart – Results" section. Students should compare the results for each suspect and record motives and guilt in the appropriate columns on the chart.
7. Student groups who successfully predicted the culprit can be awarded with a "semi-fabulous" prize (e.g., pencil, eraser, inexpensive toy)
8. The activity should close with a discussion of the components of the scientific method and a reiteration about the differences between facts and inferences. In this activity, facts were gathered through interviews, and inferences were generated through the formulation of motives.
9. **Optional Extension:** If time permits, ask students to generate a PowerPoint slide that includes a summary of the group's work, prediction, and conclusion.

Procedure (from Student Activity Guide)

Day 1: Presentation of Crime Scenario and Making Predictions… Whodunit?

1. Your teacher will divide you into groups of four.
2. Once the groups have formed, your task will be to listen carefully to the fictitious crime scenario read by your teacher. You may want to take notes to help in your inquiry.
3. When the story is finished, your teacher will distribute a sandwich bag of 4 "Cast Cards" which contain the information you will need to make a prediction about the most likely suspect responsible for Lizaree's death.
4. The roles that group members play will be randomly determined.

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5. Once the roles have been identified, the Detective will have 15 minutes to "interview" each possible suspect. As the interviews are being conducted, the Detective must complete the "Lead Investigator's Report" to be submitted to your teacher at the end of the class period along with the "Wound Chart" based on Lizaree's condition upon police arrival to the crime scene. During this time, the other 2 suspects should take notes about the conversation as well. If at any time during the questioning period, the suspect cannot answer a question, s/he may ask the teacher for help.
6. When the interviews are complete, the group must determine "whodunit" based on the evidence collected. In order to help guide and communicate the group's decision, a chart displaying each suspect and his/her possible motive will be generated.
7. At the conclusion of the class period, each group should have identified the suspect that is most likely responsible for Lizaree's death and will have 2 minutes to present their decision to the class along with their justification and supporting evidence.
8. Each student group will be required to submit their Lead Investigator's Report, Wound Chart, and Suspect Organizational Chart - Predictions at the conclusion of class.

Day 2: Testing the Prediction and Interpreting Results

1. Yesterday you and your group exposed one suspect as your perpetrator. Today you will use a new forensic analysis tool to test your prediction.
2. You and your team members will report to an assigned lab station. You will be required to wear gloves, goggles, and aprons in order to reduce contamination of your paper diagnostic devices.
3. You will need your "Suspect Organizational Chart – Results" table in order to record your observations as they are obtained.
4. At your station there should be 4 microtubes labeled: Victim, Octavia, Tony, Anna. Each microtube contains a sample of liquid that was collected at the crime scene.
5. You will carry out the remainder of the experiment on a piece of clean paper towel to prevent contamination of your samples.
6. At your station, you should also have 4 pieces of treated chromatography paper that has been punched into flower shapes and 4 Q-Tips® that will be used for loading your samples onto the paper device.


This is your forensic tool!

Paper Punch and Chromatography cutouts

7. Orient your paper cutout so that the leaflet that is yellowish is pointing to the left. This orientation ensures that this leaflet will properly test for the presence of "cyanide" while the light purple leaflet directly across from it will test for the presence of "creatine." **NOTE: This is a simulation. The reagents used do not detect the presence of these substances. Alternative indicators have been used to treat the paper in an attempt to create a realistic test**.

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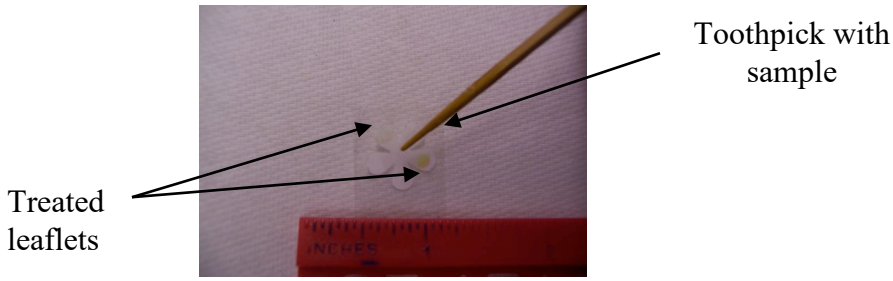
8. After orienting the paper cutouts, secure them to a piece of transparency tape. Make sure that you are wearing your gloves to perform this task. Label each piece of tape with an appropriate abbreviation for the suspects names so they are not confused during your interpretation of results (i.e., Victim – V, Octavia – O, Tony – T, Anna – A).
9. Once the paper cutouts (a.k.a., paper devices) have been prepared, obtain a Q-Tip® or glass capillary tube (depending on what you have available). Use this to transfer a sample of liquid from your microtube to the center loading point on your paper device.

