

Forensic Sciences: A Crime Scene Investigation Unit for Senior 3 Current Topics in the Sciences



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INTRODUCTION

I never guess. It is a shocking habit—destructive to the logical faculty. What seems strange to you is only so because you do not follow my train of thought or observe the small facts upon which large inferences may depend.

Sherlock Holmes, *The Sign of Four*

Forensic Sciences: A Crime Scene Investigation Unit for Senior 3 Current Topics in the Sciences contains suggested essential understandings and possible activities, assignments, investigations, and assessment ideas for curriculum implementation. What is included here is by no means exhaustive or restrictive; nor is it expected that all suggested activities will be used. The essential understandings are not arranged in order of importance or priority, and may be addressed in any order that produces a coherent sequence. Teachers decide which essential understandings will allow them to address the specific learning outcomes that frame Senior 3 Current Topics in the Sciences.

Teachers are encouraged to choose from this selection of suggested content, activities, investigations, and assignments, of varying levels of difficulty, and to develop the unit further by using some of their own content and activities. Many online and print resources are available to supplement the treatment of Forensic Sciences in the classroom. (See the Resources cited at the end of this unit.)

Rationale

Solving mysteries is a challenge many people enjoy. If they take a scientific approach, they are likely to use forensic sciences to examine evidence and to solve crimes. Students are commonly exposed to crime situations in the media, both fictional and real, and are likely aware that forensic sciences are used to solve crimes, as many current television programs and popular authors use the science of forensics to develop their dramas. However, students may not be aware of the methodology used by law enforcement personnel. By becoming involved in a simulated crime scene, students will see how forensic investigators apply scientific skills and processes in a problem-solving capacity.

A *forensics team* is a group of scientists who work together performing different jobs to solve crimes or to identify people. A forensics team may observe the crime scene and gather evidence such as hair and fibre samples, fingerprints, and tissue samples. An *investigative team* includes forensic scientists with varying areas of expertise, including toxicology, forensic biology, forensic entomology, chemistry, forensic psychology, forensic odontology, forensic anthropology, bloodstain pattern analysis, and weapons specialists. The job of forensic investigators is to use science and technology to perform tests on the evidence collected. The results from these tests can then be used to support a theory of guilt or innocence.

Forensic scientists use the same instruments and techniques used by scientists doing other types of research, including microscopes, computers, gas chromatographs, and lasers. As science has advanced, so has the ability to gather evidence and to solve crimes. At crime scenes, portable lasers provide special lighting. Imaging technology lets a police officer instantly send a photograph or fingerprint image to a central data bank for identification. Computers can enhance pictures taken by a security camera at a crime scene. New chemicals allow the visualization of otherwise unseen fingerprints. Lasers can vaporize tiny portions of a paint specimen to determine the exact paint used on a car in a hit-and-run case. A single cell can provide deoxyribonucleic acid (DNA) that molecular biology techniques can match with a suspect.

Forensic Sciences: A Crime Scene Investigation Unit

The Forensic Sciences unit was developed to allow students to integrate a number of scientific disciplines and to practise a variety of scientific skills and processes, including making comparisons, classifications, observations, measurements, and predictions, as well as formulating hypotheses, manipulating variables, and interpreting data. The unit consists of individual activities, each of which includes teacher and student pages. The unit can be designed to include any activities teachers (or students) may wish to incorporate into their forensics learning experience.

The student learning activities are highly variable, and can be structured and sequenced according to student interest, available materials, and local resources. Solving a crime requires the use of critical thinking skills that will integrate several science disciplines and be useful across the curriculum.

Integrating the Sciences

As students explore the topic of forensic sciences, many sciences may naturally be integrated. The following table outlines suggested essential understandings and their possible connections to the major science disciplines. It is important to recognize, and reinforce with students, that it is common for diverse specialties to operate simultaneously in scientific investigation.

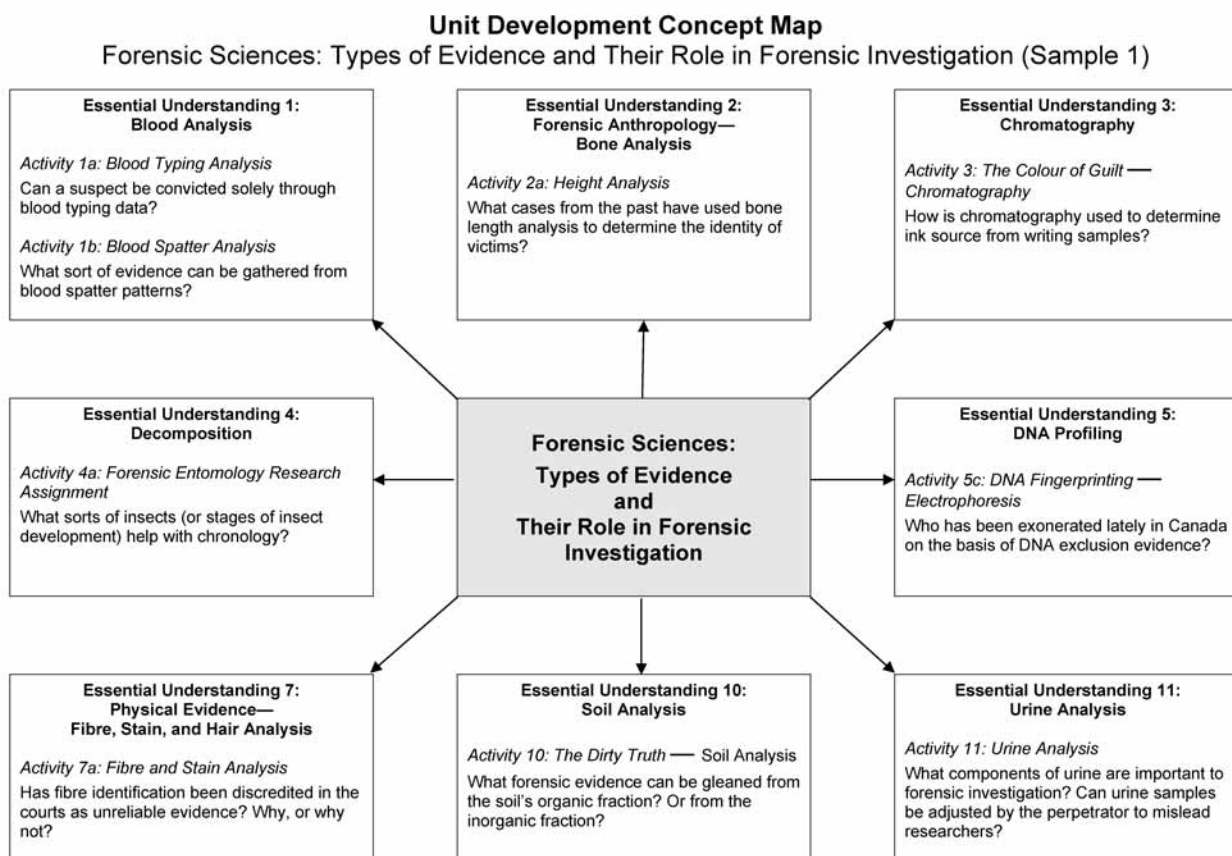
Essential Understandings					
Number	Essential Understanding	Biology	Chemistry	Physics	Geo-Sciences
1	Blood Analysis	• Blood typing	• Chemical reactions	• Blood spatter analysis	
2	Forensic Anthropology—Bone Analysis	• DNA • Bones			
3	Chromatography		• Solubility		
4	Decomposition	• Entomology • Life cycles			• Soil
5	DNA Profiling	• DNA	• Chemical extraction		
6	Fingerprinting				
7	Physical Evidence—Fibre, Stain, and Hair Analysis	• Physical characteristics			
8	Handwriting Analysis				
9	Chemical Detection		• Properties • Chemical reactions		
10	Soil Analysis				• Soil characteristics
11	Urine Analysis	• Kidney function • Disease	• Chemical reactions		
12	Further Analyses				

Planning the Forensic Sciences Unit

A unit plan evolves from a particular topic. A number of essential understandings within the area of interest could be generated either by the teacher alone or with the help of students. *Essential understandings* are concepts, skills, or bodies of knowledge that are crucial for students to comprehend to develop an in-depth understanding of the topic. The essential understandings will likely determine the specific learning outcomes (SLOs) for general learning outcome (GLO) D (Essential Concepts).

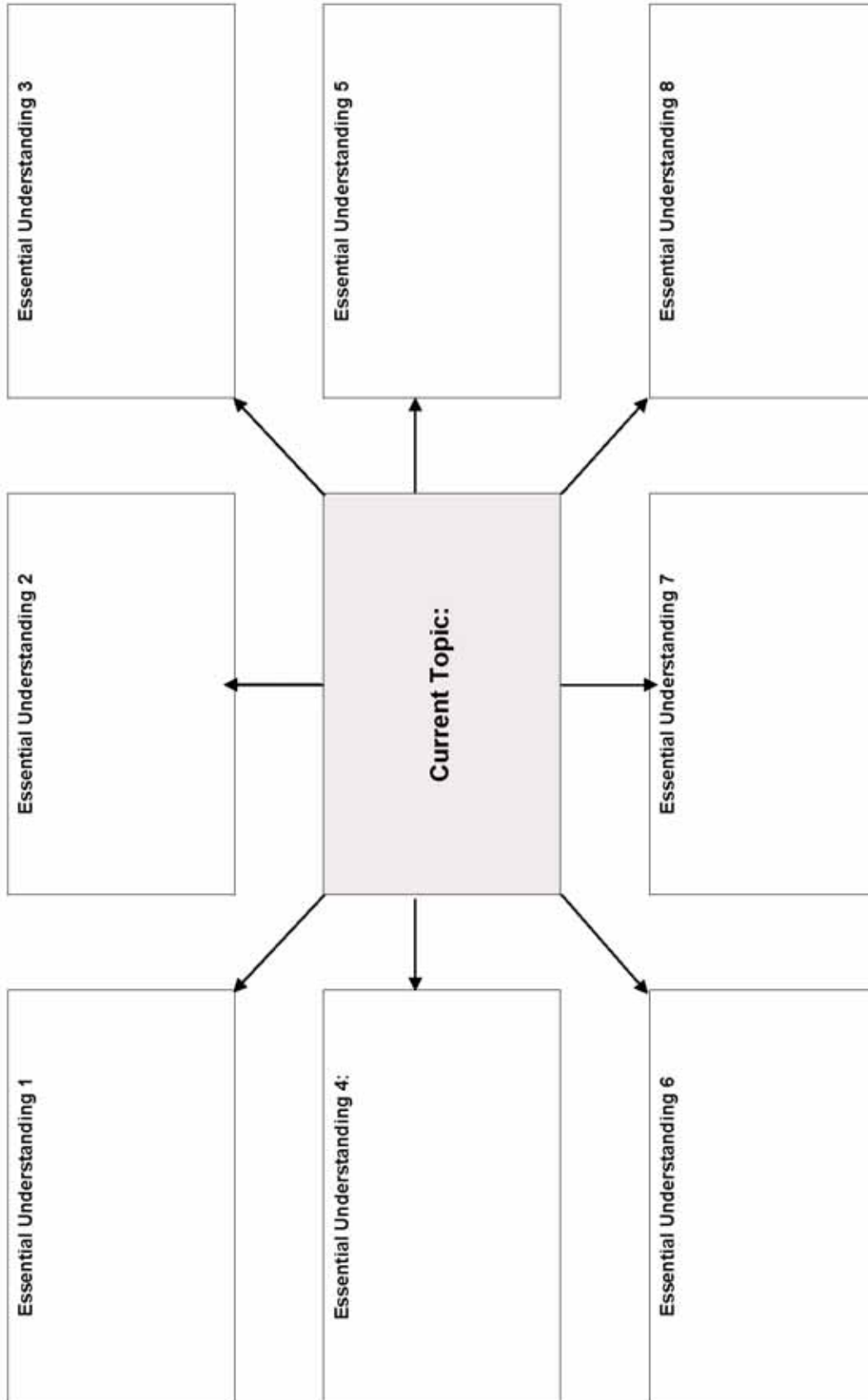
The number of essential understandings generated will depend upon the topic, the amount of time allotted to the unit, and the interest of students. There may be essential understandings of particular interest to students that develop during the presentation of the unit, and teachers are encouraged to pursue these. While the size of a unit may vary (for example, 10 to more than 50 hours), teachers are encouraged to pursue a depth of treatment that is manageable and connected to the SLOs identified for the Senior 3 Current Topics in the Sciences curriculum. (Teachers implemented the Draft version of the Forensic Sciences unit with timelines spanning 25 to 65 hours.)

In developing the Forensic Sciences unit, teachers may choose to use planning tools such as the Unit Development Concept Map (with possible essential questions) or the Unit Development Using Essential Understandings Approach shown in the samples and templates that follow. Teachers involved in field validation work found these planning tools useful.



Note: There may be more or fewer than eight essential understandings. The arrows serve to connect essential understandings to the topic.

Unit Development Concept Map



Note: There may be more or fewer than eight understandings. The arrows serve to connect essential understandings to the topic.

Unit Development			
Using Essential Understandings Approach			
Forensic Sciences: A Crime Scene Investigation Unit (Sample 1)			
Current Topic:		Forensic Sciences: Crime Scene Investigation	
Essential Understanding:		1. Blood Analysis	
		SLO Tracking	
Knowledge:	<ul style="list-style-type: none"> There is a relationship between the distance a drop of blood falls and the diameter of its spatter. There is a relationship between the angle and direction a drop of blood falls and its spatter pattern. 	SLO D3: Understand the processes and conditions in which change, constancy, and equilibrium occur.	
Skills:	<ul style="list-style-type: none"> Measurement Collaboration Data Analysis 	SLO C1: Demonstrate appropriate scientific inquiry skills, attitudes, and practices when seeking answers to questions.	
Activities:	<ul style="list-style-type: none"> Blood Spatter Analysis Lab 	SLO A2: Recognize both the power and limitations of science as a way of answering questions about the world and explaining natural phenomena.	
Assessment:	Formative	<ul style="list-style-type: none"> Blood Spatter Analysis Lab 	SLO C1 SLO C4 SLO C5
	Summative	<ul style="list-style-type: none"> Blood Spatter Analysis Lab Report 	SLO A2 SLO C4 SLO D3

Unit Development Using Essential Understandings Approach		
Current Topic:		
Essential Understanding:		
		SLO Tracking
Knowledge:	•	
Skills:	•	
Activities:	•	
Assessment:	Formative	•
	Summative	•

Linking to Specific Learning Outcomes

After developing the initial unit plan, teachers may use an SLO Tracking Chart to link instructional strategies and student learning activities to the **specific learning outcomes (SLOs)**.

A single unit will not necessarily address all SLOs. The SLOs are cumulative in nature, and it is expected that a student will have the opportunity to achieve all outcomes by the end of Senior 3 Current Topics in the Sciences.

An SLO Tracking Chart will assist teachers in determining whether each SLO has been addressed at least once during curriculum implementation. Many SLOs will be addressed more than once by virtue of the design of interdisciplinary units.

The following SLO Tracking Chart is an example of a specific learning outcome audit for a set of student learning activities in a Forensic Sciences unit. A template of the SLO Tracking Chart follows the sample.

SLO Tracking Chart									
Forensic Sciences: A Crime Scene Investigation Unit (Sample 1)									
Learning Outcomes	Forensic Sciences Activities								
	Blood Typing Analysis	Blood Spatter Analysis	Height Analysis	The Colour of Guilt— Chromatography	Forensic Entomology Research Assignment	DNA Fingerprinting— Electrophoresis	Fibre and Stain Analysis	The Dirty Truth— Soil Analysis	Urine Analysis
	1a.	1b.	2a.	3.	4a.	5c.	7a.	10.	11.
NATURE OF SCIENCE AND TECHNOLOGY									
GLO A: Differentiate between science and technology, recognizing their strengths and limitations in furthering our understanding of the world, and appreciate the relationship between culture and technology.									
SLO A1: Distinguish critically between science and technology in terms of their respective contexts, goals, methods, products, and values.	•					•			
SLO A2: Recognize both the power and limitations of science as a way of answering questions about the world and explaining natural phenomena.		•					•		
SLO A3: Identify and appreciate the manner in which history and culture shape a society's philosophy of science and its creation or use of technology.									
SLO A4: Recognize that science and technology interact and evolve, often advancing one another.	•					•			
SLO A5: Describe and explain disciplinary and interdisciplinary processes used to enable us to investigate and understand natural phenomena and develop technological solutions.				•		•		•	
SCIENCE, TECHNOLOGY, SOCIETY, AND THE ENVIRONMENT									
GLO B: Explore problems and issues that demonstrate interdependence among science, technology, society, and the environment.									
SLO B1: Describe scientific and technological developments, past and present, and appreciate their impact on individuals, societies, and the environment, both locally and globally.						•			
SLO B2: Recognize that scientific and technological endeavours have been, and continue to be, influenced by human needs and by societal and historical contexts.							•		
SLO B3: Identify the factors that affect health and explain the relationships of personal habits, lifestyle choices, and human health, both individual and social.	•								•
SLO B4: Demonstrate a knowledge of, and personal consideration for, a range of possible science- and technology-related interests, hobbies, and careers.				•	•				
SLO B5: Identify and demonstrate actions that promote a sustainable environment, society, and economy, both locally and globally.								•	

(continued)

SLO Tracking Chart									
Forensic Sciences: A Crime Scene Investigation Unit (Sample 1)									
(Continued)									
Learning Outcomes	Forensic Sciences Activities								
	Blood Typing Analysis	Blood Spatter Analysis	Height Analysis	The Colour of Guilt— Chromatography	Forensic Entomology Research Assignment	DNA Fingerprinting— Electrophoresis	Fibre and Stain Analysis	The Dirty Truth— Soil Analysis	Urine Analysis
	1a.	1b.	2a.	3.	4a.	5c.	7a.	10.	11.
SCIENTIFIC AND TECHNOLOGICAL SKILLS AND ATTITUDES									
GLO C: Demonstrate appropriate inquiry, problem-solving, and decision-making skills and attitudes for exploring scientific and/or technological issues and problems.									
SLO C1: Demonstrate appropriate scientific inquiry skills, attitudes, and practices when seeking answers to questions.	•		•				•		
SLO C2: Demonstrate appropriate technological problem-solving skills and attitudes when seeking solutions to challenges and problems related to human needs.									
SLO C3: Demonstrate appropriate critical thinking and decision-making skills and attitudes when choosing a course of action based on scientific and technological information.						•			
SLO C4: Employ effective communication skills and use a variety of resources to gather and share scientific and technological ideas and data.					•				•
SLO C5: Work cooperatively with others and value their ideas and contributions.		•	•			•			
ESSENTIAL CONCEPTS									
GLO D: Explore, understand, and use scientific knowledge in a variety of contexts.									
SLO D1: Use the concepts of similarity and diversity for organizing our experiences with the world.	•		•			•	•	•	
SLO D2: Recognize that the universe comprises systems and that complex interactions occur within and among these systems at many scales and intervals of time.					•				•
SLO D3: Understand the processes and conditions in which change, constancy, and equilibrium occur.		•		•		•			
SLO D4: Understand how energy is the driving force in the interaction of materials, processes of life, and the functioning of systems.					•				

Note: This chart is intended to highlight how student learning activities connect to the learning outcomes. It is not a comprehensive treatment of all activities in the sample Forensics Sciences unit.

SLO Tracking Chart									
Learning Outcomes	Activities								
	1	2	3	4	5	6	7	8	
NATURE OF SCIENCE AND TECHNOLOGY									
GLO A: Differentiate between science and technology, recognizing their strengths and limitations in furthering our understanding of the world, and appreciate the relationship between culture and technology.									
SLO A1: Distinguish critically between science and technology in terms of their respective contexts, goals, methods, products, and values.									
SLO A2: Recognize both the power and limitations of science as a way of answering questions about the world and explaining natural phenomena.									
SLO A3: Identify and appreciate the manner in which history and culture shape a society's philosophy of science and its creation or use of technology.									
SLO A4: Recognize that science and technology interact and evolve, often advancing one another.									
SLO A5: Describe and explain disciplinary and interdisciplinary processes used to enable us to investigate and understand natural phenomena and develop technological solutions.									
SCIENCE, TECHNOLOGY, SOCIETY, AND THE ENVIRONMENT									
GLO B: Explore problems and issues that demonstrate interdependence among science, technology, society, and the environment.									
SLO B1: Describe scientific and technological developments, past and present, and appreciate their impact on individuals, societies, and the environment, both locally and globally.									
SLO B2: Recognize that scientific and technological endeavours have been, and continue to be, influenced by human needs and by societal and historical contexts.									
SLO B3: Identify the factors that affect health and explain the relationships of personal habits, lifestyle choices, and human health, both individual and social.									
SLO B4: Demonstrate a knowledge of, and personal consideration for, a range of possible science- and technology-related interests, hobbies, and careers.									
SLO B5: Identify and demonstrate actions that promote a sustainable environment, society, and economy, both locally and globally.									

(continued)

SLO Tracking Chart <i>(continued)</i>									
Learning Outcomes	Activities								
	1	2	3	4	5	6	7	8	
SCIENTIFIC AND TECHNOLOGICAL SKILLS AND ATTITUDES									
GLO C: Demonstrate appropriate inquiry, problem-solving, and decision-making skills and attitudes for exploring scientific and/or technological issues and problems.									
SLO C1: Demonstrate appropriate scientific inquiry skills, attitudes, and practices when seeking answers to questions.									
SLO C2: Demonstrate appropriate technological problem-solving skills and attitudes when seeking solutions to challenges and problems related to human needs.									
SLO C3: Demonstrate appropriate critical thinking and decision-making skills and attitudes when choosing a course of action based on scientific and technological information.									
SLO C4: Employ effective communication skills and use a variety of resources to gather and share scientific and technological ideas and data.									
SLO C5: Work cooperatively with others and value their ideas and contributions.									
ESSENTIAL CONCEPTS									
GLO D: Explore, understand, and use scientific knowledge in a variety of contexts.									
SLO D1: Use the concepts of similarity and diversity for organizing our experiences with the world.									
SLO D2: Recognize that the universe comprises systems and that complex interactions occur within and among these systems at many scales and intervals of time.									
SLO D3: Understand the processes and conditions in which change, constancy, and equilibrium occur.									
SLO D4: Understand how energy is the driving force in the interaction of materials, processes of life, and the functioning of systems.									

Note: This chart is intended to highlight how student learning activities connect to the identified learning outcomes.

Establishing a Crime Scene

The Location

Choose an area with limited access to students, such as a storage area or an extra room at school, so that the crime scene can remain set up for continued observations. You may also choose to have the crime scene take place at another location (such as close to a pond), leaving evidence (such as soil, vegetation, and/or insects) indicating the area associated with the body found at the crime scene.

Storyline

Determine the victim(s) and suspect(s) and their relationship(s) to each other (if one can be established). Establish a scenario where all suspects have the motive, opportunity, and means to be involved in the crime, but the outcome is undetermined in advance. It is hoped that students will manage the evidence.

Suspects

Once you have established a group (about five) of suspects, decide whether to introduce them in written form or to have individuals (teachers) act out the roles. Each suspect should have the motive, opportunity, and means to be involved in the crime. Trace evidence may link a number of different suspects to the crime scene.

- **Motive:** A motive is a reason for committing the crime. Possible motives are passion, jealousy, greed, and revenge. Motive is usually determined through interviews and research.
- **Opportunity:** A suspect who can be placed at the scene of the crime, or was able to get to the scene of the crime within a certain time frame, can be said to have had opportunity.
- **Means:** A suspect considered by investigators to have been able to commit the crime can be said to have had means.

As an extension, you may want to add a witness or suspect who has been seen fleeing the crime scene.

Alibis

Establish alibis for some or all of the suspects (some alibis may be false). This information may be presented to students in written form, as in a police interview with the suspect. As the investigation proceeds, the suspect(s) might be subjected to several interviews where they might add new information and/or change their stories. You might choose to distribute information from the interviews at specific intervals. You might also provide your suspects with a written script and allow the forensic investigative teams to interview the suspects.

Suspect Files

You may wish to establish “suspect files” within the class, to which information can be added during the course of the investigation.

Evidence

Evidence is any statement or material object from which reasonable conclusions can be drawn. It is a broad category embracing anything perceptible to the five senses, including documents, exhibits, facts agreed to by both sides, and the testimony of witnesses. Evidence in a criminal trial concerns the intent, motive, means, and opportunity to commit a crime.

In general, evidence is divided into two categories: circumstantial and physical.

- **Circumstantial evidence** consists of information gleaned from witnesses and documents that point to an individual as the perpetrator of a crime.
- **Physical evidence** consists of actual objects, bodies, weapons, body-fluid stains, fingerprints, hairs, fibres, and so on, that are associated with the crime and may be linked to the perpetrator.

It is the work of forensic scientists to examine the physical evidence and, using the methods of science, to reconstruct the events that constituted the crime. The prosecutor must then combine this data with statements of witnesses and evidence from documents, such as correspondence, telephone records, and credit card receipts, to develop an overall theory of the case, which can be presented in court.

Crime Scene Details

Establish crime scene details such as the following:

- If possible, mark off the crime scene using police or yellow tape (Crime Scene—Do Not Cross).
- For the body, use a skeleton, a large doll, clothes stuffed with paper and a mask head, or simply an outline of the body marked with tape or chalk on the floor.
- Plant “trace” evidence at the crime scene (see Planting Evidence at the Crime Scene on the following page). Leave it all at once or control the gathering of evidence by leaving a few items at a time and having students return to the crime scene to gather more. Creating a tabular format sheet to track evidence will be useful in providing linkages to possible suspects.
- Consider leaving some red herrings as well, such as cigarette butts, empty cans, earrings, or candy wrappers.

Use a table such as the following to map out the types of evidence you plant at the crime scene and the suspect to whom it links.

Planting Evidence at the Crime Scene														
Evidence	Blood Typing	Blood Spatter	Bone/Foot Length	Chromatography	Decomposition	Dental	DNA	Fibres	Fingerprints	Hair	Handwriting	Powder	Soil	Urine
Victim														
Suspect A														
Suspect B														
Suspect C														
Suspect D														
Suspect E														

Collecting and Storing Evidence

Great care must be taken in collecting, labelling, and preserving any evidence connected with a crime. The police must be able to prove that the evidence has always been in their possession from the time it was taken at the crime scene until the time it appears in court. Anyone who has access to the material must be documented. Police must prove that the object shown in court is the same object that was tested in the laboratory. If this cannot be proven, the judge may rule that the chain of custody has been broken and the object may not be admitted into evidence. As soon as an object is found, it is placed in a container, sealed, and labelled. The place where the object was found and when it was found are noted by the officer who also initials the label. When the evidence goes to the police station or forensic lab, it is placed in a locked evidence room to which only a few people have access. An exact record is maintained of everyone who has had the evidence in his or her possession.

For the Forensic Sciences unit, you may wish to make the following preparations:

- Provide students with gloves for collecting evidence.
- Use zippered plastic bags to store evidence gathered at the crime scene and from the suspects. Label bags with a code (such as Exhibit # 17-34067) for which you maintain the key, or with the suspect's name and address.
- Prepare a box labelled Evidence Locker. Investigative teams must sign out the evidence stored in this box before examining it (providing exhibit number, date, and signature).

Forensic Investigation Lab Book

The information collected by the forensic investigative teams may be written up in a forensic database or in a *Forensic Investigation Lab Book*. You may wish to have individual team members initial their work to ensure that each member is contributing to the investigation. You may choose to allow them access to this information at any time, even during a quiz or final examination. Students are encouraged to keep their database or lab books neat and to organize the information in a manner that allows them to retrieve information quickly.

Instructional Overview

An overview of the steps and processes involved in the Forensic Sciences unit follows:

1. **Establish Forensic Investigative Teams**
Teams research the various types of forensic investigation specialties, and individual team members choose to be specialists in particular fields.
2. **Introduce the Crime**
Describe the crime to students and provide the teams with some initial investigative reports.
3. **Organize the *Forensic Investigation Lab Book***
Students begin to organize the format of their lab books.
4. **Create Evidence Boards**
Students may also display their evidence in flow charts on evidence boards. These may remain set up on the classroom wall.

5. **Consider Using Introductory Activities**

You may choose to have students engage in introductory observational and logical thinking activities such as the following:

- Students solve mathematical problems involving logic.
- Students form two lines of pairs facing each other for 30 seconds. Students in one line then turn away, and the students in the other line change one thing about their appearance (for example, untie shoe, remove earring, flip hair). The students in the first line then turn back and determine what is different.
- Someone runs quickly (and without warning) through the room. Students describe the individual.

6. **Document the Crime Scene**

Investigative teams observe the crime scene. They make diagrams with reference points, photographs, or videos.

7. **Gather Evidence**

Students gather and bag evidence, either all at once or at intervals during the progression of the unit. You may also choose to provide students with written information, such as witness interviews, police reports, and newspaper reports.

8. **Research**

Students research various aspects of the case, including the history of the development of specific analyses.

9. **Analyze the Evidence**

Students examine the evidence from the crime scene and compare it to samples from suspects.

10. **Prepare Investigation Report**

Students write a summary report of their investigation, which includes a description of what they think happened, with evidence to support this scenario. Explain how physical evidence collected at the scene of a crime could be used to assist in an arrest and conviction of a suspect.

11. **Tie Together All the Evidence/Reporting**

Provide various opportunities for students to examine evidence and data gathered in the crime scene investigation and to make conclusions based on the findings.

a. **Hold a Mock Trial**

Students may engage in a mock trial, assuming the various roles:

- judge
- jury
- accused
- defence team
- prosecution team
- witnesses
- expert witnesses

The evidence should be examined thoroughly, and all data questioned and analyzed. Conclusions must be related to actual evidence. The division of duties could include the opening argument, closing statement, presentation of each type of technical evidence, direct examination, and cross-examination. Students assigned to the jury will hear the case and then deliberate before the class. This will allow all students to have a speaking role.

b. **Write and Present a Fictional Crime Scene Drama**

Groups of students (preferably re-mixed from their investigative teams) write and present a crime scene drama. The evidence should be examined thoroughly, and all data questioned and analyzed. Conclusions must be related to actual evidence.

c. **Write and Present a Fictional Crime Scene Short Story**

Students (groups or individuals) write a fictional crime scene story. The evidence should be examined thoroughly, and all data questioned and analyzed. Conclusions must be related to actual evidence.

d. **Prepare News Reports**

Students (groups or individuals) write a series of news reports (fact or fiction) based on a crime scene investigation. The evidence should be examined thoroughly, and all data questioned and analyzed. Conclusions must be related to actual evidence.

Assessment

Assessment strategies may include the following:

- lab reports
- daily log of investigative team's activities
- *Forensic Investigation Lab Book*
 - research notes
 - crime scene notes
 - diagrams
 - lab investigations
 - summaries
 - conclusions
- evidence summary and conclusions
- presentation
- final report

Crime Scene Kit

Criminal investigators use a variety of materials and instruments in collecting evidence from a crime scene. These materials may include the following:

- crime scene tape
- chalk
- hand-held magnifying glass
- flashlight
- tweezers
- swabs
- tape lifts
- trace evidence vacuum
- sketchpad, logbook, pen
- camera
- video recorder
- evidence bags
- seals
- paper bags
- envelopes
- disposable clothing
- gloves
- masks
- string
- measuring tools
- coloured evidence flags
- adhesive lint pick-up roller
- portable alternative light source (infrared, ultraviolet, laser)
- fingerprinting kit (powder, brushes, lifting tape, cards, stamp/ink pad)
- casting kit (casting powder, mixing bowl, fixative)—for tire prints or footprints
- laser trajectory kit
- gunshot residue kit
- blood-detection reagents (phenolphthalein, leucomalachite, luminol)
- serology kit
- insect specimen jars
- “hazmat” (hazardous materials) kit—to assess composition of toxic materials

Crime Lab Equipment

Crime labs may include equipment such as the following:

- beakers
- flasks
- burets
- pipets
- graduated cylinders
- test tubes
- watch glasses
- stereoscopic microscopes
- compound microscopes
- phase contrast microscopes
- spectroscope
- spectrograph
- spectrometer
- spectrophotometer
- electron microscope
- ultraviolet lighting
- gas chromatograph
- mass spectrometer
- electrophoresis chamber
- nuclear reactor
- refractometer
- liquid chromatography apparatus

ESSENTIAL UNDERSTANDING 1: BLOOD ANALYSIS

Teacher Background

Blood consists of a solid portion (red blood cells, white blood cells, platelets) suspended in a watery plasma. Many chemicals are also suspended or dissolved in the plasma, including proteins, sugars, fats, salts, enzymes, and gases.

One way in which blood may be characterized is by the presence or absence of molecules located on the surfaces of the red blood cells. In the ABO blood typing group, there are two types of chemical molecules or antigens found on the red blood cells: A and B.

- If a red blood cell has only A antigens on it, it is type A.
- If the red blood cell has only B antigens on it, it is type B.
- If the red blood cell has both A and B antigens on it, it is type AB.
- If neither A nor B antigens are on the surface, it is type O.

If two different blood types are mixed together, the blood cells may clump together in the blood vessels, with potentially fatal results. Blood types must be matched before blood transfusions take place.

- Type A blood groups produce antibodies against B antigens and, hence, can accept only type A or type O blood in a blood transfusion.
- Type B blood groups produce antibodies against A antigens and, hence, can accept only type B or type O blood in a blood transfusion.
- Type AB blood groups produce neither anti-A nor anti-B antibodies and, hence, can accept type AB, type A, type B, or type O blood in a blood transfusion.
- Type O blood groups produce both anti-A and Anti-B antibodies and, hence, can accept only type O blood in a blood transfusion.

Because of these patterns, a person with type O blood is said to be a universal donor. A person with type AB blood is said to be a universal receiver. In general, however, it is still best to mix blood of matching types and Rh factors. Rh (rhesus) factor refers to the presence (Rh+) or absence (Rh-) of the D antigen on the surface of the blood cell.

Response of Blood Types to Antisera				
Blood Type	Antigen (Surface Molecule)	Antibody Produced	Agglutination with Anti-A Serum	Agglutination with Anti-B Serum
A	A	Anti-B	Yes	No
B	B	Anti-A	No	Yes
AB	A and B	None	Yes	Yes
O	None	Anti-A and Anti-B	No	No

Blood Analysis—Reference: Sinclair, Thea. “Forensic Lab Activity—Blood Analysis.” *A Case of Murder: A Forensic Science Unit*, 19 April 2005 <<http://accessexcellence.org/AE/ATG/data/released/0157-theasinclair/Heading5.html>>.

Suggestions for Instruction

The following concepts could be developed in this section:

- blood typing
- chemical reactions

- Implement a prior knowledge strategy, such as a Concept Map or a KWL (Know, Want to Know, Learned) strategy (see *SYSTH* 9.6-9.14), to activate students' prior knowledge and recognize entry-level misconceptions.
- Once concepts have been examined in class, use a Concept Organizer Frame (see *SYSTH* 11.23-11.25) to help students develop an understanding of the concepts.

Suggested Student Activities

- Activity 1a: Blood Typing Analysis
- Activity 1b: Blood Spatter Analysis

* *SYSTH* refers to *Senior Years Science Teachers' Handbook* (Manitoba Education and Training).

Activity 1a

Teacher Notes

Blood Typing Analysis**Specific Learning Outcomes**

SLO A1	Distinguish critically between science and technology in terms of their respective contexts, goals, methods, products, and values.
SLO A4	Recognize that science and technology interact and evolve, often advancing one another.
SLO B3	Identify the factors that affect health and explain the relationships of personal habits, lifestyle choices, and human health, both individual and social.
SLO C1	Demonstrate appropriate scientific inquiry skills, attitudes, and practices when seeking answers to questions.
SLO D1	Use the concepts of similarity and diversity for organizing our experiences with the world.

Overview

The Blood Typing Analysis activity involves the study of the ABO blood groups using simulated blood and antisera. Adaptations may be made to include the Rh factor.

Setting the Crime Scene

Leave vials of simulated blood (preparation instructions follow) or blood spots/spatter (ketchup or costume blood) at the crime scene (see also Activity 1b: Blood Spatter Analysis). Blood may belong to the victim and/or suspect(s). Students may either interview subjects to determine blood types, or ask for “samples” of their blood.

To determine whether a spot is actually blood, students can first drop hydrogen peroxide on a dried smear of beef blood using a prepared microscope slide (provided by investigators from the crime scene). Students must wear gloves when handling the blood slides. Real blood bubbles when a drop of hydrogen peroxide is placed on it. This reaction is due to the presence of the enzyme catalase in mammalian blood. This test works even after the blood is dried. Note that ketchup, oil stains, coffee, and tobacco juice will not cause hydrogen peroxide to bubble, and could be used to confuse the crime scene.

Materials

- simulated A, B, AB, and O blood
- simulated anti-A and anti-B sera
- spot plate
- toothpicks
- unknown blood samples (prepared by teacher)
- blood evidence gathered at crime scene
- reagents: calcium chloride, barium chloride, sodium carbonate, ammonium carbonate

Blood typing kits may be purchased from a scientific supply company. Simulated blood and antisera may be prepared as described below:

Preparing the A, B, AB, and O Blood

To four vials, each containing 100 ml water, add the following:

- Type A — 6 g CaCl_2
- Type B — 2.5 g BaCl_2
- Type AB — 6 g CaCl_2 and 2.5 g BaCl_2
- Type O — nothing (water only)

To each solution, add about 25 ml of 25 per cent Congo Red. (This may be varied.) Prepare the unknowns and blood evidence using the same method.

Preparing the Antisera

- Anti-A — 100 ml 0.1 M Na_2CO_3 and 1 drop of blue food colouring
- Anti-B — 100 ml 0.2 M $(\text{NH}_4)_2\text{CO}_3$ and 1 drop of yellow food colouring

Procedure

Part 1: Observing the Reactions of Known Blood Samples with Antisera

The ABO blood typing system and chemical reactions/precipitation may need to be introduced or reviewed. Students then use simulated blood and antisera (precipitation of chemical solutions) to examine the different blood types. Care must be taken to ensure that equipment is clean.

Part 2: Identifying the Blood Types of Unknown Samples (Practice)

For practice, students use the procedure from Part 1 to identify the blood types of unknown samples.

Part 3: Identifying the Blood Evidence Gathered at the Crime Scene

Students use the procedure from Part 1 to identify the blood type(s) of blood evidence gathered at the crime scene.

Activity 1a

Student Page

Blood Typing Analysis

Background

One way in which blood may be characterized is by the presence or absence of molecules located on the surfaces of the red blood cells. In the ABO blood typing group, there are two types of chemical molecules or antigens that are found on the red blood cells: A and B.

- If a red blood cell has only A antigens on it, it is type A.
- If the red blood cell has only B antigens on it, it is type B.
- If the red blood cell has both A and B antigens on it, it is type AB.
- If neither A nor B antigens are on the surface, it is type O.

Objectives

- Examine the ABO system of blood classification using simulated blood and antiserum.
- Determine the blood type of unknown blood samples.
- Determine the blood type(s) of blood evidence found at the crime scene.

Materials

- simulated A, B, AB, and O blood
- simulated anti-A and anti-B sera
- spot plate
- toothpicks
- unknown blood samples (prepared by teacher)
- blood evidence gathered at crime scene

Note: Ensure all equipment is clean and discard all used materials (such as toothpicks).

Procedure

Record your observations, results, and explorations in your *Forensic Investigation Lab Book*.

Part 1: Observing the Reactions of Known Blood Samples with Antiserum

1. Gently swirl or shake the container with blood type A to re-suspend the cells.
2. Using a clean spot plate, place three drops of blood type A into two of the wells.
3. Add three drops of anti-serum A to one well and three drops of anti-B serum to the other.
4. Gently swirl the plate or use a clean toothpick to stir the solution (30 to 60 seconds).
5. Observe carefully, looking for clumping (agglutination) around the edges.
6. Record your results in a data table.
7. Repeat Steps 1 to 6 for blood types B, AB, and O, making sure all equipment is clean prior to use.

Part 2: Identifying the Blood Types of Unknown Samples (Practice)

1. Obtain two unknown blood samples from the teacher.
2. Repeat the procedure from Part 1 with the unknowns.
3. Record your results in a data table.
4. Compare your results with those from Part 1 to identify the unknowns.
5. Check with your teacher to ensure that you have correctly identified the unknowns.

Part 3: Identifying the Blood Evidence Gathered at the Crime Scene

1. Obtain the blood sample(s) that were gathered from the crime scene.
2. Repeat the procedure from Part 1 with the evidence.
3. Record your results in a data table such as the one below.
4. Compare your results with those from Part 1 to identify the blood evidence.

Blood Typing from Evidence at Crime Scene					
Blood Source	Agglutination				Blood Type
	Anti-A		Anti-B		
	Yes	No	Yes	No	
Crime Scene					
Victim					
Suspect A					
Suspect B					
Suspect C					
Suspect D					

Analysis

1. Explain how blood collected at the scene of a crime could be used in a criminal investigation.

2. Identify and describe other situations, in addition to criminal investigations, where a working knowledge of blood types and the procedure to determine blood type might be used.

Activity 1b

Teacher Notes

Blood Spatter Analysis

Specific Learning Outcomes

-
- SLO A2:** Recognize both the power and limitations of science as a way of answering questions about the world and explaining natural phenomena.
-
- SLO C5:** Work cooperatively with others and value their ideas and contributions.
-
- SLO D3:** Understand the processes and conditions in which change, constancy, and equilibrium occur.
-

Overview

Bloodstain patterns left at crime scenes may be examined for clues as to what may have occurred during violent crimes. Forensic scientists will examine size, shape, and distribution of the blood spatter. Students will release drops of artificial blood at different heights onto sheets of paper to reproduce drops of blood from a crime scene. They will then examine the spatter from the crime scene.

Setting the Crime Scene

Leave blood spots/spatter (ketchup or costume blood) at the crime scene. Blood spatter should be consistent with the location of the injury, and the angle of spatter must be authentic, taking into consideration the height of the assailant. Blood may belong to the victim and/or suspect(s). The material on which the blood spatter is tested may be varied (for example, paper, cloth, wood, plastic, glass).

Materials

- simulated blood (see preparation instructions below)
- test tube
- dropper
- paper
- metre stick
- rulers
- ring stand

Preparation of Simulated Blood

Add together:

- corn syrup
- red food colouring
- cocoa powder
- water
- flour

Note: Vary the amount of flour and water to change the viscosity (tomato-based vegetable juice or tomato soup concentrate could also be used).