Loading the sample with a toothpick or Q-Tip®



NOTE: DO NOT REUSE LOADING INSTRUMENTS! Once you have used your Q-Tip® or glass capillary tube to load the sample, discard it! Capillary tubes should be discarded in the broken glass receptacle and Q-Tips® should be discarded in the regular waste container.

10. A (+) test for the presence of "creatine" occurs when the color change of the treated leaflet is violet/purple. A (+) test for the presence of "cyanide" occurs when the color change of the treated leaflet is blue/purple. Record the color changes that you observed on each paper device on your "Suspect Organization Chart – Results" handout.
11. Dispose of your Q-Tips®, paper towel, and gloves in the general waste (if you used capillary tubes, dispose of these on the broken glass receptacle). Leave the microtubes at your station. Return your goggles and apron, and show your results to your teacher.
12. Your teacher will return your group's "Suspect Organizational Chart – Predictions" handout in order for you to compare your predictions with your actual results.
13. Respond to the Conclusion Questions as a group.

Cleanup:

Dispose of used Q-Tips® and paper towel in general waste receptacle. Suspect/victim samples in microtubes, forceps, and tape can be reused for subsequent classes.

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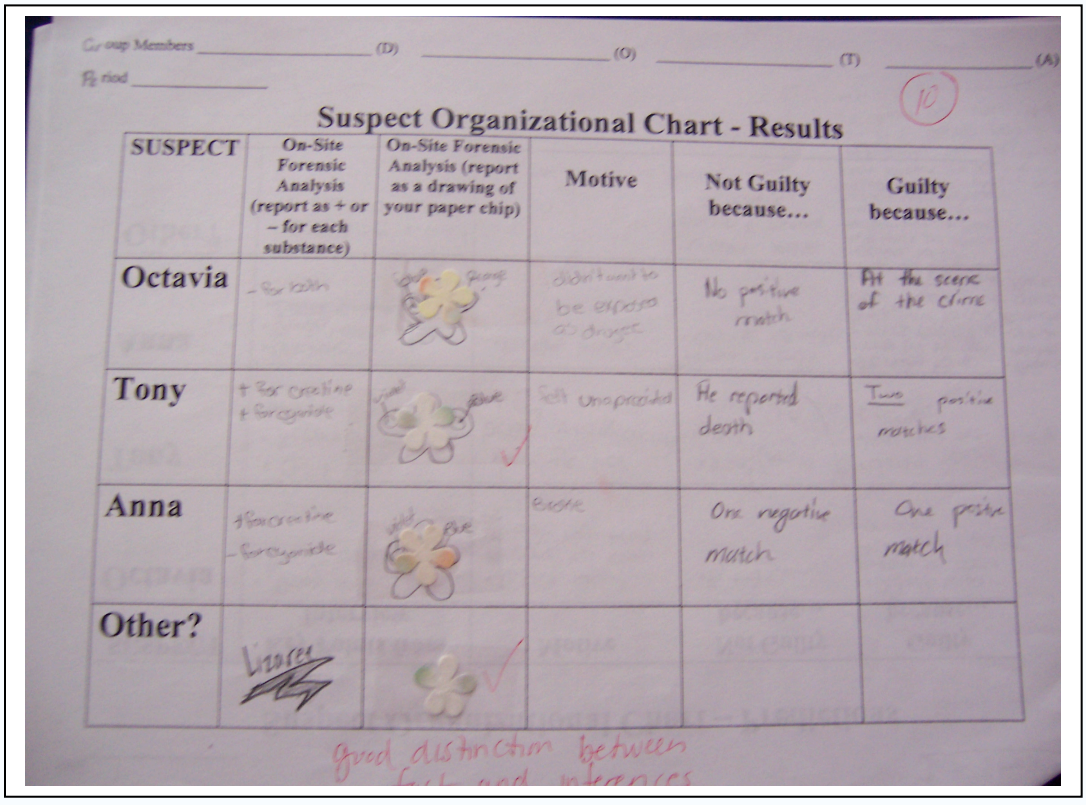
- **Worksheet (with answers)**