Procedure

Part 1: Comparing the Distance from which a Drop of Blood Falls to Its Diameter

Create blood with a suitable viscosity to be used consistently throughout the lab. The trial heights may be varied and decided upon by students.

Part 2: Measuring Mystery Spatter (Practice)

Prepare a number of mystery spatters ahead of time. Label or code them so that you have a record of the heights from which you dropped the blood. Students will correlate the diameter of the spatter to their baseline data and determine the approximate height from which the drop of blood fell.

Part 3: Examining Blood Spatter Evidence

Take into consideration the height and angles involved in creating the blood spatter.

Extensions

Students could calculate distance, angle, and direction from the reference point of the crime scene.

1. Calculate the direction blood travels. Lay paper on the floor (outdoors may be safer). Use a toothbrush dipped in “blood.” Hold the toothbrush in hand with arm hanging freely at side and bristles pointed up to the ceiling. Quickly jerk the forearm into a right angle. Examine and describe the blood spatter.
2. Calculate the angle of impact by creating an inclined plane (on cardboard) along which a drop of blood will travel. Measure the length of elongation and the maximum width of the droplet. Repeat, varying the angle of the incline. Record and graph the data.
3. Use the blood spatter obtained in Extension 1 to determine the origin of the blood spatter. Choose five to seven teardrop-shaped droplets. Draw an extended longitudinal axis through the head and tail of each droplet using a ruler. The point of intersection of the extended lines provides a relationship that approximates the physical point of origin.

Activity 1b

Student Page

Blood Spatter Analysis**Objectives**

- Determine the relationship between the distance a drop of blood falls and the diameter of its spatter.
- Relate the results to the crime scene spatter.

Materials

- simulated blood (provided by teacher)
- test tube
- dropper
- paper
- metre sticks
- rulers
- ring stand

Procedure

Record your observations, data, and analysis in your *Forensic Investigation Lab Book*.

Part 1: Comparing the Distance from which a Drop of Blood Falls to Its Diameter

1. Place newspaper on the floor and a clean sheet of white paper on top of the newspaper.
2. Hold a dropper 10 cm above the paper and drop **one** drop of blood. Be careful that you do not get blood on yourself, or on the floor, the table, or your materials. For more accuracy, clamp the dropper to a ring stand.
3. Measure the diameter of the spatter in millimetres. Record your data in a data table (see example provided).
4. Repeat Steps 1 to 3 two more times and calculate the average diameter for a blood spatter at 10 cm.
5. Repeat this process, increasing the height from which you drop the blood each time. You may need to stand on a table or chair. The heights printed in the following table are suggestions only.
6. Graph the data.

Blood Spatter Analysis: Comparing Distance and Diameter				
Distance (cm)	Diameter (cm)			
	Trial 1	Trial 2	Trial 3	Average
10				
40				
80				
100				
150				
200				

Part 2: Measuring Mystery Spatter (Practice)

1. Obtain a mystery spatter from your teacher. Measure the diameter and determine the distance from which the blood fell by comparing the diameter to the results obtained in Part 1. Refer to your data to make this determination.

Part 3: Examining Blood Spatter Evidence

1. Analyze the blood spatter evidence obtained at the crime scene. Determine the distance (to the point of origin from which the blood fell) by comparing the diameter to the results obtained in Part 1.

Analysis

1. Describe the relationship between the distance of the fall and the diameter of a blood droplet.

2. What other observations were you able to make about blood spatter?

3. Are there sources of error that could create problems for your technique? If so, itemize these and raise these points as though you were a legal expert attempting to question blood spatter evidence.

ESSENTIAL UNDERSTANDING 2: FORENSIC ANTHROPOLOGY—BONE ANALYSIS

Teacher Background

Forensic anthropology is the study of skeletal and other human remains to identify an individual and/or to determine the circumstances involved in someone's death. Forensic anthropologists work to determine the age, sex, ancestry, stature, and unique features of a skeleton. At times, they rely on living descendants to provide information about the deceased.

Osteology (the study of bones) is very important when forensic scientists wish to identify remains at a crime scene. When forensic scientists arrive at a crime scene area, they are often faced with very badly decomposed remains, along with many other types of physical evidence.

Forensic investigators must be able to distinguish human bone from animal bone. For instance, bird bones are hollow. Because humans are bipedal (walk on two feet), our bones have unique features. The valgus knee and the femur do not line up exactly with the tibia, which helps us maintain our centre of gravity. Humans have a large calcaneus (heel bone) and a big toe bone, as we pass all our weight to our feet when walking.

The human body has 206 bones. The average male skeleton weighs about five (5) kilograms (about 11 pounds), and the average female skeleton weighs about three and one-half (3.5) kilograms (about 7.7 pounds).

Investigators can often determine the following basic identifying factors from bones:

- **Gender:** Many gender differences are visible when the skull is examined. Males have sloping foreheads, while females have straighter foreheads. Males have extreme supraorbital ridges, while females have slight ridges, with sharp orbital borders. Males have areas of pronounced muscle attachment visible on the cheek bones and large canines. Females have rounded chins, while the chins of males are more square. The male pelvis is narrower than that of the female.
- **Age:** Age may be estimated from *calcifications* (stages at which the bones are uniting), successive changes in the pelvis, evidence of bone disease such as arthritis, and the way the teeth are worn.
- **Previous trauma:** Evidence of a once broken or fractured bone indicates a previous trauma that may lead to a victim's identity through comparisons with medical records.
- **Height:** If the skeleton is incomplete, forensic scientists are able to approximate the height of an individual by measuring the length of the foot. The length of a person's foot is approximately 15 per cent of his or her height.

$$15/100 = \text{Length of Foot} / x \text{ (person's height)}$$

Formulas applied to the length of the femur, tibia, or fibula will also approximate the height. The ratio of body parts is slightly different in growing children.

Suggestions for Instruction

The following concept may be developed in this section:

- ▶ characteristics of the human skeleton using ratios

- Implement a prior knowledge strategy, such as Listen-Draw-Pair-Share (see *SYSTH* 9.15-9.17), to review the structure of the human skeleton, to activate students' prior knowledge, and to recognize misconceptions.

Suggested Student Activities

- Activity 2a: Height Analysis
- A greater challenge would be to give groups of students a number of different measurements to perform, such as
 - total height
 - length of foot, ankle to hip, tibia, femur, arm (wrist to shoulder), radius, humerus, index finger
 - circumference of wrist, neck, or leg (just above the knee)
 - arm span (fingertip to fingertip)
 - width of back (shoulder to shoulder)

Students need to determine whether any relationships exist between these measurements and whether any one measurement could allow a forensic investigator to determine the height of an individual. Height is a linear function of several bone lengths: humerus, radius, femur, and tibia. In the form of $y = m \cdot x + b$, students may use their graphing calculators to examine the relationship. Or they may use plotting software such as *Graphical Analysis 3* (Vernier Software & Technology) provided by Manitoba Education, Citizenship and Youth to all Senior Years schools through a site licence.

- Activity 2b: Searching for the Romanovs

Activity 2a

Teacher Notes

Height Analysis

Specific Learning Outcomes

-
- SLO C1:** Demonstrate appropriate scientific inquiry skills, attitudes, and practices when seeking answers to questions.
-
- SLO C5:** Work cooperatively with others and value their ideas and contributions.
-
- SLO D1:** Use the concepts of similarity and diversity for organizing our experiences with the world.
-

Overview

Students establish a linear relationship between height and length of foot, length of humerus, and so on, and then determine the height of the individual (victim, suspect).

Setting the Crime Scene

Leave a footprint, shoe (see Essential Understanding 10: Soil Analysis), foot steps (stride), or pieces of skeleton (foot, humerus, radius, femur, tibia) at the crime scene.

Materials

- flexible measuring tape (at least 2 m length)

Procedure

Part 1: Determining the Relationship between Foot Length and Height

Students measure the length of the left foot and the height of a number of different individuals and determine the relationship between them. Alternatively, students determine the relationship between the length of the *humerus* (tibia, radius, femur) or the length of stride (distance from the back of the left heel of one footprint to the back of the heel on the next footprint) and height. **Note:** When using stride length, have students stride (walk, jog, run) over a distance of 2 to 3 m and then calculate the average length of one stride.

Part 2: Determining the Height of an Individual Based on Foot Length

Students use the data gathered in Part 1 and the relationship that was determined to estimate the height of the victim and/or suspect based on evidence from the crime scene (footprint, stride length, foot, femur, humerus, and so on).

Activity 2a

Student Page

Height Analysis

Objectives

- Determine the relationship between the length of the foot (stride, humerus, tibia, femur, radius) and the height of an individual.
- Use this relationship to determine the height of an unknown individual (victim, suspect) based on evidence from the crime scene.

Materials

- Flexible measuring tape (at least 2 m length)

Procedure

Record your data and conclusions in your *Forensic Investigation Lab Book*.

Part 1: Determining the Relationship between Foot Length and Height

1. Student “test subjects” place the heels of their left feet against a wall. Measure the length of the left foot (from where heel touches wall to tip of toe) in centimetres. Record measurements in a data table.
2. Measure the height of each individual in centimetres. Record measurements in another column in the data table.
3. Graph your data.
4. Divide the length of the foot by the height of each individual, and multiply by 100. Record in another column in your data table.

Relationship between Foot Length and Height			
Name of Individual	Foot Length (cm)	Height (cm)	Foot Length to Height Ratio X 100

Part 2: Determining the Height of an Individual Based on Foot Length

1. Using the data and conclusions from Part 1, determine the height of the victim and/or suspect based on his or her foot impression, shoe size, and/or foot bones.

Analysis

1. What conclusion(s) are you able to make about any relationship that may exist between height and foot length? For instance, what pattern do you see in the values that represent the ratio of foot length to height?

2. Test your conclusions further by measuring the length of a few more feet and predicting the height of those individuals.

Activity 2b

Teacher Notes

Searching for the Romanovs

Specific Learning Outcomes

-
- SLO B1:** Describe scientific and technological developments, past and present, and appreciate their impact on individuals, societies, and the environment, both locally and globally.
-
- SLO B2:** Recognize that scientific and technological endeavours have been, and continue to be, influenced by human needs and by societal and historical contexts.
-
- SLO C3:** Demonstrate appropriate critical thinking and decision-making skills and attitudes when choosing a course of action based on scientific and technological information.
-
- SLO D1:** Use the concepts of similarity and diversity for organizing our experiences with the world.
-

Overview

Students use the length of bones to determine height. Using the height and genetic similarities, they determine the identity of skeletons thought to be those of the Romanov family and servants.

Students will need to know the primary bones in the human skeleton, their articulation relationships, and some background information on genetics—chromosomes, DNA, and possible mitochondrial DNA (mtDNA).

Activity 2b

Student Page

Searching for the Romanovs

Background

It is believed that shortly after the night of July 16, 1918, Czar Nicholas II, his wife Czarina Alexandra, their four daughters, Olga, Tatyana, Maria, and Anastasia, and their only son Alexei, were herded into the cellar, together with three of their servants and the family doctor Eugeny Botkin. They were all shot by a Bolshevik firing squad, although a number of the victims were allegedly stabbed to death when gunfire failed to kill them.

In 1989, a document written in 1920 was found. It described the night of the massacre and what happened to the bodies. Apparently, after the shooting occurred, some of the family and some of the servants were still alive. The executioners then stabbed those who were still breathing. The bodies were placed onto a truck with the intention of disposing of them down a mine shaft. However, the truck broke down during the trip to the mine. The Bolsheviks reportedly stripped the bodies and burned them with gasoline. To make future identification of the bones harder, they doused the bodies with sulfuric acid. The bones were thrown into a shallow pit, and the pit was filled with dirt.

The report gave clues to the location of the grave, and, in 1991, two Russians, an amateur historian and a former policeman who had turned to writing thrillers, found what they figured might be the burial site. After referring to archival materials and photographs, which gave an indication of a burial site, Gely Ryabov and Alexander Avdonin announced that they had discovered a communal grave approximately 20 miles from Ekaterinburg. Consequently, the Russian government authorized an official investigation coordinated by the Chief Forensic Medical Examiner of the Russian Federation.

The grave consisted of a shallow pit (less than a metre deep) and contained human skeletal remains. Many of the bones were badly damaged. All the skeletons showed evidence of violence prior to death or subsequent to it. For instance, some skulls had bullet entry points. Facial areas of the skulls were destroyed, rendering classical facial identification techniques difficult.

The Russians asked scientists in England to work with them to examine the bones. They speculated that newly available DNA technologies, which involve extracting tiny amounts of DNA from bone fragments and then amplifying the DNA so that there is enough material to study, might help in the identification of the bones and in determining their relations to each other. The bones were evaluated with three different DNA tests.

The first test involved identification of a gene that is found in both the X and the Y chromosomes. It is slightly different in the two and thus distinguishes male from female bones. This DNA test showed that there were five female and four male bodies in the grave.

Scientists also studied mitochondrial DNA (mtDNA), which is passed directly from mothers to their children and can be studied to show maternal lineages. The mtDNA patterns can link children to their mothers, grandmothers, and earlier generations. The mtDNA analysis showed that skeleton seven was related to the skeletons of the three children. The mtDNA from these four skeletons is also related to that of Prince Phillip, the great nephew of the Czarina.

Searching for the Romanovs: Copyright © 1996-2004, The Shodor Education Foundation, Inc.
<<http://www.shodor.org/workshops/forensic/cases/romonov.html>>. Adapted by permission.

The location of the grave, the condition of the bones, the finding of gold and platinum fillings in the teeth (only available to the rich), the relationships of the DNA samples from the grave to DNA samples from the descendants of the Imperial family, and other evidence all strengthen the case that the bones of the Romanovs had been found. The Chief Forensic Medical Examiner has requested your assistance in verifying the authenticity of the remains. It is believed that 11 individuals were killed by the Bolsheviks (the Romanov family, three servants, and their doctor).

Analyze the evidence to help determine who was buried in the grave.

Tandem Repeats in Genome

Normal genomes contain many extremely variable regions. These regions of the genome can have a specific sequence of nitrogenous bases repeated any number of times. We can often trace an individual’s genetic sequence to his or her parents by comparing the number of copies of a genetic sequence in a region. For every chromosome we have, we get one copy of that chromosome from our mother and one copy from our father. Therefore, we expect that, given any two specific variable regions of the genome, one of our chromosomes will have the same number of repeats as our father and one will have the same number of repeats as our mother.

Formulas for Determining Height from Bone Length (measured in centimetres)

- Femur → $2.38 (\text{femur length}) + 61.41 = \text{height}$
- Humerus → $3.08 (\text{humerus length}) + 70.45 = \text{height}$
- Radius → $3.78 (\text{radius length}) + 79.01 = \text{height}$
- Tibia → $2.52 (\text{tibia length}) + 78.62 = \text{height}$
- Fibula → $2.68 (\text{fibula length}) + 71.78 = \text{height}$

Determining Height from Bone Length						
Skeleton	Tandem Repeats	Femur Length (cm)	Humerus Length (cm)	Radius Length (cm)	Height (cm)	Possible Identification
1	9, 10	44.79	31.5			
2	6, 10	37.64	26.15			
3 (Child)	8, 10	38.9	27.1			
4	7, 10	42.5	30.0			
5 (Child)	7, 8	38.9	27.21	20.34		
6 (Child)	8, 10	37.6	26.2	23.0		
7	8, 8	39.4	27.40			
8	6, 9	38.32	26.68			
9	6, 6	37.32	25.92			

Analysis

1. Use the genomic evidence (tandem repeats) to determine the possible parents of the children (the Czar and Czarina).
2. Which individuals could not possibly be parents of the children? Explain.
3. Anastasia was about 164 cm (5' 4 ¾") tall. Could her skeleton be one of those found in the pit? Explain.
4. Which skeleton do you think is that of the Czar? the Czarina? Explain your reasoning.
5. Research to find more information on the discovery and analysis of the remains of the Romanov family. Who do scientists believe was actually found in the pit, according to your information sources?

ESSENTIAL UNDERSTANDING 3: CHROMATOGRAPHY

Teacher Background

Some materials appear homogenous, but are actually a combination of substances. *Chromatography* is an ancient method used to separate and identify parts of a mixture. Ink is a mixture of several colours and, therefore, can be separated using chromatography. If ink is exposed to certain liquids called solvents, the colours will dissolve and separate within the liquids. Some inks are water-soluble and some are alcohol-soluble. If the solution is then allowed to move, pulled by capillary action, through an absorbent matrix, such as chromatography paper, the different colours will create bands on the paper.

In general, more polar materials will hydrogen-bond better to the water, causing these materials to move slowly away from water-based solvents and migrate slowly up the paper. It is probably best to explain that the components of the ink that are more soluble in the chromatography solvent will move faster along the paper and thus will appear closer to the top of the paper. Components that are less soluble in the solvent will move more slowly and appear closer to the bottom of the paper. Inks of the same type will always produce the same banding pattern when this technique is used. A banding pattern of the components of the ink mixture is called a chromatogram.

Suggestions for Instruction

The following concept may be developed in this section:

- separation of substances through chromatography

- Review and/or introduce chromatography using a strategy such as a Word Web or a Word Cluster (see *SYSTH* 10.11-10.12) to place chromatography in context.

Suggested Student Activity

- Activity 3: The Colour of Guilt—Chromatography

Activity 3

Teacher Notes

The Colour of Guilt—Chromatography

Specific Learning Outcomes

-
- SLO A5:** Describe and explain disciplinary and interdisciplinary processes used to enable us to investigate and understand natural phenomena and develop technological solutions.
-
- SLO B4:** Demonstrate a knowledge of, and personal consideration for, a range of possible science- and technology-related interests, hobbies, and careers.
-
- SLO D3:** Understand the processes and conditions in which change, constancy, and equilibrium occur.
-

Overview

In this learning activity students use paper chromatography as a method of examining evidence from the crime scene. Students analyze the ink from different pens to observe that each has a unique chromatogram.

Setting the Crime Scene

- Leave a note written in black ink at the crime scene. The note may contain relevant information, and may also be used in other activities (see Activity 7a: Fibre and Stain Analysis and Activity 8: The Science of Handwriting Analysis?).
- Leave a smear (chromatogram) from a certain colour of candy (brightly coloured, candy-coated chocolate discs) at the crime scene (could be due to rain, a leak, and so on). Link the colour to a suspect and/or victim (for example, colour on hands, candy in pocket, favourite candy).

Materials

- chromatography paper or filter paper for chromatography
- several different black felt pens or types of black ink
- pencil
- capillary tube
- test tubes (or clear plastic cups) to hold chromatogram
- test tube rack
- paper clips
- tape
- scissors
- candy-coated chocolate discs of different colours
- wax marking pencil
- note from crime scene

- solvent (solubility of inks will vary):
 - water
 - alcohol
 - solution of rubbing alcohol, vinegar, and water
 - acetone (nail polish remover)

Procedure

Part 1: Separating Black Ink Using Chromatography

Students learn how to make a chromatogram. Using different pens with black ink, students determine that each ink has a unique chromatogram, depending on the combination of ink colours put together to make black. Use masking tape to label each pen (for example, #1 to #6).

Part 2: Examining the Mystery Note Using Chromatography

Students make a chromatogram from the ink on a note found at the crime scene and compare these results to their results in Part 1. Students must have their piece of note taped to the filter paper with the ink facing the filter paper.

Part 3: Identifying the Colours in the Candy Coating

To demonstrate that food colouring as well as ink can make a chromatogram, students can rub the coating from candies, such as candy-coated chocolate discs, onto the filter paper. The candy will have to be slightly damp so the colour from the candy can be transferred onto the filter paper.

Part 4: Determining Which Colour of Candy Was Left at the Crime Scene

Students use their results from Part 3 to examine the candy evidence from the crime scene.

Activity 3

Student Page

The Colour of Guilt—Chromatography

Background

Some materials appear homogenous, but are actually a combination of substances.

Chromatography is an ancient method used to separate and identify parts of a mixture. Ink is a mixture of several colours and, therefore, can be separated using chromatography. If ink is exposed to certain liquids called solvents, the colours will dissolve and separate within the liquids. Some inks are water-soluble and some are alcohol-soluble. If the solution is then allowed to move, pulled by capillary action, through an absorbent matrix, such as chromatography paper, the different colours will create bands on the paper.

Objectives

- Use chromatography to determine the colour composition of various black inks.
- Use chromatography to identify the black pen used to write a note found at a crime scene.
- Use chromatography to identify the colours used in the coating of candy-coated chocolate discs.

Materials

- chromatography paper or filter paper for chromatography
- several different black felt pens or types of black ink
- pencil
- capillary tube
- test tubes (or clear plastic cups) to hold chromatogram
- test tube rack
- paper clips
- tape
- scissors
- candy-coated chocolate discs of different colours
- wax marking pencil
- note from crime scene
- solvent (solubility of inks will vary):
 - water
 - alcohol
 - solution of rubbing alcohol, vinegar, and water
 - acetone (nail polish remover)

Procedure

Record your work in your *Forensic Investigation Lab Book*.

Part 1: Separating Black Ink Using Chromatography

1. Cut strips of chromatography (filter) paper approximately 17 cm long and 1.5 cm wide (one strip per pen to be tested). Strips should fit into a test tube without touching sides. Test the fit in a dry test tube before adding solvent.
2. Cut one end of each strip into a point. This tip will touch the solvent.
3. Use a capillary tube to place a black dot (about 2 cm up from the pointed end of the strip) from each ink type on the strips (one per type of black ink). Make sure you label each strip or chromatogram with a pencil so you can tell them apart.
4. Place a small amount of water (or other solvent) at the bottom of each test tube.
5. Loop the top of the filter paper over a pencil or attach it to a paper clip suspended across the top of the test tube.
6. Hang the strip of paper into the test tube, with the tip just touching the solvent. Do not let the dot go below the solvent level.
7. Allow the solvent to soak up the strip and watch what happens to the ink. Wait until the solvent no longer appears to be separating the ink. This may take 30 to 60 minutes. Take the strips out of the test tubes and let them dry. Once dry, relabel your strips, and tape them into your *Forensic Investigation Lab Book*. Your results will be used in Part 2.

Part 2: Examining the Mystery Note Using Chromatography

1. Cut out an individual letter from the mystery note provided and tape it to the filter paper with the ink facing the filter paper.
2. Run the chromatography experiment (see Part 1) and tape the chromatogram to your *Forensic Investigation Lab Book*. Compare the chromatograms of the ink you tested to the chromatogram of the mystery note from the crime scene. Record which type of ink was used to write the note. What specific evidence enabled you to come to this conclusion?

Part 3: Identifying the Colours in the Candy Coating

1. Make chromatogram strips (one per candy) and collect candy-coated discs of different colours. Using a pencil, record the colour of each candy on a chromatogram strip.
2. Wet the edge of the candy with a very small drop of water and rub its edge on a chromatography strip until the colour is gone from the edge of the candy. Repeat this procedure by placing a drop of water on the top of the candy and rotating that surface to make a distinct dot on the chromatogram. The dot should be at approximately the same spot as the pen dot in Part 1.
3. Repeat the last procedure with the other candies on the other chromatogram strips.
4. Run the chromatography experiment as described in Part 1 and observe the patterns produced on the strips.

ESSENTIAL UNDERSTANDING 4: DECOMPOSITION

Teacher Background

Establishing the time of death is difficult and often involves a combination of factors, including witness interviews. Forensic investigators will also examine the following:

- Body temperature may be affected by environmental conditions, layers of body fat, amount of clothing, and drugs. A decrease in body temperature *post-mortem* (after death) is proportional to the ambient environment temperature. Typically, a body cools one to one and a half degrees Celsius per hour until it reaches environmental temperature. Review Newton’s Law of Cooling.
- Post-mortem lividity or *livor mortis* (discolouration) occurs when the blood settles to the lowest parts of the body due to gravity. The discolouration appears one to two hours after death and becomes fixed within eight to 10 hours.
- *Rigor mortis*, which is the stiffening of muscles, starts as early as 15 minutes after death and lasts as long as 36 hours.
- Clouding of the eye due to potassium buildup occurs within two to three hours if the eyes are open, and 24 hours if the eyes are closed.
- The rate of food digestion, which ranges between four and six hours, may be affected by type of food, metabolic rate, drugs, emotional condition, and exercise.
- Decay and decomposition rates depend on various factors, such as weather, environment, and scavengers.

Forensic scientists must be experts on decomposition and must study rotting corpses to help police solve cases. The stages of decomposition are: paling of the skin, flattening of the eyes, blue colouration of the extremities, desiccation of mucous membranes, putrefaction of the body (swelling and rotting as bacteria proliferate), blackening of the skin, bloating, blistering, and peeling of the skin, liquefaction of organs, and loosening of teeth, hair, and nails. Temperature will affect the rate of decomposition, as will exposure to the environment and scavengers. Even the smell of putrefaction and amount of bloating follow a specific cycle, and can help in estimating the time of death. Under warm and humid conditions, a body can decompose into a skeleton within a few weeks; while in other conditions, it may take much longer, even years. In a hot, dry, and arid environment, a body might mummify. Forensic scientists have established “body farms” to study in detail the processes of decomposition.

Decomposition—Reference: Staerkeby, Marten. “Establishing Time of Death with Forensic Entomology.” *The Ultimate Guide to Forensic Entomology*, 18 April 2005 <http://folk.uio.no/mostarke/forens_ent/forensic_entomology.html>.

Arthropods are often the first to encounter a corpse. This involves the study of entomology, as the appearance of bugs on, in, around, and under the corpse gives many clues to the timing and location of death. As the carcass decays, it attracts various insect species. Insects arrive in stages, and as each group feeds on the body, it changes the body for the next group. The blowflies usually are the first to arrive, within minutes. They lay their eggs, which hatch into maggots that feed on the decaying tissue. Other insects feed on the body at varying stages as it ferments. *Necrophagous species* (flies and beetles) feed directly on the corpse for about the first two weeks. Predators and parasites of the flies, and beetles and wasps that prey on eggs and maggots may arrive next. Spiders may also use the body as a habitat to prey on other insects. By observing which species are present and what stage of development they have reached (egg, larva, pupa, or adult) and comparing that information to local weather data, scientists are able to establish a chronology of death. Small things such as insect larval stage and pupal casings observed in a crime scene photograph can narrow down the time of death and help police gain a conviction. Forensic entomologists might even examine the gut contents of insects to establish what a person ingested or to obtain DNA materials.

Suggestions for Instruction

The following concepts may be developed in this section:

- ▶ the life cycle of insects
- ▶ decomposition

- Use a Concept Map (see *SYSTH* 9.6-9.7) to establish the relationships within decomposition.
- Students research the use of entomology in forensic sciences (see *SYSTH*, Chapter 14: Technical Writing in Science).

Suggested Student Activities

- Activity 4a: Forensic Entomology Research Assignment
- Activity 4b: A Bug’s Tale
- As part of Activity 4b, students write a Forensic Entomology Report detailing the entomological evidence from the crime scene or released to student project teams for analysis and conclusions.
- Students could also research mummies, the mummification process (for example, Tollund Man, Lindow Man, Yde Girl, Cherchen, Tarim Basin, Takla Makan, Lemon Grove, Chiribaya, Chinchorro, Chachapoya, Guanache, Egyptian kings [Tutankhamun, Ramses II “the Great”]), or instances of remaining “incorrupt” (no signs of decay) many years after death (for example, Bernadette Soubirous of France—19th century).

Forensic Entomology Research Assignment

Specific Learning Outcomes

SLO B4:	Demonstrate a knowledge of, and personal consideration for, a range of possible science- and technology-related interests, hobbies, and careers.
SLO C4:	Employ effective communication skills and use a variety of resources to gather and share scientific and technological ideas and data.
SLO D2:	Recognize that the universe comprises systems and that complex interactions occur within and among these systems at many scales and intervals of time.
SLO D4:	Understand how energy is the driving force in the interaction of materials, processes of life, and the functioning of systems.

Overview

Students research the use of entomology in forensics and the role of an entomologist on a forensic investigative team.

In preparation for the research assignment and report, review the following with students:

- the fundamentals of technical writing (see *SYSTH*, Chapter 14)
- how to find and record information (see *SYSTH* 14.15)
- the main components of a research paper (see *SYSTH* 14.10)

Activity 4a

Student Page

Forensic Entomology Research Assignment

Research Notes

Topic: _____

Research Questions:

1. _____

2. _____

3. _____

4. _____

Resource Type(s): _____

Reference(s): _____

Answers to Questions:

1. _____

2. _____

3. _____

4. _____

Activity 4b

Teacher Notes

A Bug's Tale

Background

Insects arrive on a body shortly after death, allowing forensic entomologists to gather information to estimate the time of death (post-mortem interval). The succession of different species on cadavers happens in a fairly predictable sequence, depending on the state of the body and the part of the body exposed. For example, beetles feeding on bone will only arrive when bone becomes accessible.

Insect life cycles follow predictable patterns (see table below), and determining the stages of life cycles is critical in an investigation. To establish baseline times for the life cycles, forensic entomologists may rear blowflies discovered at the scene under temperature and humidity conditions similar to those to which the body was exposed. They are then able to compare the life cycle stage of the insects gathered as evidence to this baseline data and estimate a time of death. Life cycles are dependent on species, temperature, and humidity. If the death occurred in the winter, investigation becomes difficult, as few insects are active in the winter.

Life Cycle of Blowflies

Genus: *Diptera*

Species: *Calliphoridae* or “Blowflies”

Life Cycle Stage	Timing	Description	Observations
Eggs	1 day	2 mm	Located especially around the body's natural orifices, such as the nose, eyes, ears, anus, penis, vagina, and in any wounds.
Larvae — First Instar	1.8 days	5 mm	
Larvae — Second Instar	2.5 days	10 mm	
Larvae — Third Instar	4-5 days	17 mm	
Prepupae	8-12 days	12 mm	Larvae become restless and start to move away from the body, crop organ is gradually emptied of blood, and internal features are gradually obscured by the larvae's enlarged body.
Pupae	18-24 days	9 mm Darkens with age	Presence of empty puparia an indication that the person in question has been dead approximately 20 days.

A Bug's Tale—Reference: Staerkeby, Marten. “Establishing Time of Death with Forensic Entomology.” *The Ultimate Guide to Forensic Entomology*, 18 April 2005 <http://folk.uio.no/mostarke/forens_ent/forensic_entomology.html>.

Activity 4b

Student Page

A Bug's Tale

A forensic entomologist made the following observations about the crime scene. Read the description and construct a data table in your *Forensic Investigation Lab Book*. Include the type of insect, time of arrival, time of departure, and the inferences you might make from this information. Explain when the victim probably died and how you determined the time of death.

Forensic Entomologist's Report

Observations about Crime Scene

The body was bloated and swollen, in the beginning stages of putrefaction. The body temperature was 10 degrees Celsius at the scene. The ambient temperature was 9 degrees Celsius. Second instar maggots were obvious in all orifices. Rove beetles and other parasites were also present.

Analysis

- Using the forensic entomologists' observations about the crime scene, construct a data table that captures the following information.

Data Table			
Type of Insect	Time of Arrival	Time of Departure	Inferences

2. Approximately *when* did the victim die?

3. How do you know this?

Activity 4b

Student Page

Student's Forensic Entomology Report

Date: _____ Case Number: _____

Forensic Entomologist: _____

Location Description

Recent Meteorology (Last Seven Days):

Temperature Conditions: _____

Precipitation Patterns: _____

Humidity Conditions: _____

Resting Place:

Urban Setting: Enclosed Building Vacant Building Vacant Lot
 Garbage Container Other _____

Rural Setting: Open Field Vegetation
 (type of vegetation) _____
 Forest Roadside Ditch Bare Ground

Current Temperatures:

Ambient (air): _____ Body: _____

Soil (depth): _____ Water: _____

Description of Remains

Approximate Age: _____ Sex: _____

Date and Time Found: _____

Clothing: _____

Wounds on Body? Yes No

Type: _____ Where: _____

Body Position: _____

Exposure of Body: Full Sun Shaded Area

Part Sun Portion of Day (%) _____

(continued)

Description of Remains (*continued*)

- Stage of Decomposition: Initial (Stage 1) Putrefaction (Stage 2)
 Advanced Putrefaction (Stage 3) Butyric (Stage 4)
 Dry Decay (Stage 5)

Evidence of Insect Scavengers:

Further Comments:

ESSENTIAL UNDERSTANDING 5: DNA PROFILING

Teacher Background

The Structure and Function of DNA

DNA (deoxyribonucleic acid) is found in almost every living thing. An organism is composed of thousands of tiny cells, most of which contain long, string-like DNA tightly folded into chromosomes within a nucleus. If uncoiled, the DNA molecules in a human cell would measure almost two metres in length. That is the total length of the 3.3 billion base pairs that make up the total human genetic complement, or genome, found in virtually every cell. Except for identical twins, the sequence of the base pairs within the DNA helix is unique for every person, and forms the individual's genetic code or blueprint. The growth and development of an organism is governed by instructions encoded within the DNA molecule.

In humans, each parent contributes one chromosome to each of the 23 pairs found in all normal people. Genes are the fundamental unit of heredity and are sections of DNA coding for the growth and development of the organism. Thousands of genes are located on the chromosomes. Each gene can have different versions called alleles. Genes determine all inherited traits, including those that give the individual specific characteristics (such as eye colour) as well as common characteristics (such as the structure of the heart).

The DNA polymer is a long, double-stranded string of repeating units called bases or nucleotides: adenine (A), cytosine (C), guanine (G), and thymine (T). This sequence of letters makes up the genetic code and determines which characteristics will be expressed by a particular gene. Cutting all the sentences out of 40 volumes of encyclopedias and taping them end to end would represent the amount of information contained within the DNA of each of our cells.

In the two strands, A pairs with T and G with C. These pairings are what connect the two strands of DNA together to form a tightly coiled, twisted ladder. This spiral staircase, the famous double helix, is the natural form in which DNA is found within the nucleus of the cells.

The DNA and, hence, the genetic code of humans is almost the same for all individuals. It is the very small amount that differs from person to person that forensic scientists analyze to identify people. These differences are called polymorphisms and are the key to DNA typing. Polymorphisms may include variations in the length of repeating sequences or a difference between alleles or specific nucleotides. When several different sequences are considered, the chances that any two individuals will have exactly the same variation are very remote.

Forensic DNA Testing (DNA Fingerprinting)

Forensic investigators commonly look for DNA in specimens of blood, semen, body tissues, hair (especially roots), and saliva (for example, envelope flaps, stamps, cigarette butts, cups, telephones, bite marks). Collection of usable evidence depends on the location (type of surface or substrate) of the sample, contamination, age (survival is low in soft tissues such as liver and kidney, longer in muscle and brain, and longest in dense bone and teeth).

Exemplars or specimens drawn from suspects or victims are usually liquid blood or sometimes buccal (inside cheek) swabs.

Minute amounts of DNA evidence gathered from a crime scene may be analyzed and compared to reference samples. Procedures are limited by quantity, contamination, and amount of degradation. DNA is degraded by things such as warmth and age. Scientists are continually improving forensic testing methods.

Initially, scientists must remove the DNA sample from its location (for example, clothing), and then purify it through extraction and precipitation. Detergent is used to destroy the integrity of the cell and nuclear membranes, which releases the DNA, and proteins attached to the DNA are digested by enzymes. Small quantities of DNA may be amplified through PCR (polymerase chain reaction).

The DNA is cut into different-sized fragments using restriction enzymes (chemical scissors) that recognize specific DNA sequences. The DNA sample, containing a variety of fragment sizes, is then placed at one end of a gel. Electrophoresis gels have several lanes, including marker lanes that measure how far fragments move through the gel and a lane for control DNA that produces a known pattern and can be used to verify that the test was properly conducted. The DNA in the gel can be stained and seen under ultraviolet (black) light. An electric current is used to pull the negatively charged DNA fragments through the gel toward the positive pole. The gel contains pores or holes, through which the DNA moves. The smaller fragments move more rapidly, and the relative position of the fragments within the gel is determined by their length or their molecular weight. A radioactive DNA probe binds to and illuminates the DNA samples, and a picture or blot may be made.

Interpretation of Forensic DNA Analysis Data

A comparison of DNA ladders may be made by examining the number and location of bands of DNA between samples. A match may be declared if two samples have RFLP (restriction fragment length polymorphism) band sizes that are all within 5 per cent of one another. The suspect can then be included in the group of individuals who were at the crime scene. If no match occurs, the suspect could not have been the source of evidence and is excluded. The data may be inconclusive, which often occurs when the DNA is old and heavily contaminated.

Forensic scientists apply population frequency statistics, based on the probability of a genetic profile occurring, to determine the chance that two samples are identical or do not match. This is a contentious issue, and other facts must also be considered when examining genetic evidence. For example, the genetic profile from the blood at a crime scene may match that of a suspect, with a pair of matching profiles found in one in 200 individuals. It appears that there is a high probability that the blood came from someone else. Scientists must then take other factors into consideration, such as the probability that the suspect was at the crime scene versus one of the other members of the population with the same genetic blood profile. Because of the complexities of populations, databases must be interpreted with extreme care. For example, DNA fragment sizes rare in one population may be more common in other populations. Further sub-populations or populations within populations must be considered.

Suggestions for Instruction

The following concepts may be developed in this section:

- the structure and function of DNA
- DNA fingerprinting
- population genetics

- Develop a DNA Concept Map, KWL chart, or Listen-Draw-Pair-Share strategy (see *SYSTH* 9.6-9.17) to activate and organize students' prior knowledge.
- Use a Concept Organizer Frame (see *SYSTH* 11.23-11.25) to organize conceptual knowledge after instruction.

Suggested Student Activities

- Activity 5a: Extracting DNA from Onion Cells
- Activity 5b: DNA Fingerprinting—Bar Code Simulation
- Activity 5c: DNA Fingerprinting—Electrophoresis
- Students research applications of DNA fingerprinting and issues that may arise. Examples include paternity testing, proof of wrongful convictions, insurance requirements, DNA criminal databases, and so on.

Activity 5a

Teacher Notes

Extracting DNA from Onion Cells

Specific Learning Outcomes

SLO B1:	Describe scientific and technological developments, past and present, and appreciate their impact on individuals, societies, and the environment, both locally and globally.
SLO C1:	Demonstrate appropriate scientific inquiry skills, attitudes, and practices when seeking answers to questions.
SLO C5:	Work cooperatively with others and value their ideas and contributions.
SLO D2:	Recognize that the universe comprises systems and that complex interactions occur within and among these systems at many scales and intervals of time.
SLO D4:	Understand how energy is the driving force in the interaction of materials, processes of life, and the functioning of systems.

Overview

Isolating DNA from cells is an important first step in doing DNA analysis. This procedure is used to extract large amounts of DNA from onions, and similar protocols are used to isolate DNA from other sources, such as liver tissue or peas. Students will learn how familiar chemicals are used to purify DNA.

Materials

- chopped onion
- mortar and pestle or blender (optional)
- large test tube
- cheesecloth
- funnel
- 500 ml beaker (hot water bath)
- ice bath
- ice-cold (chilled) 50 per cent ethanol
- wooden stick (skewer)
- detergent solution (1 part table salt + 1 part liquid soap/shampoo + 8 parts water)
- enzyme solution (1 part meat tenderizer + 19 parts water)

Extracting DNA from Onion Cells: Adapted from Northern Arizona University. Science & Technology Resources: <http://jan.ucc.nau.edu/~lrm22/lessons/dna_extraction/dna_extraction.html>. Adapted by permission.

Activity 5a

Student Page

Extracting DNA from Onion Cells

Overview

Isolating DNA from cells is an important first step in doing DNA analysis. This procedure is used to extract large amounts of DNA from onions, and similar protocols are used to isolate DNA from other sources, such as liver tissue or peas. You will learn how familiar chemicals are used to purify DNA.

Objectives

- Mechanically and chemically break down onion tissue to allow DNA to be extracted from the nucleus of plant cells.
- Use a process to allow nuclear material to be collected.

Materials

- chopped onion
- mortar and pestle or blender (optional)
- large test tube
- cheesecloth
- funnel
- 500 ml beaker (hot water bath)
- ice bath
- ice-cold (chilled) 50 per cent ethanol
- wooden stick (skewer)
- detergent solution (1 part table salt + 1 part liquid soap/shampoo + 8 parts water)
- enzyme solution (1 part meat tenderizer + 19 parts water)

Procedure

1. Chop about 10 ml of onion into tiny pieces. *This causes physical disruption of the cell walls.*
2. Place chopped onion in the mortar and grind with the pestle. *This continues the physical breakdown of the cell walls, allowing the cytoplasm to leak out.*
3. Add about 10 ml of detergent solution and grind again (a blender may be used). *The detergent breaks down the lipids in the phospholipid bilayers of the cell and nuclear membranes. This process allows DNA to be released from the nucleus and allows nuclear material to be released from the cell.*

Extracting DNA from Onion Cells: Adapted from Northern Arizona University. Science & Technology Resources: <http://jan.ucc.nau.edu/~lrm22/lessons/dna_extraction/dna_extraction.html>. Adapted by permission.

4. Filter the mixture into a large test tube through cheesecloth placed in a funnel. *This allows the unwanted, large cellular material to be separated from the smaller DNA.*
Note: To avoid breaking the fragile DNA strands, do not agitate from this point on.
5. Add about 3 to 4 ml of the enzyme solution to the test tube. *This causes the DNA to uncoil by denaturing (breaking down) the histone proteins that are keeping the DNA tightly coiled into chromosomes.*
6. Stand the test tube with the mixture in a beaker of hot tap water for 10 minutes. *Heat increases the rate of chemical reactions and speeds up the action of the enzymes.*
7. Place the test tube in the ice bath for 3 to 5 minutes. *Cooling decreases the rate of chemical reactions, slowing the action of the enzymes before they destroy the DNA.*
8. Carefully pour 10 ml of ice-cold ethanol into the test tube to form a separate layer on top. Wisps of gel should form where the two layers meet. *The polar/non-polar division between layers causes the DNA to precipitate.*
9. Use a stick gently to wind up the precipitated DNA. It should look like white mucus.

Analysis

1. Is the substance obtained at the end pure DNA? Explain.
2. Where might errors occur in the procedure?
3. How might the process of DNA extraction be useful to forensic investigators?
4. Where else might the process of DNA extraction be used?

Activity 5b

Teacher Notes

DNA Fingerprinting—Bar Code Simulation**Student Learning Outcomes**

SLO A2:	Recognize both the power and limitations of science as a way of answering questions about the world and explaining natural phenomena.
SLO B2:	Recognize that scientific and technological endeavours have been, and continue to be, influenced by human needs and by societal and historical contexts.
SLO B4:	Demonstrate a knowledge of, and personal consideration for, a range of possible science- and technology-related interests, hobbies, and careers.
SLO C3:	Demonstrate appropriate critical thinking and decision-making skills and attitudes when choosing a course of action based on scientific and technological information.
SLO D1:	Use the concepts of similarity and diversity for organizing our experiences with the world.