SUSPECT	On-Site Forensic Analysis (report as + or – for each substance)	On-Site Forensic Analysis (report as a drawing of your paper chip)	Motive	Not Guilty because…	Guilty because…
Octavia	(-) Creatine (-) Cyanide		Afraid Lizaree will convey her secret because she knows Lizaree did not invent the processor	Lizaree's closest friend and a changed person; Neither test is positive for creatine or cyanide	
Tony	(+) Creatine (+) Cyanide		Jealous of Lizaee's celebrity; threatened by withdrawal of financial support; access to cyanide through arboriculture		**Access to cyanide and creatine; positive for creatine and cyanide**
Anna	(+) Creatine (-) Cyanide		Needs money to keep her business; access to cyanide through processing fruit pits	Knows Lizaree would help her financially if asked (she helped Tony); positive for creatine only	
Other?	?		?	?	?



Group Members _____ (D) _____ (O) _____ (T) _____ (A)

Period _____

10

Suspect Organizational Chart - Results

SUSPECT	On-Site Forensic Analysis (report as + or – for each substance)	On-Site Forensic Analysis (report as a drawing of your paper chip)	Motive	Not Guilty because…	Guilty because…
Octavia	– for both		didn't want to be exposed as dryer	No positive match	At the scene of the crime
Tony	+ for creatine + for cyanide		felt unprovoked	He reported death	Two positive matches
Anna	+ for creatine – for cyanide		Broke	One negative match	One positive match
Other?	Lizaree				

Good distinction between [illegible]

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- **Questions for Discussion**

Interpreting Results

1. Did your observations match your predictions?
   If not, how did your observations differ from your predictions?

2. What part of this experiment served as the control?
   The sample collected from the victim's apartment.

3. Do your observations leave you with any more questions? Do they enable you to make more predictions? If so, what are they?
   Answers will vary. Some students may describe the limitations of the experiment as only a piece of evidence rather than a true determinant of guilt or innocence. Some students may also consider that the results are circumstantial and have no bearing on the true guilt of the suspect.

Applying the Results

4. Write a persuasive argument (as a defense attorney) for the innocence of the culprit. This will require you and your partners to identify loopholes in the technology as well as limitations to the experiment and the crime scenario in general.

5. Design a follow-up experiment based on your results. For example, if the content of the sample obtained from the victim's apartment matches the sample obtained at Anna's Health Club, does this mean the case is closed?

6. How is the scientific method being employed in this scenario? Your answer must address each of the steps displayed in the diagram below.