Background

DNA fingerprinting may be familiar to many students since many television shows, movies, and books now refer to the procedure. The purpose of this learning activity is to introduce students to the process of DNA fingerprinting using bar codes. It is not intended to be an exhaustive study of DNA analysis, but rather an activity that models the procedure and provides students with a greater appreciation for the process. Use your discretion in the amount and level of detail you wish to use to describe DNA.

This learning activity assumes that students realize that DNA is genetic material responsible for the uniqueness of each person. Each person's DNA is uniquely different from everyone else's. Restriction enzymes (proteins) can be added to DNA samples that will "cut" the DNA whenever a specific sequence is present. Since everyone's DNA sequence is unique, the pattern of cut DNA will also be unique.

Setting the Crime Scene

Leave a DNA sample (bar code) at the crime scene. You may choose to establish where the DNA came from: blood, skin, hair, saliva, and so on. You may also choose to leave more than one type of DNA evidence and/or connect this evidence to more than one person.

The DNA fingerprinting lab uses bar codes as a model for the electrophoresis gel used in scientific laboratories (which is also used in Activity 5c to do DNA analysis). It is important for students to realize that each person has a unique bar code or DNA profile. Their task in this activity is to match a specific DNA profile to a list of collected DNA profiles. This activity provides an opportunity to focus on specific data-collecting skills students need to develop. For example, if they are to develop appropriate lab notes for use in their assessment tasks, this is a good lab for having students collect and present their results.

This activity is not complicated, but it does require you to make a page of bar codes. Some samples are provided (see Student Page for Activity 5b). Each bar code should be numbered so that a match can be made. Students will compare the DNA evidence gathered at the crime scene to the known DNA samples from the suspects and victim(s).

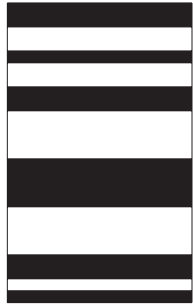
Materials

- set of bar codes (copy from products or cut out of attached Student Page) labelled with suspects' codes/names
- DNA evidence sample (bar code) on clear acetate (should match with one from suspects)

Activity 5b

Student Page

DNA Analysis—Sample Bar Codes



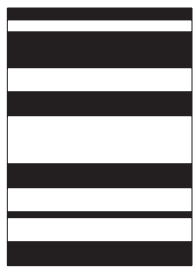


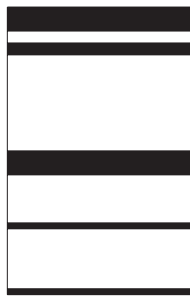














Activity 5c

Teacher Notes

DNA Fingerprinting—Electrophoresis

Student Learning Outcomes

SLO A1:	Distinguish critically between science and technology in terms of their respective contexts, goals, methods, products, and values.
SLO A4:	Recognize that science and technology interact and evolve, often advancing one another.
SLO A5:	Describe and explain disciplinary and interdisciplinary processes used to enable us to investigate and understand natural phenomena and develop technological solutions.
SLO B1:	Describe scientific and technological developments, past and present, and appreciate their impact on individuals, societies, and the environment, both locally and globally.
SLO C3:	Demonstrate appropriate critical thinking and decision-making skills and attitudes when choosing a course of action based on scientific and technological information.
SLO D1:	Use the concepts of similarity and diversity for organizing our experiences with the world.
SLO D3:	Understand the processes and conditions in which change, constancy, and equilibrium occur.

Background

DNA fingerprinting may be familiar to many students, as many television shows, movies, and books refer to the procedure. The purpose of this learning activity is to introduce students to the process of DNA fingerprinting using electrophoresis.

Each person's DNA is uniquely different from everyone else's. Restriction enzymes (proteins) can be added to DNA samples, which will "cut" the DNA whenever a specific sequence is present in the DNA. Since everyone's DNA sequence is unique, the pattern of cut DNA will also be unique.

Setting the Crime Scene

Place a small sample of DNA evidence at the crime scene or provide students with a sample. Students will run an electrophoresis separation with the "suspect's" DNA, and compare with sample from crime scene. You may choose to establish where the DNA came from: blood, skin, hair, saliva, and so on. You may also choose to leave more than one type of DNA evidence and/or connect this evidence to more than one person.

It is important for students to realize that each person has a DNA profile. Their task in this activity is to match a specific DNA profile to a list of collected DNA profiles.

Materials

- Various electrophoresis kits and apparatus are available from scientific supply companies.
 - Example: *PCR Forensics Simulation Kit* (from a biological supply company)
- Use different DNA samples or ink samples to link to various individuals.

Activity 5c

Student Page

DNA Fingerprinting—Electrophoresis

Background

DNA analysis is a complicated process involving several steps. First, the DNA is removed from the cell nucleus, after which the DNA strands are separated from the rest of the cell parts and chopped into smaller pieces. Then, human DNA pieces are combined with radioactive DNA. (The scientist will be able to track the pieces of human DNA later.) The DNA pieces are separated from one another into bands according to size, using gel electrophoresis. This process is similar to chromatography. Pictures are taken of the separated DNA pieces to record the individual's DNA profile.

Objectives

- Use electrophoresis to separate DNA fragments.
- Create DNA fingerprints and compare them to known samples to establish an identity.
- Determine whether DNA fingerprinting is an effective method of identifying a specific person.

Materials

- electrophoresis apparatus (provided by teacher)

Procedure

1. Ensure that both ends of the gel electrophoresis chamber are sealed.
2. Prepare a 1 per cent agarose gel solution and heat it briefly until it melts.
3. Pour the agarose gel into the gel electrophoresis chamber. Place the comb into the agarose mixture to create wells for the DNA and allow the mixture to harden.
4. When the agarose is solid, cover it with TBE electrophoresis buffer, ensuring that the gel is submerged. Carefully remove the comb.
5. Carefully load DNA samples that have been cut with restriction enzymes into the different wells, using a clean pipette each time.
6. Put the lid on the gel chamber. Be sure the wells are at the negative electrode. Plug the leads into the 120V power supply and run the electrophoresis until the fragments have separated. Depending on the power supply, you may have to ask your teacher to turn off the power later in the day or the next morning.
7. If required, visualize the bands by placing the gel carefully in methylene blue stain. Let the stain set for 30 minutes, and then remove the gel while wearing gloves on your hands. Place the gel in distilled water for de-staining, rinsing several times. Finally, set the gel on the white light source and compare the bands.
8. Measure and draw the DNA banding patterns exactly as they appear on the gel. Record your work in your *Forensic Investigation Lab Book*.

ESSENTIAL UNDERSTANDING 6: FINGERPRINTING (DACTYLOSCOPY)

Teacher Background

Almost every time you touch something, you leave a fingerprint. Fingerprints are impressions that are created by ridges on the skin. When a person touches an object, the perspiration, oils, dirt, and amino acids on the skin stick to the surface of the object, leaving an imprint of your fingertips. Prints that you can see with the unaided eye are called visible prints. Invisible prints are called latent prints, and they are the most common. A third type of print is a plastic print. This print is an impression on objects such as soap or clay. A forensic scientist is interested in fingerprints as a means of identification to help solve crimes. *Dactyloscopy* is a technique used to compare fingerprints for identification.

Fingerprints have been used as a means of identification for centuries. In ancient Babylon, fingerprints were used on clay tablets for business transactions, and in ancient China, thumb prints have been found on clay seals. In 1000, a Roman attorney showed that a palm print was used to frame someone for murder. In 1892, Francis Galton published a book describing his method of classifying fingerprints. In 1911, the first criminal conviction based on fingerprint evidence occurred. Thomas Jennings was charged and convicted of the murder of Charles Hiller, who died during a burglary in 1910.

A fingerprint is an individual characteristic. No two identical fingerprints have been taken from different individuals, not even from identical twins. A fingerprint will remain unchanged during an individual's lifetime. Injuries such as burns or scrapes will not change the ridge structure; when new skin grows in, the same pattern will come back. Fingerprints have general characteristic ridge patterns that permit them to be systematically classified. The individuality of any fingerprint is based upon its ridge structure and specific characteristics. The specific characteristics of individual fingerprints used for identification are the number of ridges and their approximate location. The average fingerprint has 150 individual ridge characteristics. A match is assumed if between 10 and 16 specific points of reference correspond exactly.

Fingerprinting: Adapted from Mrs. Seagraves' QUEST Class and Thematic Units. Forensic Science Activities: <<http://www.geocities.com/Athens/Atrium/5924/forensicscienceactivities.htm>>. Copyright © 1999-2001 by S. Seagraves. Adapted by permission.

Types of Fingerprints

There are three basic types of fingerprints: the *arch*, the *loop* and the *whorl*.



Plain Arch

Arches are formed by ridges running from one side to the other and curving up in the middle. Tented arches have a spike effect.



Loop

Loops have a stronger curve than arches, and the ends exit and enter the print on the same side. Radial loops slant toward the thumb, and ulnar loops slant toward the other side.



Plain Whorl

Whorls are complete ovals, often formed in a spiral pattern around a central point. There are plain whorls and central pocket loop whorls.

Composite patterns are a mix of two of the previous patterns, while accidental patterns are irregular.

Suggestions for Instruction

The following concept may be developed in this section:

- classification based on similarities and differences

- Use an activating prior knowledge strategy (see Appendix 2) to establish what students know about fingerprinting.
- Have students make and classify a number of fingerprints within the classroom. They may then practise trying to identify each other based on fingerprints.

Suggested Student Activities

- Activity 6: Fingerprinting
- Students debate whether fingerprinting is a science (see *SYSTH* 4.19-4.21).

Activity 6

Teacher Notes

Fingerprinting

Specific Learning Outcomes

-
- SLO A1:** Distinguish critically between science and technology in terms of their respective contexts, goals, methods, products, and values.
-
- SLO A3:** Identify and appreciate the manner in which history and culture shape a society's philosophy of science and its creation or use of technology.
-
- SLO D1:** Use the concepts of similarity and diversity for organizing our experiences with the world.
-

Overview

The intent of this learning activity is to have students gather fingerprint evidence at the crime scene. They will also learn how to make a fingerprint and classify fingerprints based on the pattern on the print.

Setting the Crime Scene

In setting fingerprints at the crime scene, have the suspect rub his or her finger across the bridge of the nose, across the temples, or through the hair (to gather oils). Then have the suspect press firmly with finger(s) on a clean glass or clear plastic cup without smudging, and leave this piece of evidence at the scene. A partial print will make the investigation more interesting. The print should be faintly visible.

Recording and Classifying Fingerprints

The use of ink from a pad (though it can be messy and difficult to clean off hands) is the simplest method for making fingerprints. The finger is covered with ink and then firmly rolled on a white piece of paper or a blank index card.

Another way to record fingerprints is to have students rub a pencil on a small area of a piece of paper, and then rub their fingers over the graphite. Next, have them place a piece of tape on their fingers, lift, and place the tape on a clean sheet of white paper or a blank index card. The tape may also be placed on an overhead and the fingerprint projected for the class to analyze.

Label the fingerprint to identify the individual's name, hand, and finger.

Simplify the classification of fingerprints by using three major categories: loop, arch, and whorl. Using these categories, students should be able to identify their fingerprints.

Note: Getting good results from dusting for fingerprints can be challenging, and may require plenty of practice.

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Materials (depending on choice of activities and/or methods)

- cocoa (light surface) or talcum powder (dark surface)
- stamp pads (washable ink)
- glasses or plastic cups (or other surface) for fingerprints
- small soft brush (soft camel hair or fibreglass)
- superglue (the larger tubes work better than the tiny tubes)
- zippered plastic evidence bag (large enough for the object with the fingerprints)
- magnifying glass
- construction paper
- white paper
- transparent tape
- index cards

Activity 6

Student Page

Fingerprinting

Objectives

- Collect fingerprints from the crime scene.
- Classify fingerprints according to the patterns of loop, arch, and whorl.
- Use this fingerprint classification system to match an unknown fingerprint from known samples.

Materials (depending on choice of activities and/or methods)

- cocoa (light surface) or talcum powder (dark surface)
- stamp pads (washable ink)
- glasses or plastic cups (or other surface) for fingerprints
- small soft brush (soft camel hair or fibreglass)
- superglue (the larger tubes work better than the tiny tubes)
- zippered plastic evidence bag (large enough for the object with the fingerprints)
- magnifying glass
- construction paper
- white paper
- transparent tape
- index cards

Procedure

Take a magnifying glass and study the patterns on your fingers. What do you notice? Are the patterns the same on each finger?

Part 1: Collecting Fingerprint Evidence from the Crime Scene (from hard surfaces)

At the crime scene, fingerprints must be removed and transported to the crime lab. They may then be compared to the database of fingerprints on file. One way that detectives locate fingerprints is by dusting for them. Fingerprints are coated with powder, then lifted and taken for identification at the lab.

1. Sprinkle cocoa powder over the object (for instance, a glass) and brush the powdered area gently with a fine brush (camel hair or fibreglass) to remove the excess powder and expose the print. On dark surfaces, use talcum powder instead of cocoa to lift the print.
2. Place a piece of transparent tape over the print and lift the print from the glass. Place the tape on light coloured construction paper.

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Alternative Method

1. Place the object (for example, cup) in a labelled zippered plastic evidence bag. Add about three drops of superglue to the bag, making sure that the drops do not hit the actual fingerprint.
2. In about an hour, the fingerprints should be clearly visible in white.

Caution: Follow all directions when working with a strong adhesive, and pay particular attention to where fingertips are placed. Keep hands away from face and eyes.

Part 2: Making and Identifying Fingerprints

There are many methods of gathering fingerprints, but using a stamp pad to make fingerprints is a common method. Follow the procedure below to make fingerprint cards for possible suspects.

1. Make a fingerprint record chart, allowing space for the thumb, index, middle, ring, and baby fingerprints of each hand. Record the date, the individual's name, and the hand (left or right).
2. Roll the finger lightly on the stamp pad, and then roll the inked finger onto the space in the chart (you may have to practise this technique until you can produce a legible fingerprint).
3. Repeat this method for each finger on the right hand.
4. Examine each print and identify its pattern. Record this information on the chart.
5. Repeat Steps 1 to 4 for the left hand.

Part 3: Identifying an Unknown Fingerprint

1. Examine the fingerprint(s) obtained from the crime scene.
2. Compare fingerprint evidence to the fingerprints of the possible suspects.

Analysis

Record your analysis in your *Forensic Investigation Lab Book*.

1. Record your conclusions.
2. Explain clearly how you arrived at your conclusions.
3. Discuss as a class, or in a small group, the validity of using fingerprints collected from the scene of a crime to identify a suspect.

ESSENTIAL UNDERSTANDING 7: PHYSICAL EVIDENCE—FIBRE, STAIN, AND HAIR ANALYSIS

Teacher Background

In 1910, Edmund Locard founded a small police laboratory in Lyon, France, dedicated to forensic science. Locard put forward the theory that a criminal almost always leaves behind physical clues at the scene of a crime.

What looks like a bit of lint might actually offer numerous clues to an investigator. Scientists microscopically comb samples for human and animal hair, clothing threads, carpeting, paper, and even plant fibres. They may attempt to identify everything found at the crime scene, and perhaps use the information to place a suspect at the scene.

Forensic analysts are often asked to compare hair found at a crime scene with hair from a particular individual. Hair samples can be used to exclude a suspect but not to convict someone. Hair is considered to be contributing evidence. Different hairs on the same person can show variations, so a larger sample is better than a small one. The examiner compares a variety of factors, including colour, coarseness, granule distribution, hair diameter, and the presence or absence of a medulla. Hair may also carry evidence such as dirt or blood.

Each hair grows out of a tiny pocket in the skin called a follicle. The base of the hair (the part attached to the follicle) is called the root hair. The presence of the root hair may indicate that the hair was pulled out, as opposed to having fallen out. A strand of hair has three layers: cuticle, cortex, and medulla. The cuticle is the outer covering. It consists of tough overlapping scales that point toward the tip end. The cortex contains pigment granules, which give hair its colour. The colour, shape, and distribution of the granules provide important points of comparison between the hair of different individuals. The medulla is a hollow tube that runs the length of the hair. Sometimes it is present, sometimes not. Sometimes the canal is continuous, while in other cases it is fragmented. If the hair is from an animal, it may be possible to identify the species, since different species have different scale patterns on the cuticle of the hair. Animal hair characteristically has a thicker medulla and cuticle than human hair, thus providing more warmth.

Suggestions for Instruction

The following concepts may be developed in this section:

- physical properties of substance
- classification based on similarities and differences

- Brainstorm types of physical evidence that might be found at a crime scene.

Suggested Student Activities

- Activity 7a: Fibre and Stain Analysis
- Activity 7b: Hair Analysis

Activity 7a

Teacher Notes

Fibre and Stain Analysis

Specific Learning Outcomes

SLO A2:	Recognize both the power and limitations of science as a way of answering questions about the world and explaining natural phenomena.
SLO B2:	Recognize that scientific and technological endeavours have been, and continue to be, influenced by human needs and by societal and historical contexts.
SLO C1:	Demonstrate appropriate scientific inquiry skills, attitudes, and practices when seeking answers to questions.
SLO D1:	Use the concepts of similarity and diversity for organizing our experiences with the world.

Overview

Students will observe, describe, compare, and classify various fibres (paper and cloth) and stains. They will then use this information to analyze evidence obtained at the crime scene.

Setting the Crime Scene

Give each group of forensic investigators one piece of the same kind of paper and one stained cloth (as described below).

Materials

Known samples may either be provided in labelled bags or the investigators must obtain them from the suspects. Six is an arbitrary number of samples.

- six samples of different paper (same colour, different types) in labelled bags
- six samples of different red cloth (all red, different types) in labelled bags
- four pieces of one type of cloth (each with a different stain and one left unstained) in labelled bags
- salt, vegetable oil, lead nitrate, and potassium iodide (to make the stain)
- hand lens
- compound microscope
- stereoscopic microscope
- tweezers
- slides and cover slips
- sticky tape (to gather evidence from the crime scene)

Procedure

Part 1: Examining Paper Fibres

Students examine six known types of paper (same colour, different types) and record observations using their eyes and then a hand lens, stereoscope, and/or microscope. Students examine texture, arrangement of fibres, and any other unique features. Students then examine the evidence obtained at the crime scene and compare it to the known samples.

Part 2: Examining Cloth Fibres

Students examine six known pieces of cloth (same colour, different types) and record observations using their eyes and then a hand lens, stereoscope, and/or microscope. Students examine texture, arrangement of fibres, and any other unique features. Students then examine the evidence obtained at the crime scene and compare it to the known samples.

Part 3: Identifying Unknown Stains

One important aspect of this part of the activity is to ensure that the stains are similar in appearance but different in composition. As well, the differences in the stains should be observed at the hand lens or microscopic level to ensure that students cannot differentiate between the stains at the normal eye level. The three stains that work well on red cloth consist of

- a mixture of salt and water (Once dry, the salt crystals will become trapped in the cloth.)
- a dilute solution of lead nitrate and potassium iodide solution (This yellow solution will dry to leave yellow lead iodide crystals.)
- a vegetable oil stain (On the red cloth, the stain will look like the two other stains, but will be caused by discolouration in the material rather than by crystals.)

Students examine the four known cloth samples (three stained and one unstained). They then observe the unknown sample from the crime scene and match it to one of the three known stains. Using another type of material for one stain sample would force students to concentrate more on the stains than on the material.

Fibre and Stain Analysis

Background

In 1910, Edmund Locard founded a small police laboratory in Lyon, France, dedicated to forensic science. Locard put forward the theory that a criminal almost always leaves behind physical clues at the scene of a crime.

What looks like a bit of lint might actually offer numerous clues to an investigator. Scientists microscopically comb samples for human and animal hair, clothing threads, carpeting, paper, and even plant fibres. They may attempt to identify everything found at the crime scene, and perhaps use the information to place a suspect at the scene.

Objectives

- Observe and record the characteristics of various samples of paper fibres, cloth fibres, and stains on cloth.
- Use similarities and differences of collected samples as a means of identification.
- Attempt to match the physical evidence obtained from the crime scene to a suspect.

Materials

- paper samples
- cloth samples
- hand lens
- compound microscope
- stereoscopic microscope
- tweezers
- slides and cover slips
- sticky tape

Procedure

Construct an organized data table to record your results and observations in your *Forensic Investigation Lab Book*. Be sure to include detailed and labelled diagrams and note the magnification.

Part 1: Examining Paper Fibres

1. Examine each of the known paper samples with your eyes, the hand lens, stereoscope, and/or compound microscope. Note colour, texture, arrangement of fibres, and any other observable features. Record your observations.
2. Examine the paper sample obtained at the crime scene. Record your observations.

Activity 7b

Teacher Notes

Hair Analysis

Specific Learning Outcomes

SLO A2:	Recognize both the power and limitations of science as a way of answering questions about the world and explaining natural phenomena.
SLO B2:	Recognize that scientific and technological endeavours have been, and continue to be, influenced by human needs and by societal and historical contexts.
SLO C1:	Demonstrate appropriate scientific inquiry skills, attitudes, and practices when seeking answers to questions.
SLO D1:	Use the concepts of similarity and diversity for organizing our experiences with the world.

Overview

Students will observe, describe, compare, and classify various types of hair samples based on their characteristics. Students then examine the evidence obtained at the crime scene and compare it to the known samples.

Setting the Crime Scene

Leave hair samples for each group at the crime scene. You may choose to leave more than one type (for instance, some from the suspect, a dog or cat, or a victim). Students may use sticky tape to gather evidence from the crime scene.

Materials

- hair (your own or from friends, family members, hair salon, family pet, or other animal) in labelled bags
- hand lens
- compound microscope
- stereoscopic microscope
- tweezers
- slides and cover slips
- sticky tape

Procedure

Have students draw and describe at least six different types of hair using their eyes, the hand lens, stereoscope, and microscope. Students may note the presence or absence of a hair follicle, hair colour, coarseness, granule distribution, hair diameter, and the presence or absence of a medulla.

Hair Analysis

Background

Forensic analysts are often asked to compare hair found at a crime scene with hair from a particular individual. Different hairs on the same person can show variations, so the larger the sample the better. The examiner compares a variety of factors, including colour, coarseness, granule distribution, hair diameter, and the presence or absence of a medulla. Hair may also carry evidence such as dirt or blood.

Each hair grows out of a tiny pocket in the skin called a follicle. The base of the hair (the part attached to the follicle) is called the root hair. The presence of the root hair may indicate that the hair was pulled out, as opposed to having fallen out. A strand of hair has three layers: cuticle, cortex, and medulla. The cuticle is the outer covering. It consists of tough overlapping scales that point toward the tip end. The cortex contains pigment granules, which give hair its colour. The medulla is a hollow tube that runs the length of the hair. Sometimes it is present, sometimes not. Sometimes the canal is continuous, while in other cases it is fragmented. If the hair is from an animal, it may be possible to identify the species, since different species have different scale patterns on the cuticle of the hair. Animal hair characteristically has a thicker medulla and cuticle than human hair, thus providing more warmth.

Objectives

- Observe and record the characteristics of various samples of hair.
- Use similarities and differences in collected samples as a means of identification.
- Attempt to match the physical evidence obtained from the crime scene to a suspect.

Materials

- hair samples
- hand lens
- compound microscope
- stereoscopic microscope
- tweezers
- slides and cover slips
- sticky tape

Procedure

Construct an organized data table to record your observations and results in your *Forensic Investigation Lab Book*. Be sure to include detailed and labelled diagrams and note the magnification.

1. Obtain six known samples of hair.
2. Examine the hair with your eyes, the hand lens, stereoscope, and microscope. Record your observations. Note characteristics such as colour, thickness, texture, and any unique characteristics such as split ends. Remember to observe both ends of the hair.
3. Make a wet mount slide of a hair.
4. Observe the hair with the compound microscope and record its characteristics, including colour, thickness, texture, and any unique characteristics such as split ends. Remember to observe both ends of the hair. Look for medulla, cuticle, and scales. Look for the distribution of pigment granules.
5. Record and make drawings of your observations.
6. Repeat this procedure for the other hair samples. Note and record any differences.
7. Examine the hair sample(s) obtained from the crime scene.
8. Examine and record your observations.

Analysis

Record your analysis in your *Forensic Investigation Lab Book*.

1. Determine whether the hairs at the crime scene are from the victim or from one of the suspects.
2. Justify your decision.
3. Does the examination of hair fibre evidence provide valid scientific data and allow forensic investigators to link crime scenes to individuals? Explain.
4. Outline a recent case in Canada where hair and/or fibre evidence was called into question as the primary means of obtaining a conviction. In the case you uncovered, was the person set free due to problems with this sort of evidence? Explain.

ESSENTIAL UNDERSTANDING 8: HANDWRITING ANALYSIS

Specific Learning Outcomes

SLO A1:	Distinguish critically between science and technology in terms of their respective contexts, goals, methods, products, and values.
SLO A2:	Recognize both the power and limitations of science as a way of answering questions about the world and explaining natural phenomena.
SLO A3:	Identify and appreciate the manner in which history and culture shape a society's philosophy of science and its creation or use of technology.
SLO C1:	Demonstrate appropriate scientific inquiry skills, attitudes, and practices when seeking answers to questions.
SLO D1:	Use the concepts of similarity and diversity for organizing our experiences with the world.

Teacher Background

Handwriting analysis involves the study of shapes, forms, and inconsistencies. Just as in fingerprinting analysis, forensic scientists will examine a combination of characteristics when attempting to identify a particular handwriting. They will examine the way the lines form the letters, the slant (forward, backward, or straight up and down), spacing, and ornamentation (dotting of i's, crossing of t's). Forensic investigators also use psycholinguistic analysis to examine a person's choice of words, spelling, punctuation, and grammar in written (and spoken) communication.

When making handwriting comparisons, the forensic scientist will attempt to obtain an exemplar or sample of the person's handwriting. The scientist may have the individual recreate the document, using the same writing tools and paper and taking dictation at varying speeds and emphases. The scientist may also obtain writing samples by searching through an individual's effects.

Handwriting analysts maintain that lying results in slight physiological changes that might affect the slant, pressure, or spacing in writing. Those who try to disguise their style of writing often write faster than normal, are deliberately careless, or write smaller or larger than they normally do. They may also try to change the slant of their writing. They may print instead of write, or they may change hands. If forensic scientists have enough handwriting samples from the suspect, they can usually determine whether or not the suspect has written certain documents.

Being somewhat subjective, handwriting analysis is not a science, and handwriting analysts are often not accepted as expert witnesses in trials.

Suggestions for Instruction

The following concept could be developed in this section:

► classification based on similarities and differences

- Use an activating prior knowledge activity (see Appendix 2) to establish what students know about handwriting.
- Have students make and classify a number of handwriting samples within the classroom. They may then practise trying to identify each other based on their handwriting. Consider varying the conditions under which the samples are created (for example, time, distractions) and/or have students try to fool each other.

Suggested Student Activities

- Activity 8: The Science of Handwriting Analysis?
- Students research, discuss, and debate whether handwriting analysis is a science in the strict sense (see *SYSTH* 4.19–4.21).
- Students could research the ransom notes sent after the kidnapping of Charles A. Lindbergh, Jr. (1932), the young son of the famous aviator, or they could research Clifford Irving's forgery of letters and the autobiography he claimed Howard Hughes had written (1970).

Activity 8

Teacher Notes

The Science of Handwriting Analysis?

Specific Learning Outcomes

SLO A1:	Distinguish critically between science and technology in terms of their respective contexts, goals, methods, products, and values.
SLO A2:	Recognize both the power and limitations of science as a way of answering questions about the world and explaining natural phenomena.
SLO A3:	Identify and appreciate the manner in which history and culture shape a society's philosophy of science and its creation or use of technology.
SLO C1:	Demonstrate appropriate scientific inquiry skills, attitudes, and practices when seeking answers to questions.
SLO D1:	Use the concepts of similarity and diversity for organizing our experiences with the world.

Background

The individuality of each person's handwriting comes from the individuality of each person's motor control pattern. It is because each body's motor control pattern is unique that handwriting can be used for identification.

Setting the Crime Scene

Leave a note (see also Activity 3: Chromatography and Activity 7a: Fibre and Stain Analysis) at the crime scene. The note may give clues to the crime. Have someone "forge" the handwriting and/or signature of the writer of the note (victim or suspect). What the note contains and where the evidence points will be developed in your initial crime scenario.

Materials

- sheet of signatures
- unlined white paper
- tracing paper
- pen
- rulers

Procedure

Part 1: Introduction to Handwriting Analysis

Discuss with students the possible uses of handwriting analysis. Ask them whether they think handwriting analysis is a science. Have students examine their own signatures in a variety of ways.

Part 2: Identifying Authentic Signatures (Practice)

Write your signature at the top of a sheet of paper. Have five or six other persons closely imitate your signature below it. Include at least one other legitimate signature in the mix. Distribute copies of the sheet to the forensic investigative teams to see whether they can determine which signatures are forged and which are legitimate.

Part 3: Examining the Handwriting/Signature on a Note Found at the Crime Scene

The forensic investigative teams will examine the signature(s) found on the note(s) at the crime scene and compare the signature(s) to those of the victim(s) and/or suspect(s).

Activity 8

Student Page

The Science of Handwriting Analysis?

Background

The individuality of each person's handwriting comes from the individuality of each person's motor control pattern. It is because each body's motor control pattern is unique that handwriting can be used for identification.

When examining each suspect's handwriting, look at the following:

- slant
- size of letters
- distinct formations
- spacing of letters
- spacing of words

Objective

- Create and examine signatures/handwriting samples to establish personality traits that could assist in suspect identification.

Materials

- sheet of signatures (provided by teacher)
- unlined white paper
- tracing paper
- pen
- ruler

Procedure

Record your observations and results in your *Forensic Investigation Lab Book*.

Part 1: Introduction to Handwriting Analysis

1. On an unlined sheet of paper, write your signature three times: first normally, then holding your pen in a fist moving only the wrist and arm, and finally with the pen clenched in the crook of your elbow. What do you notice about your signatures?
2. Write your name in the air with your nose or foot. What do you notice?
3. Write your name twice on a sheet of white paper and place tracing paper over the signatures. Make a small mark on the tracing paper at the high point of each letter of both signatures. Use a ruler to connect the consecutive dots, creating a zigzag line across the top of each signature. What do you notice about the two zigzag lines?

ESSENTIAL UNDERSTANDING 9: CHEMICAL DETECTION

Teacher Background

A forensic scientist may discover powder or other unknown substances at a crime scene. To identify the unknown substance, a forensic chemist will perform a variety of chemical tests.

Suggestions for Instruction

The following concepts could be developed in this section:

- characteristic properties of substances (Senior 3 Chemistry)
- chemical reactions (Senior 3 Chemistry)

- Use a Compare and Contrast strategy (see *SYSTH* 10.15-10.17) to review physical and chemical characteristics.

Suggested Student Activities

- Activity 9: Chemical Detection
- Students conduct research on arson dogs trained to detect chemical compounds used to set fires that can indicate foul play.

Activity 9

Teacher Notes

Chemical Detection

Specific Learning Outcomes

-
- SLO A2:** Recognize both the power and limitations of science as a way of answering questions about the world and explaining natural phenomena.
-
- SLO C1:** Demonstrate appropriate scientific inquiry skills, attitudes, and practices when seeking answers to questions.
-
- SLO D1:** Use the concepts of similarity and diversity for organizing our experiences with the world.
-

Overview

Students perform a variety of positive tests on known white powders. They will learn how to determine the composition of a mystery powder through observation and classification of reaction type.

Setting the Crime Scene

Leave a small sample of one of the following powders (or a mixture of powders) at the crime scene: salt, sugar, cornstarch, baking soda, plaster, and potassium iodide. Leave enough for each group to scrape up a sample. If possible, try to connect the powder to the suspects (guilty or innocent) or the victim. The sample could also be a red herring.

Materials

- salt
- sugar
- cornstarch
- baking soda
- plaster
- potassium iodide (KI)
- vinegar
- iodine (from KI solution)
- water
- lead II nitrate solution $\text{Pb}(\text{NO}_3)_2(\text{aq})$
- black paper
- hand lens or microscope
- clothespin
- aluminum
- hotplate or candle
- spot/well plate or egg carton
- eyedropper
- toothpicks

Procedure

Part 1: Determining the Characteristics of Various White Powders

Students perform a series of tests on six unknown powders. By determining what a positive test for the powder is, they will be able to determine the composition of an unknown powder that may contain more than one type of white powder. The following table shows the positive test for each of the powders. NR means no recordable reaction.

Test Results						
Test Powder	Appearance (Hand Lens/ Microscope)	Heat Test	Vinegar Test	Iodine Test	Solubility in Water Test	Reaction with Lead II Nitrate Test
Salt	White crystals	NR	NR	NR	Dissolves	NR
Sugar	White crystals	Turns brown	NR	NR	Dissolves	NR
Cornstarch	Fine-grained powder	NR	NR	Black	Clumps	NR
Baking Soda	Fine-grained powder	NR	Bubbles	NR	Minor dissolving	NR
Plaster	Powder	NR	NR	NR	Does not dissolve	NR
Potassium Iodide	Clear crystals	NR	NR	NR	Dissolves	Yellow

Part 2: Identifying an Unknown Mixture of White Powders

Make up sample mystery powders using two or more of the white powders. Have students identify the mystery powders using the same tests. Use codes for each sample, recording the composition of the mystery powders for each code. The emphasis in this task is on having students perform the tests correctly and record the data in an appropriate manner that allows them to draw conclusions that can be supported by their data.

Part 3: Identifying the Unknown Powder from the Crime Scene

Students analyze the powder evidence gathered from the crime scene using the tests previously practised in this investigation.

Activity 9

Student Page

Chemical Detection

Background

Crime labs work with pharmaceutical companies to develop tests for drugs as they are developed. Forensic investigators are able to identify very small samples of a drug, using files developed through previous positive testing as a reference. Drug identification is very important, especially when investigators arrive on a scene to find someone has ingested a potentially poisonous drug.

Objectives

- Perform several tests on small amounts of known white powders to determine which produces a positive reaction.
- Identify the different powders in a mystery mixture that contains at least two known powders.
- Analyze and identify powder evidence left at the crime scene.

Materials

- salt
- sugar
- cornstarch
- baking soda
- plaster
- potassium iodide (KI)
- vinegar
- iodine (from KI solution)
- water
- lead II nitrate solution $\text{Pb}(\text{NO}_3)_{2(\text{aq})}$
- black paper
- hand lens or microscope
- clothespin
- aluminum
- hotplate or candle
- spot/well plate or egg carton
- eyedropper
- toothpicks

Procedure

You are going to test six different powders. Construct a well-organized data table in your *Forensic Investigation Lab Book*, in which you will record all your observations. You will then have a set of positive tests, ways to tell each powder from the others. You will then practise on an unknown powder. Finally, you will analyze the powder collected at the crime scene.

Part 1: Determining the Characteristics of Various White Powders

Test #1: Hand Lens/Microscope Test

1. Place a small amount of each powder on a square of black paper and observe the particles with a hand lens. Examine the appearance of each powder. Describe shape, grain size, and other notable characteristics.
2. Rub each powder between your fingers and describe its texture.
3. Use the wafting technique to note any odours to the powders.
4. Record your observations in the data table.
5. Dispose of the powders as directed by the teacher.

Test #2: Heat Test

1. Make a foil boat or a foil spoon (use a clothespin for a handle).
2. Place a small amount of each powder in the foil.
3. Hold the spoon over a candle flame or place the boat on a hotplate.
4. Heat the powder carefully.
5. Record your observations in the data table.

Test #3: Vinegar Test

1. Place a small amount of each powder in a separate well on a spot plate (or egg carton).
2. Add a few drops of vinegar to each powder. Stir with a clean toothpick each time.
3. Record your observations in the data table.
4. Clean the spot plate.

Test #4: Iodine Test

<p>Caution: Handle iodine with care. Do not touch with bare hands!</p>

1. Place a small amount of each powder in a separate well on a spot plate (or egg carton).
2. Add a few drops of iodine (KI solution) to each powder. Stir with a clean toothpick each time.

3. Record your observations in the data table.
4. Clean the spot plate.

Test #5: Solubility in Water Test

1. Place a small amount of each powder in a separate well on a spot plate (or egg carton).
2. Add a few drops of water to each powder. Stir with a clean toothpick each time.
3. Record your observations in the data table.
4. Clean the spot plate.

Test #6: Reaction with Lead II Nitrate Test

1. Place a small amount of each powder in a separate well on a spot plate (or egg carton).
2. Add a few drops of lead II nitrate solution to each powder. Stir with a clean toothpick each time.
3. Record your observations in the data table.
4. Clean the spot plate.

Part 2: Identifying an Unknown Mixture of White Powders

1. Take one unknown mixture from the tray and record the number of the mixture. Each mixture contains two or three of the known powders in different combinations.
2. Identify which powders are present in the unknown mixture, using the positive tests determined in Part 1.
3. Construct a table to summarize your observations and conclusions.

Part 3: Identifying the Unknown Powder from the Crime Scene

Analyze the powder evidence gathered from the crime scene using the tests you have practised in this investigation. Record your observations in your *Forensic Investigation Lab Book*.

ESSENTIAL UNDERSTANDING 10: SOIL ANALYSIS

Teacher Background

Soil may be defined as the naturally deposited material covering the earth's surface whose chemical, physical, and biological properties are capable of supporting plant growth. Soils vary widely in their composition, depending on their origin and the natural forces of erosion and decomposition acting upon them over time.

The analysis of soil from a crime scene often provides investigators with clues. For example, properties of a certain type of soil, such as the acidity or alkalinity (pH) or the capillary action, can place the suspect in a certain geographical place. As bodies decompose, they leak fatty acids into the ground beneath them. Analysis of the types and amounts of fatty acids can reveal the time of death, as well as pinpoint exactly how long any given body has been lying in a particular place. The soil, saturated with bone minerals and fatty acids, can also reveal the presence of a corpse, even if the body itself has been removed or destroyed. The "stain" left by a body's *volatile acids* ("volatile" meaning very easily taken up into the air as vapour), which also suppress plant life around it, can last up to two years, leaving a kind of phantom "fingerprint" in the earth. Thus, soil, like maggots, offers much forensic information.

Suggestions for Instruction

The following concept could be developed in this section:

► soil types and formation

- Discuss the factors involved in soil formation, such as living matter (plants, animals, and micro-organisms), climate (cold, heat, snow, rainfall, and wind), parent materials (chemical and mineralogical composition), relief (slope and land form), and time.
- Discuss the different soil types (loam, sandy loam, clay loam, and humus loam).

Suggested Student Activity

- Activity 10: The Dirty Truth

Activity 10

Teacher Notes

The Dirty Truth

Specific Learning Outcomes

-
- SLO A5:** Describe and explain disciplinary and interdisciplinary processes used to enable us to investigate and understand natural phenomena and develop technological solutions.
-
- SLO B5:** Identify and demonstrate actions that promote a sustainable environment, society, and economy, both locally and globally.
-
- SLO D1:** Use the concepts of similarity and diversity for organizing our experiences with the world.
-

Overview

Students will make a shoe print mould, examine soil microscopically, assess the capillary action of soil, determine the water-holding capacity of soil, and determine the soil's pH. One way to obtain a variety of soil samples is by having students bring them from home.

Setting the Crime Scene

Leave a shoe (or tire) print in soil at the crime scene. Have a number of different (labelled) shoes (with different soil samples stuck to them) available for comparison.

Materials

- plaster of Paris powder
- known soil samples with specific percentages of sand, clay, and humus (You may premix these yourself.)
- unknown soil sample evidence from crime scene
- sand
- clay
- humus
- powder funnel
- cloth gauze
- elastic band
- stereoscopic microscope
- 100 ml graduated cylinder
- 250 ml beaker
- pH paper
- water
- clock or watch

Procedure

Part 1: Making a Mould of Shoe (or Tire) Print

The investigative teams use plaster of Paris to make a mould of the shoe (or tire) print left at the crime scene.

Part 2: Examining Soil Microscopically

Students examine known and unknown soil samples microscopically.

Part 3: Assessing the Capillary Action of Soil

Students determine the capillary action of known and unknown soil samples.

Part 4: Determining the Water-Holding Capacity of Soil

Students determine the water-holding capacity of known and unknown soil samples.

Part 5: Determining the pH of Soil

Students determine the pH of known and unknown soil samples.

Activity 10

Student Page

The Dirty Truth

Background

Soil may be defined as the naturally deposited material covering the earth's surface whose chemical, physical, and biological properties are capable of supporting plant growth. Soils vary widely in their composition, depending on their origin and the natural forces of erosion and decomposition acting upon them over time.

The analysis of soil from a crime scene often provides investigators with clues. For example, properties of a certain type of soil, such as the acidity or alkalinity (pH) or the capillary action, can place the suspect in a certain geographical place. As bodies decompose, they leak fatty acids into the ground beneath them. Analysis of the types and amounts of fatty acids can reveal the time of death, as well as pinpoint exactly how long any given body has been lying in a particular place. The soil, saturated with bone minerals and fatty acids, can also reveal the presence of a corpse, even if the body itself has been removed or destroyed. The "stain" left by a body's *volatile acids* ("volatile" meaning very easily taken up into the air as vapour), which also suppress the growth of plant life around it, can last up to two years, leaving a kind of phantom "fingerprint" in the earth. Thus, soil, like maggots, offers much forensic information.

Objectives

- Classify soils based on their physical and chemical characteristics.
- Classify unknown soil from the crime scene.

Materials

- plaster of Paris powder
- known soil samples with specific percentages of sand, clay, and humus
- unknown soil sample evidence from crime scene
- sand
- clay
- humus
- powder funnel
- cloth gauze
- elastic band
- stereoscopic microscope
- 100 ml graduated cylinder
- 250 ml beaker
- pH paper
- water
- clock or watch

Procedure

Record your observations, drawings, data, and conclusions in your *Forensic Investigation Lab Book*.

Part 1: Making a Mould of Shoe (or Tire) Print

1. Mix the plaster of Paris as directed.
2. Pour a thin layer of the plaster into the shoe (or tire) impression left at the crime scene. Make sure that the entire impression is covered and try to avoid bubbles. Let the plaster dry.
3. Once the mould has hardened, carefully remove the mould from the imprint.
4. Measure the length and width of the mould.
5. Examine and draw the tread.
6. Compare your mould and data to the available shoe samples and record your conclusions.