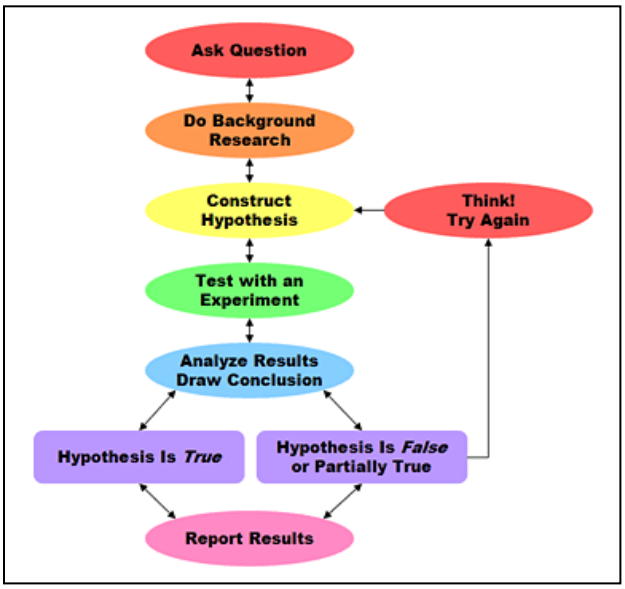

Image Source:
http://www.eas.slu.edu/People/RBHerrmann/Courses/EASA193F07/

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Drawing Conclusions

7. Example: Based on your results, can you say for certain that _____Tony____ is the culprit in this crime? Explain your answer.
   Tony has been implicated as a potential suspect in this crime as a result of the forensic analysis performed. However, this does not mean for certain that Tony is the perpetrator of the crime. Other compelling evidence must be collected and analyzed before guilt can be determined.

Assessment

1. Students will be assessed on the consistency of their results and the accuracy of their responses to the discussion questions (worksheet).
2. This lesson as it is can serve as an assessment, particularly if a lab report is assigned at the conclusion of the lesson/activity.
3. Students can demonstrate their understanding of the scientific process by presenting their results in the form of a newspaper article or PodCast/TV media story.

National and State Science Standards

National Science Education Standards

6.1 Science as Inquiry Standards

1. Abilities necessary to do scientific inquiry

a. IDENTIFY QUESTIONS AND CONCEPTS THAT GUIDE SCIENTIFIC INVESTIGATIONS. Students should formulate a testable hypothesis and demonstrate the logical connections between the scientific concepts guiding a hypothesis and the design of an experiment. They should demonstrate appropriate procedures, a knowledge base, and conceptual understanding of scientific investigations.

b. RECOGNIZE AND ANALYZE ALTERNATIVE EXPLANATIONS AND MODELS. This aspect of the standard emphasizes the critical abilities of analyzing an argument by reviewing current scientific understanding, weighing the evidence, and examining the logic so as to decide which explanations and models are best. In other words, although there may be several plausible explanations, they do not all have equal weight. Students should be able to use scientific criteria to find the preferred explanations.

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2. Understanding about scientific inquiry

a. Scientists conduct investigations for a wide variety of reasons. For example, they may wish to discover new aspects of the natural world, explain recently observed phenomena, or test the conclusions of prior investigations or the predictions of current theories.

b. Results of scientific inquiry--new knowledge and methods--emerge from different types of investigations and public communication among scientists. In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge. In addition, the methods and procedures that scientists used to obtain evidence must be clearly reported to enhance opportunities for further investigation.

Massachusetts State Curriculum Frameworks:

A. Inquiry Skills

1. **SIS1. Make observations, raise questions, and formulate hypotheses.**
   a. Observe the world from a scientific perspective
   b. Pose questions and form hypotheses based on observations, experiments, and knowledge
   c. Read, interpret, and examine the credibility and validity of claims
2. **SIS2. Conduct scientific investigations.**
   a. Articulate and explain the major concepts being investigated and the purpose of an investigation
   b. Identify controls, independent and dependent variables
   c. Employ appropriate methods for accurately and consistently making observations, making and recording measurements at appropriate levels of precision, collecting data or evidence in an organized way
   d. Properly use instruments and equipment
   e. Follow safety guidelines.
3. **SIS3. Analyze and interpret results of scientific investigations.**
   a. Present relationships between and among variables in appropriate forms
   b. Assess the reliability of data and identify reasons for inconsistent results, such as sources of error or uncontrolled conditions
   c. Use results of an experiment to develop a conclusion to an investigation that addresses the initial questions and supports or refutes the stated hypothesis
   d. State questions raised by an experiment that may require further investigation
4. **SIS4. Communicate and apply the results of scientific investigations.**
   a. Develop descriptions of and explanations for scientific concepts explored
   b. Review information and summarize data collected
   c. Construct a reasoned argument and respond appropriately to critical comments and questions
   d. Use and refine scientific models that simulate physical processes or phenomena.

Massachusetts Department of Education, Science and Technology Curriculum Frameworks, 2006 http://www.doe.mass.edu/frameworks/scitech/1006.pdf

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