Part 2: Examining Soil Microscopically

1. Obtain small samples of sand, clay, and humus.
2. Using a stereoscopic microscope, make drawings of each sample.
3. Examine and draw your unknown sample. Try to identify the sand, clay, and humus in your sample.
4. Classify the unknown sample as loam, sandy loam, or clay loam. Record your conclusions.

Part 3: Assessing the Capillary Action of Soil

1. Wet a square piece of gauze and attach it to the bottom of a powder funnel using an elastic band.
2. Measure 100 ml of water into a 250 ml beaker.
3. Weigh out 100 g of one of the known soil samples.
4. Place the soil sample in the funnel and pack it down firmly.
5. Place the funnel in the beaker. Make sure the stem of the funnel reaches the water. Depending upon the relative amounts of sand, clay, and humus in the soil sample, water will be absorbed up from the beaker into the soil.
6. Measure the amount of water remaining in the beaker after every five minutes for 30 to 60 minutes.
7. Record the absorption data.
8. Retain the soil sample and funnel for Part 4.
9. Using a new funnel, repeat the procedure with your unknown soil sample.
10. Graph the rate of water uptake versus time for both soil samples. Find the slopes of each graph and describe the significance of each slope.

Part 4: Determining the Water-Holding Capacity of Soil

1. After Part 2 is completed, place the powder funnel containing the soil sample from Part 2 over the empty 100 ml graduated cylinder.
2. Pour the remainder of the 100 ml of water from the 250 ml beaker into the soil sample.
3. Allow the water to run through the packed soil sample.
4. When the water has stopped running through, record the amount of water that ran through the soil sample into the graduated cylinder.
5. Record the volume of water held (volume held = 100 ml – volume in graduated cylinder).
6. Keep the water in the graduated cylinder for Part 5.
7. Repeat Part 4 procedure using your unknown soil sample.

Part 5: Determining the pH of Soil

1. Use the water sample that passed through the soil sample in Part 4 and the pH paper to determine the pH of the known and unknown soil samples.
2. If the water is coloured or clouded by soil particles, filter or centrifuge it to obtain a sample that is as clear as possible.

Analysis

1. Summarize your conclusions based on the evidence obtained from the soil samples.

ESSENTIAL UNDERSTANDING 11: URINE ANALYSIS

Teacher Background

Urine analysis is a crucial and interesting exploration for students. With the necessary cautions in place regarding the use of natural body fluids, it is essential that students handle only *synthetic urine* that has been produced artificially. One good “recipe” for synthetic urine follows later on in this activity. From a forensic investigation point of view, urine analysis can reveal characteristics of an individual’s body chemistry *at a moment in time*, making such an analysis useful for time and date related to crime scene investigations.

Among the characteristics that can be examined for a urine sample, the following are important for the purposes of this urine analysis activity:

- **Visual examination:** Colour, transparency, turbidity, and odour(s) are considered important attributes in this initial examination.
- **Specific gravity:** Synonymous with *density*, specific gravity (as measured by a hydrometer) provides a comparison with pure water ($s.g._{water} = 1.00$), and also gives evidence of the amount of dissolved solids in the urine sample, the degree to which the sample is dilute, or the presence of health problems. A high specific gravity is indicative of greater dissolved solids and can indicate dehydration.
- **pH:** Urine pH can vary from about 4.5 (quite acidic) to 8.0 (slightly alkaline), and is an indicator of diet, drug use, and other factors. It also has the advantage of being a time-specific data source that can have value in a forensic investigation.
- **Sediment analysis:** Analysis of sediment can provide clues such as an abnormal condition of blood in urine or the presence of crystals that may indicate drug use. Students could be provided with diagrams to assist in identification, particularly in the case of the identification of crystals that have precipitated out of the urine suspension.
- **Protein presence (e.g., albumin):** Normally, protein should not be present in urine, and is an indicator of problems if it is present. For instance, fever, strenuous exercise, and some diseases (especially kidney disease) may cause protein to appear in urine. The presence of protein in urine may also be an indication of normal pregnancy.
- **Glucose presence:** Testing for sugar (as glucose) may give an indication of diseases such as diabetes or kidney dysfunction. Under normal conditions, sugar(s) should not be present in urine.

Suggestions for Instruction

The following concepts may be developed in this section:

- kidney function and disease (Senior 3 Biology)
- chemical reactions (Senior 3 Chemistry)

- Review/discuss kidney function and urine formation. Include a look at conditions and diseases that might be tested for with a urine test.

Suggested Student Activity

- Activity 11: Urine Analysis

Activity 11

Teacher Notes

Urine Analysis

Specific Learning Outcomes

-
- SLO B3:** Identify the factors that affect health and explain the relationships of personal habits, lifestyle choices, and human health, both individual and social.
-
- SLO C4:** Employ effective communication skills and use a variety of resources to gather and share scientific and technological ideas and data.
-
- SLO D2:** Recognize that the universe comprises systems and that complex interactions occur within and among these systems at many scales and intervals of time.
-

Overview

Students will perform different tests on *synthetic urine*. Each test will provide possible clues for the investigator. Many of the results will provide clues rather than a direct result. Students will have to evaluate the relevance of the data in the context of the situation.

Setting the Crime Scene

You might choose to leave a urine sample (of suspect/victim) at the crime scene and/or have the investigative teams gather urine samples from the various suspects. The sample might give clues to the investigation, might match to a suspect, or might be a red herring.

Materials

- stock and sample urine solutions (preparation instructions follow)
- hydrometers
- pH testing paper
- centrifuge
- microscope (including slides and cover slips)
- test tubes
- beakers
- hot plate
- Benedict's solution
- water
- clock or watch

Preparation of Urine Samples

For Tests 1 to 6 of this Urine Analysis activity, make the following solutions.

Basic Stock Solution	Basic Stock Solution with Additives	Basic Stock Solution with Additives and Impurities: Sample Solutions for Crime Scene
To 1 L of distilled water, add: <ul style="list-style-type: none"> • 3 g sodium chloride (NaCl) • 3 g ammonium oxalate • 3 g potassium phosphate 	To the 1 L Basic Stock Solution, add: <ul style="list-style-type: none"> • 2 drops of 1M HCl • 1 acetylsalicylic acid (ASA) tablet • 1 g glucose • 1 g albumin powder • 5 g urea • blood cells (obtain fresh meat from butcher or meat department) 	To a 1 L Basic Stock Solution with Additives, add: <p>Sample 1:</p> <ul style="list-style-type: none"> • 24 ml 0.1M NH₃(aq) • 1 g glucose <p>Sample 2:</p> <ul style="list-style-type: none"> • 5 g urea • 1 g albumin powder <p>Sample 3:</p> <ul style="list-style-type: none"> • 1 g glucose • 1 g albumin powder • blood cells (from fresh meat) <p>Sample 4:</p> <ul style="list-style-type: none"> • 1 ASA tablet • 2 drops of 3M HCl
<p>Note:</p> <ul style="list-style-type: none"> • Solutions will keep for about a week in the fridge. • Adjust pH as required. • Fresh blood cells should be added to appropriate sample(s) each time the sample is used as they tend to lyse in solution. • Blood obtained from butcher or meat department usually contains few whole blood cells. Centrifuge blood and pour off liquid. Re-suspend cells in a small portion of “urine” and add to sample. 		

Sample Preparation Key

Sample	pH	Protein (Albumin)	Glucose	Sediment			Specific Gravity
				Amorphous Phosphate	Crystals	Blood Cells	
1	8	–	+	+	Oxalate	–	Varies
2	6	+	–	+	Oxalate	–	Varies
3	6	+	+	+	Oxalate	+	Varies
4	2/3	–	+	+	Oxalate, Acetylsalicylic Acid	–	Varies

Procedure

Part 1: Analyzing Known Urine Samples

Test 1: Making Initial Examination of Urine

Students make a visual examination of the odour and colour of the *synthetic urine* sample. Even though the urine is synthetic, it may take some time for students to settle down with the idea of working with urine. It is important for them to consider the samples real and to perform the procedures accordingly. This means that they should keep their equipment clean and be aware of potential health concerns if they spill their samples.

Test 2: Determining Specific Gravity of Urine

Some time may be needed to show the class the proper use of a hydrometer to determine specific gravity. Students should understand that having a change in the specific gravity of urine could indicate a medical problem.

Test 3: Testing for pH of Urine

Students use pH testing paper to determine the pH of urine.

Test 4: Analyzing Sediment

Analysis of sediment can provide clues such as an abnormal condition of blood in the urine or the presence of crystals that may indicate drug use. Students could be provided with diagrams to assist in identification, or this step can be omitted.

Test 5: Testing for Presence of Albumin (a Protein)

Students heat part of the liquid (supernatant) fraction of the urine. If protein is present, it will denature and make the solution cloudy.

Test 6: Testing for Presence of Glucose

Testing for sugar may give an indication of diseases, such as diabetes. Students will need to use care when working with Benedict's solution and a hot plate.

Part 2: Analyzing Unknown Urine Sample (Practice)

Given a choice of samples to choose from, students are to determine the composition of the urine by performing the tests. Each sample has a different set of conditions. You may choose to make up your own samples or follow the sample preparation key provided.

Part 3: Analyzing Evidence from the Crime Scene

Students use the procedures they have practised to analyze the unknown sample(s) from the crime scene/suspects.

Urine Analysis

Background

Urine analysis is a crucial and interesting exploration. With the necessary cautions in place regarding the use of natural body fluids, it is essential that you handle only *synthetic urine* that has been produced artificially. From a forensic investigation point of view, urine analysis can reveal characteristics of an individual's body chemistry *at a moment in time*, making such an analysis useful for time and date related to crime scene investigations.

Among the characteristics that can be examined for a urine sample, the following are important for the purposes of this urine analysis activity:

- **Visual examination:** Colour, transparency, turbidity, and odour(s) are considered important attributes in this initial examination.
- **Specific gravity:** Synonymous with *density*, specific gravity (as measured by a hydrometer) provides a comparison with pure water ($s.g._{water} = 1.00$), and also gives evidence of the amount of dissolved solids in the urine sample, the degree to which the sample is dilute, or the presence of health problems. A high specific gravity is indicative of greater dissolved solids and can indicate dehydration.
- **pH:** Urine pH can vary from about 4.5 (quite acidic) to 8.0 (slightly alkaline), and is an indicator of diet, drug use, and other factors. It also has the advantage of being a time-specific data source that can have value in a forensic investigation.
- **Sediment analysis:** Analysis of sediment can provide clues such as an abnormal condition of blood in urine or the presence of crystals that may indicate drug use.
- **Protein presence (e.g., albumin):** Normally, protein should not be present in urine, and is an indicator of problems if it is present. For instance, fever, strenuous exercise, and some diseases (especially kidney disease) may cause protein to appear in urine. The presence of protein in urine may also be an indication of normal pregnancy.
- **Glucose presence:** Testing for sugar (as glucose) may give an indication of diseases such as diabetes or kidney dysfunction. Under normal conditions, sugar(s) should not be present in urine.

Objectives

- Conduct various tests on a known urine sample to identify characteristics of urine.
- Identify the characteristics of an unknown urine sample.
- Examine the unknown sample obtained as evidence from the crime scene.

Materials

- stock and sample urine solutions (provided by teacher)
- hydrometers
- pH testing paper
- centrifuge
- microscope (including slides and cover slips)
- test tubes
- beakers
- hot plate
- Benedict's solution
- water
- clock or watch

Procedure

In your *Forensic Investigation Lab Book*, design a table for recording your results. The table should have space to record your data and drawings for various tests on two known samples, one unknown practice sample, and the evidence from the crime scene.

Part 1: Analyzing Known Urine Samples

Test 1: Making Initial Examination of Urine

1. Examine each urine sample for odour. Describe the odour you smell.
2. Comment on the colour of each sample. Use terminology such as yellow, amber, dark, pale, and so on.
3. Describe the clarity of each sample. Use terminology such as clear, cloudy, and so on.

Test 2: Determining Specific Gravity of Urine


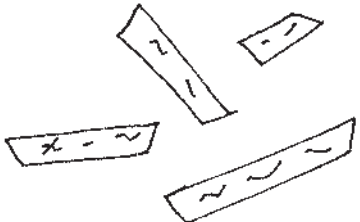
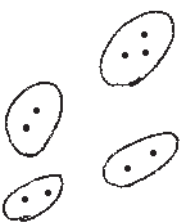

1. Remove the hydrometer from its cylinder and empty the water from the cylinder into the sink. Fill the hydrometer cylinder three quarters full with the urine sample.
2. With a spinning motion, float the hydrometer in the urine. Make sure that the hydrometer stays suspended in the urine and does not adhere to the sides of the cylinder.
3. When the hydrometer has stopped spinning and is not touching the sides of the cylinder, read the specific gravity of each sample at the bottom of the meniscus formed at the hydrometer column. Record the specific gravity.
4. Pour the urine sample in the hydrometer cylinder into a test tube for Tests 3 and 4 of the activity. Pour any remaining urine back into the sample container.
5. Rinse and repeat with each sample.
6. Rinse and fill the hydrometer cylinder with water and place the hydrometer in the water.

Test 3: Testing for pH of Urine

1. Use pH testing paper to test the sample.
2. Compare with the coloured pH scale provided.
3. Record the pH in the table.
4. Repeat with each sample.

Test 4: Analyzing Sediment

1. In this test, you will be looking for blood cells, crystals, and phosphate granules in the urine sample. The presence of blood cells in the urine may be indicative of an abnormal condition, and the crystals may indicate the presence of drugs.
2. Fill one small test tube with the urine sample.
3. Set the tube in the centrifuge opposite someone else's sample and spin it for five minutes. (Please check with the teacher to make sure that your setup is correct before you turn on the centrifuge).
4. After centrifuging, pour off the liquid or supernatant and place it into a clean test tube. Place the test tube to the side to be used in Test 5.
5. Shake the test tube to re-suspend the sediment in the small amount of urine left in the test tube. Pour this onto a slide and prepare a wet mount to observe under the microscope.
6. Describe the sediment you observe under the microscope. (Remember to note any blood cells, phosphate granules, or crystals you observe.)
7. Repeat with each sample.

What You May See in the Urine Sample	
	
Amorphous phosphates (normal)	Oxalate crystals (normal)
	
Red blood cells (may indicate disease)	Acetylsalicylic acid crystals (Aspirin present)

Test 5: Testing for Presence of Albumin (a Protein)

1. Observe and record the clarity of the supernatant.
2. Separate the supernatant into two parts. Place one part to the side for use in Test 6.
3. Place the second part of the supernatant in a test tube. Then place the test tube in a hot water bath.
4. Compare the cloudiness of the heated supernatant with the unheated portion of the supernatant. If cloudiness increases in the heated sample, then protein is present.
5. Repeat with each sample.

Test 6: Testing for Presence of Glucose

1. Add 10 drops of Benedict's solution to the unheated portion of the supernatant from Test 5.
2. Fill a second test tube one quarter full of water and add 10 drops of Benedict's solution (this is the control).
3. Boil both test tubes for 4 to 5 minutes and then allow test tubes to cool.
4. An orange precipitate will form when glucose is present.
5. Repeat with each sample.

Caution: Use care when working with Benedict's solution and a hot plate.

Part 2: Analyzing Unknown Urine Sample (Practice)

As practice, you will be required to complete an analysis of an unknown urine sample using the procedures you learned in Part 1.

1. Obtain 50 ml of one of the unknown urine samples.
2. Perform the urine analysis procedure on your unknown sample and compare the results to the known samples.
3. Check your results with the teacher's key.

Part 3: Analyzing Evidence from the Crime Scene

Repeat the procedures in Part 1 to analyze the evidence obtained at the crime scene.

Analysis

1. Do research to determine the normal ranges of the tests you have completed for human urine.
2. Pick one specific test and research the possible diseases or medical illnesses that can occur if a person exceeds the normal range.

ESSENTIAL UNDERSTANDING 12: ENRICHMENT AND EXTENSIONS—FURTHER ANALYSES

The types of evidence forensic investigators may analyze are seemingly endless. Along with many of the analyses outlined in the previous essential understandings, a forensic investigator may examine the following:

- **Teeth/Bite Marks**

Teeth are the hardest substance in the body and tend to last the longest. They exhibit individual characteristics that allow dental impressions to be as reliable for identification as fingerprints. Teachers may choose to leave evidence, such as dental impressions on a foam cup, at the crime scene, and have students research investigative methods involved in the analysis of such evidence.

- **Radiation Half-Life**

Half-life (for radioactive materials) represents the time required for a sample of radioactive material to “decay” to other isotopes such that half the original sample mass is still radioactive. For instance, if you were to say that a 10 gram uranium sample had a half-life of 500,000 years, after 500,000 years there would be 5 grams of radioactive uranium and the other 5 grams would be “stable” isotopes such as lead (Pb).

- **Lip Prints**

A person’s lip prints are unique, although the credibility of this type of evidence has not been firmly established. The basic types of lip prints used by forensic scientists are: branching grooves, short vertical grooves, long vertical grooves, diamond grooves and rectangular grooves. An activity similar to that of fingerprinting may be used in this unit. Chromatography might also be used on lipstick.

- **Ear Prints**

As with lip prints, ear prints have characteristic patterns.

- **Footprints, Handprints, Knee Prints**

Students can determine whether footprints, handprints, or knee prints are unique to each individual, and have value at a crime scene.

- **Weight**

Students might determine weight from the depth of a print, similar to the determination of height.

- **“Trash Archeology”**

Students analyze “garbage” to determine what information might be gained.

- **Glass Fragments**

The type of glass and direction of impact can be determined by analysis of glass fragments (density, refractive index, fracture marks).

- **Dust/Dirt**
An analysis of dust might link a suspect to a crime scene.
- **Pollen**
Traces of pollen might link a suspect to a crime scene.
- **Paint**
Paint can be examined and matched (using colour and gas chromatography).
- **Bullets and Cartridges**
Bullets and cartridges have characteristic markings, which link them to a gun.
- **Voice Prints**
A tape recording of a disguised voice might be compared against the voices of the suspects.

FINAL FORENSIC SCIENCES PERFORMANCE TASK: SAMPLE CRIME SCENE

The summative assessment example that follows was adapted from the classroom experiences of a Manitoba teacher implementing Forensic Sciences: A Crime Scene Investigation Unit. The scenario could be introduced at the outset as a unit organizer, or it could be used as a culminating set of student activities once the various forensic sciences principles and analyses have been developed as prior learning. The Final Forensic Sciences Performance Task Evaluation Rubric at the end of this activity provides one example of a selection of parameters that could be assessed.

Materials

Supply each investigative team with the following materials:

- latex gloves
- plastic zippered bags
- vials
- tweezers
- Evidence Sheets

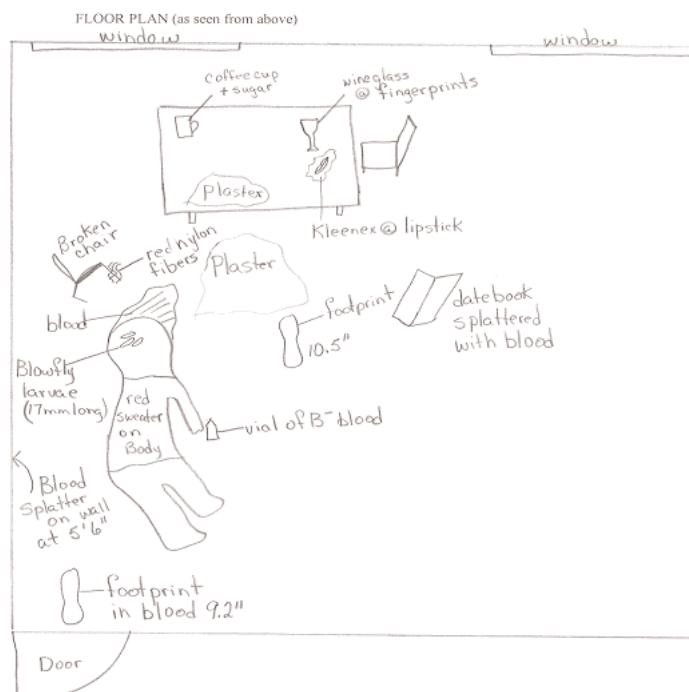
Also supply each team member with an identification tag that is to be worn around the neck on a string (business cards make good inserts).

Setting the Crime Scene

Students are expected to draw a detailed sketch of the crime scene, with key measurements, and take photographs with a digital camera. They then carry out appropriate forensic tests for the pieces of evidence that they gathered. Each team then reconstructs the crime scene and accounts for events in light of the evidence they gathered.

In the following sample, the teacher used an open classroom to set up the crime scene that took place in a cabin. It was taped off with crime-scene tape obtained from a local law-enforcement office.

Crime Scene Set Up



Forensic Sciences Performance Task: Sample Crime Scene: Adapted by permission of Brenda Sokoloski, Rivers Collegiate, Rolling River S.D.

Planting Evidence at the Crime Scene

1. Date Book

- Splatter the date book with a simulated blood sample.
- Make the following entries in the date book:
 - June 24 – Marty 9 a.m.
 - June 26 – Hammer 9 a.m.
 - Summer 10 a.m.
 - June 27 – Dentist 10 a.m.
 - July 1 – Boo! Holiday Over

2. Clothing Samples

- Give samples of the following clothing to the investigative teams.
 - Suspects' clothing:
 - Laura Cream-Fillet's skirt
 - Michael Curtis Hammer's windbreaker
 - George Fillet's cotton sweatshirt
 - Victim's clothing:
 - red sweater

3. Lipstick Samples

- Use three different red pens to simulate lipstick samples on the chromatography paper.
- Label each sample (and indicate to students that these were from lipstick that each had on her person):
 - Marty Stewart
 - Laura Cream-Fillet
 - Diana Summer
- Give samples of the lipstick found on the tissue to each investigative team for comparison purposes.
- Place the pen used by Diana Summer on the tissue bearing the outline of a lip print.
- Place this evidence on the table.

4. Footprints

- Make two shoe prints:
 - One print is from the suspect (stepping into the plaster), as found on the table. (Don't use too much of the mixture, as it can be messy.)
 - The other print is found within the bloodstain.
- Footprint lengths:
 - plaster print is 10.5 in. (26.7 cm) long
 - bloodstain print is 9.2 in. (23.4 cm) long

5. **Fingerprints**

- Supply a set of fingerprints from all suspects *and* from the victim.
- Put a set of fingerprints from Diana Summer on the wine glass.

Note: Students may have difficulty lifting the print from the wine glass. Perfect this technique prior to this crime scene analysis for best results.

6. **Blood under Victim's Fingernails**

- Leave a vial of simulated blood (B⁻) at the scene near the outline of the victim's hand.

7. **Blowfly Larvae**

- Using modelling clay, make blowfly larvae (17 mm long). Place them near the victim's eyeballs. This will indicate that the body has been dead for about five days. It would take the blowflies about a day to find their way into the cabin and start the decomposition through their feeding.

8. **Broken Chair**

- Stick red nylon fibres in the blood on the leg of a broken chair. (Use an available disposable chair.)

9. **Blood Splatters**

- Spatter blood on the wall in a pattern that spreads out from a height of about 5' 6" (1.7 m).
- Pool blood around the area where the victim's head was situated.

10. **Plaster of Paris**

- On the table, leave a small quantity of plaster and spill some on the floor where a footprint is found.

11. **Coffee Cup**

- Place a coffee cup on the table. Inside the coffee cup, place a large quantity of sugar that has been in the coffee and left there. (It didn't dissolve.)

Conclusion:

The crime scene setup with the above evidence should direct suspicion towards Diana Summer (lipstick match, wineglass fingerprint, and footprint) and to Michael Hammer (footprint in plaster, plaster from a construction site, and sugar in the coffee cup). The red fibres belong to Michael Hammer's windbreaker. Both these suspects were scheduled to meet with John Bergman on June 26. The blood (B⁻) under the victim's fingernails matches the blood type of both suspects.

The reconstruction of the crime may be open to interpretation, but students may come up with the idea that both Michael Hammer and Diana Summer met with John Bergman. The two suspects had drinks (wine and coffee). A fight broke out, and Bergman scratched and drew blood from Hammer. During the struggle, Summer hit Bergman with the chair, which knocked Bergman against the wall and splattered his blood on the wall. Bergman then fell to the floor and bled profusely. Fibres from Hammer's windbreaker stuck to the chair leg. The blowflies on Bergman's body indicate he has been dead about four to five days. He never made his dental appointment on June 27, as he died on June 26.

Evidence Sheet

Date: _____ Time: _____ Exhibit #: _____

Description of the Evidence: _____

Location of the Evidence: _____

Name and Description of the Test Performed: _____

Conclusions: _____

Investigator's Signature: _____

Crime Scene Sketch

Victim and Suspect Background/Biographies

Victim		
Name:	John Bergman	The victim's body was found on July 2, 2003, at 10 a.m. in his summer cabin at 1210 Lakeview Drive in Dullville, Ontario. Mr. Bergman often held meetings at his cabin for his clients and business associates. Mr. Bergman was very unpopular in the local town. He was the majority owner of the lakeshore property, and wanted to tear down most of the businesses there to make way for the construction of a massive new casino.
Occupation:	Construction contractor	
Age:	58 years	
Height:	6' 0" (1.83 m)	
Weight:	195 lbs. (88.5 kg)	
Blood Type:	O ⁻	
Health:	Diabetic, but under control through diet and exercise	
Description of the Body:		

Suspects		
Name:	Michael Curtis Hammer	Michael Hammer is a local carpenter who has had many heated discussions with the victim regarding the proposed casino. If the casino was built, he would lose a great deal of business, and probably would have to declare bankruptcy. He now owes the bank over \$100 000. Mr. Hammer is the brother of Mrs. Diana Summer. His usual work uniform consists of blue jeans, a pair of work boots, a light T-shirt, and a red rayon windbreaker.
Occupation:	Carpenter and owner of M.C. Hammer Construction	
Age:	42 years	
Marital Status:	Not married	
Height:	5' 10" (1.78 m)	
Weight:	215 lbs. (97.5 kg)	
Blood Type:	B ⁻	
Health:	Overweight from too many doughnuts, and lots of coffee with sugar and 30% cream	
Name:	George Fillet	George is the local dentist who could see that he would need to relocate his business somewhere else if the casino was built. Also, his marriage is in jeopardy, as his wife is unwilling to leave her town and feels very strongly that George is too soft to do anything about the casino. George usually wears his red cotton University of Guelph sweatshirt whenever he is not working. George claims that he could not have killed John Bergman because he worked all week. As a matter of interest, John missed his appointment on June 27 at 10 a.m.
Occupation:	Dentist and local hotel owner	
Age:	38 years	
Marital Status:	Married with two children, ages 12 and 14	
Height:	5' 11" (1.80 m)	
Weight:	168 lbs. (76.2 kg)	
Blood Type:	AB ⁺	
Health:	Good	
Name:	Diana Summer	Diana is the manager for the bank in town. John Bergman has been intimidating Ms. Summer for the past 12 months, trying to get her to approve loans in excess of \$1 million for the building of the casino. Ms. Summer was to meet with Mr. Bergman on June 26 at his cabin, but she claims she never kept the appointment. The day in question she wore a grey wool dress and used her favourite lipstick when she went to work.
Occupation:	Manager for Ontario Trust and Mortgages Co-Op	
Age:	39 years	
Marital Status:	Divorced	
Height:	5' 3" (1.60 m)	
Weight:	120 lbs. (54.4 kg)	
Blood Type:	B ⁻	
Health:	Very good—she runs every day past John Bergman's cabin	

(continued)

Forensic Sciences: A Crime Scene Investigation Unit

Suspects <i>(continued)</i>	
<p>Name: Laura Cream-Fillet Occupation: Works at the bakery and coffee shop on Wednesday and Thursdays Age: 35 years Marital Status: Married to George Fillet Height: 5' 7" (1.70 m) Weight: 122 lbs. (55.3 kg) Blood Type: B⁺ Health: Good</p>	<p>Laura works at the local bakery every Wednesday and Thursday, and makes deliveries to the local businesses in the mornings. She can remember Mr. Bergman ordering doughnuts one of those days, either June 25 or 26. She can't quite remember. She delivered them to him at the cabin about 9 a.m. She was wearing her white smock and red polyester skirt, and was using her favourite lipstick. Laura can become very aggressive when angry. She has very strong feelings that the casino should not be built in her town.</p>
<p>Name: Marty Stewart Occupation: Interior designer with her own company Age: 51 years Marital Status: Divorced Height: 5' 1" (1.55 m) Weight: 150 lbs. (68.0 kg) Blood Type: A⁺ Health: Borderline diabetic and arthritic in the hands</p>	<p>Mrs. Stewart had a meeting on June 24 with Mr. Bergman to discuss the interior decorating of the casino. Marty was late for the meeting, and a heated argument took place. The argument was loud enough that the neighbour, Mrs. Nosey, could hear. Mrs. Nosey said she remembers seeing Marty in her pink wool dress and wearing what looked like a pink lipstick. She wasn't quite sure about the lipstick colour though. Marty left very shortly after her arrival. She was obviously upset, as she spun her tires wildly when leaving the driveway.</p>
Neighbour	
<p>Mrs. Nosey</p>	<p>Mrs. Nosey is a very lonely individual who keeps track of her neighbours. She remembers Marty coming to the cabin on June 24. She says she also saw the doughnut truck that week. Later that week (can't remember which day) she remembers seeing someone enter the cabin about 9 a.m., and another enter the cabin at 10 a.m. Shortly after 10:30 a.m. there was a lot of yelling and furniture breaking inside the cabin. Right after that, the two people left the cabin and travelled in a blue car. One person was taller than the other, and Mrs. Nosey thinks one had a red coat or shirt on.</p>

**Final Forensic Sciences Performance Task:
Evaluation Rubric**

Total

Group Members: _____

Type of Project: _____

Forensic Investigation

Criteria	Rating				Total
	0	5	10	15	
Crime Scene Scenario					
• Creativity and originality					
• Development of evidence/clues					
• Development and documentation of suspect/victim background/biographies (e.g., fingerprints, footprints, hair samples, lip prints, bite marks)					
• Coherence of story/plot and alignment with evidence					
Paperwork					
• Materials list (crime scene supplies)					
• Detailed description (crime scene)					
• Diagram of crime scene (to scale)					
• Police reports on the crime scene (Evidence Sheet)					
• Quality of evidence descriptions					
• Photographs of crime scene					
• Forensic logbook					

Comments:

Student Self-Reflection on the Forensic Sciences Unit

Throughout our examination of the techniques, processes, and information-gathering activities of this Forensic Sciences unit, there has been an important emphasis on developing “essential understandings” about forensics and the manner in which science operates in the criminal justice system. Now that we have completed this unit of study, we will take time to look back and see what we have learned, identify lingering questions that were not answered for us, and then ask some new questions that have arisen in our minds.

In your *Forensic Investigation Lab Book* (or *Journal*), complete a one- to two-page self-reflection that addresses some of the thoughts and questions raised in the Forensic Sciences unit. Write freely and thoughtfully. You will then have an opportunity to discuss with your class what you are willing to share.

Here are some suggestions (framed as questions) to help you get started.

- What surprised you along the way as you developed understandings about the various forensic techniques used in the unit?
- Do you still have unanswered questions or are you wondering about some aspect of forensic sciences?
- What important things did you discover and learn about what it means to *be* a forensic scientist trying to solve a crime?
- Among the various forensic techniques that you worked through, which one(s) interested you most? Could you explain why?
- Were some forensic techniques challenging to master? If so, which one(s)? Explain why.
- Were you surprised at the amount of science that came out of your study of forensics? Did you have to apply a lot of this new knowledge right away in order to analyze evidence? Explain.
- How will your study of forensics change the way you view “prime time” forensic investigation shows or reports in the media about the work of forensic scientists?

RESOURCES

Print Resources

- Bevel, Virgil Thomas, and Ross M. Gardner. *Bloodstain Pattern Analysis: With an Introduction to Crime Scene Reconstruction*. CRC Series in Practical Aspects of Criminal and Forensic Investigation. Boca Raton, FL: CRC Press, 1997.
- Bowers, Vivien. *Crime Science: How Investigators Use Science to Track Down the Bad Guys*. Toronto, ON: Owl Books/Maple Tree Press, 1997.
- Coleman, Howard, and Eric Swenson. *DNA in the Courtroom: A Trial Watcher's Guide*. Seattle, WA: GeneLex Press, 1994.
- Guiberson, Brenda Z. *Mummy Mysteries: Tales from North America*. New York, NY: Henry Holt, 1998.
- Jackson, Donna M. *The Bone Detectives: How Forensic Anthropologists Solve Crimes and Uncover Mysteries of the Dead*. Boston, MA: Little, Brown, 1996.
- Lane, Brian. *Crime and Detection*. New York, NY: DK Publishing, 2000.
- Manitoba Education and Training. *Senior Years Science Teachers' Handbook: A Teaching Resource*. Winnipeg, MB: Manitoba Education and Training, 1997.
- McCrone, Walter C. "Artful Dodgers." *The Sciences* (Jan./Feb. 2001): 32-37.
Chemical techniques involved in authenticating works of art.
- Mellett, Peter. *Solving a Crime (Expert Guide)*. Des Plaines, IL: Heinemann Library, 1999.
An illustrated story that follows the investigation of the theft of a museum artefact.
- Otfinoski, Steven. *Whodunit? Science Involves Crime*. New York, NY: W.H. Freeman, 1995.
Case studies and the forensic science that solved them.
- Ramslund, Katherine. *The Forensic Science of C.S.I.* New York, NY: Berkley Publishing Group, 2001.
- Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 6th ed. Englewood Cliffs, NJ: Prentice Hall, 1998. 379-383.
- Thomas, Peggy. *Talking Bones: The Science of Forensic Anthropology*. New York, NY: Facts on File, 1995.
- Tocci, Salvatore, and Franklin Watts. *High-Tech IDs: From Finger Scans to Voice Patterns*. New York, NY: Franklin Watts, 2000.
The latest in forensic and other identifying technologies.
- Walker, Pam, and Elaine Wood. *Crime Scene Investigation: Real Life Science Labs for Grades 6-12*. San Francisco, CA: Jossey-Bass, 2002.
- Wilcox, Charlotte. *Mummies, Bones and Body Parts*. Minneapolis, MN: Carolrhoda Books, 2000.

Collecting Crime Evidence from Earth

Andrews, Sarah. "Fiction Meets Fact: A Visit to the FBI Lab." *Geotimes* 50.1 (2005): 20-21.

---. *Earth Colors*. New York, NY: St. Martin's Minotaur Press, 2005.

This is Andrews's ninth fiction novel in the mystery series featuring Emma Hansen, a forensic geologist. In this story, Hansen tackles pigment analysis and other techniques to determine whether a famous painting has been fraudulently reproduced. Meanwhile, someone is quietly poisoning her client's family members. This is one of many "page turners" that Andrews has written, including titles such as *Killer Dust* and *The Bone Hunter*, and all contain good, solid science.

Murray, Ramond C. "Collecting Crime Evidence from Earth." *Geotimes* 50.1 (2005): 18-22.

---. *Evidence from the Earth*. Missoula, MT: Mountain Press Publishing Co., 2004.

Looking for more background in the field of forensic geology? Murray's latest book follows up his earlier groundbreaking treatise *Forensic Geology* (1975). He connects some notorious and interesting cases where geology has provided key evidence from earth materials. The chapters detail collection methods, instrumentation used, examination methods, and the unique manner in which geological thinking helps to solve mysteries.

Sever, Megan. "Murder and Mud in the Shenandoah." *Geotimes* 50.1 (2005): 24-29.

---. "Forensic Geology on the Small Screen." *Geotimes* 50.1 (2005): 46-47.

Scientific Fraud

Abbott, David M. "Investigating Mining Frauds." *Geotimes* 50.1 (2005): 30-32.

In this article, Abbott—who was a geologist for 21 years working for the Securities and Exchange Commission in the U.S.—details examples of where geological knowledge was the binding tie in the line of evidence to uncover scientific fraud. He calls this "lying about the science for profit," and produces some little-known stories of how ore samples have been "spun" to yield analytical values that would be right out of Rumpelstiltskin.

Online Resources

A Comprehensive Forensic Sciences Site for Teachers and Students

Brandon School Division. Crocus Plains Regional Secondary School. Current Topics (30S).

Forensic Science: <<http://www.brandonsd.mb.ca/crocus/stafflinks/M/McKellar/currenttopics30S/forensics.htm>>

This comprehensive website has been created and is maintained by Coleen McKellar, a Senior Years science teacher at Crocus Plains Regional Secondary School in Brandon MB. The site is organized around a wide variety of themes and topics of interest related to a study of Forensic Sciences in the Senior 3 Current Topics in the Sciences classroom. It is particularly valuable for students who are engaged in inquiry or project-related research, and saves the teacher a great deal of time in accessing reputable material for student use. Many of the activities in the Forensic Sciences sample unit are represented in the links that have been archived at this site.

Bloodstain Evidence

International Association of Bloodstain Pattern Analysts (IABPA):

<<http://www.iabpa.org/index.html>>

“Violent crimes can result in bloodshed. When liquid blood is acted upon by physical forces, bloodstains and bloodstain patterns may be deposited on various surfaces, including the clothing of the individuals present at the crime scene. When examined by a qualified analyst, these bloodstain patterns can yield valuable information concerning the events that led to their creation. The information gained can then be used for the reconstruction of the incident and the evaluation of the statements of the witnesses and the crime participants.” (Home page)

Crime Scene Investigation

Crime Scene Investigation: <<http://www.crime-scene-investigator.net/index.html>>

This website offers information on evidence collection, crime scene and evidence photography, and articles on forensic investigations, along with listings of other resources and links.

Criminal Identification

Brazoria County Sheriff’s Department. Identification Department:

<<http://www.brazoria-county.com/sheriff/id/>>

Information on blood spatters, fingerprints, forensic entomology, crime scene photography, crime scene searches, firearms, and skeleton identification.

Crime Scene Scenario: Who Done It?

The Woodrow Wilson National Fellowship Foundation. Woodrow Wilson Biology Institute.

Who Done It? <<http://www.woodrow.org/teachers/bi/1993/who.html>>

Crime scene scenario by Liz Fulton, Carol Alderman, and Carol Sanders.

CyberBee. Who Durnit? <<http://www.cyberbee.com/whodurnit/crime.html>>

Analyze a crime scene online and solve the crime.

DNA Detectives

Access Excellence @ the National Health Museum. 1995 Access Excellence Fellows’ Collection. *DNA Detectives*.

<http://www.accessexcellence.org/AE/AEC/AEF/1995/black_dna.html>

Lab activity by Suzanne Black. “Many of the revolutionary changes that have occurred in biology over the past fifteen years can be attributed directly to the ability to manipulate DNA in defined ways. The principal tools for this recombinant DNA technology are enzymes that can “cut” and “paste” DNA. Restriction enzymes are the “chemical scissors” of the molecular biologist; these enzymes cut DNA at specific nucleotide sequences. A sample of someone’s DNA, incubated with restriction enzymes, is reduced to millions of DNA fragments of varying sizes. A DNA sample from a different person would have a different nucleotide sequence and would thus be enzymatically “chopped up” into a very different collection of fragments. We have been asked to apply DNA fingerprinting to determine which suspect should be charged with a crime perpetrated in our city.” (Introduction)

DNA Electrophoresis Technique

Southwest Biotechnology and Information Centre (SWBIC). Educational Resources. DNA Fingerprinting: Analysis of Crime Scene DNA:

<<http://www.swbic.org/education/crime.php>>

---. Crime Lab Simulation: DNA Analysis with Agarose Gel Electrophoresis:

<<http://www.swbic.org/education/crime.doc>>

A crime lab simulation that involves running a DNA analysis with agarose gel electrophoresis. Discover how the remarkable DNA electrophoresis technique has revolutionized our ability to analyze field evidence in the crime lab.

DNA Fingerprinting

Public Broadcasting Service (PBS). WGBH Educational Foundation. Nova Online. Killer's Trail. Create a DNA Fingerprint.

<<http://www.pbs.org/wgbh/nova/sheppard/analyze.html>>

University of Washington. Basics of DNA Fingerprinting:

<<http://protist.biology.washington.edu/fingerprint/dnaintro.html>>

Class project by Kate Briton and Kim-An Lieberman. "This page was created as a class project at the University of Washington to provide to the Internet basic information on the structure and function of DNA as it relates to DNA fingerprinting. This topic is especially pertinent in today's society because of the rising use of DNA fingerprinting as evidence in court cases."

Utah State University. Biomath Lab. DNA Fingerprinting Probabilities:

<<http://biomath.biology.usu.edu/Fipse/Labs/Dna/DownloadPage/DNAFINGE.pdf>>
Statistical analysis of the accuracy of DNA fingerprinting.

DNA Workshop

Public Broadcasting Service (PBS). WGBH Educational Foundation. A Science Odyssey. DNA Workshop: You Try It: <<http://www.pbs.org/wgbh/aso/tryit/dna/>>

This activity places you within the cell, involving you with the processes of DNA replication and protein synthesis.

Facial Reconstructions

Forensic Art. Historical Exhumation Project. Facial Reconstruction:

<<http://www.forensicartist.com/hep/index.htm>>

Fingerprints

Michigan State University. Biometrics Research. Fingerprint Identification:

<<http://biometrics.cse.msu.edu/fingerprint.html>>

Onin Portal. Latent Print Examination. The History of Fingerprints:

<<http://onin.com/fp/fphistory.html>>

Forensic Archaeology (Pompeii and Mount Vesuvius)

Educational Travel Alliance (eTrav) Inc. eTrav Pathways. Pompeii and Mount Vesuvius:

<<http://www.etrav.com/pathways/html/pompeii.asp>>

Daily life in Pompeii and Herculaneum.

Health Portal. Herculaneum Meltdown:

<http://ipagehealth.subportal.com/health/Safety_and_Public_Health/110012.html>

This article by Neil Sherman addresses the causes of death from the eruption of Vesuvius.

Forensic Entomology

Forensic Entomology. Insects in Legal Investigations:

<<http://www.forensic-entomology.com/index.html>>

Forensic Entomology Pages, International:

<http://folk.uio.no/mostarke/forens_ent/forensic_entomology.html>

Royal Canadian Mounted Police. *Forensic Entomology: The Use of Insects in Death*

Investigations: <<http://www.rcmp-learning.org/docs/ecdd0030.htm>>

Forensic entomology “is the study of the insects associated with a human corpse in an effort to determine elapsed time since death. Insect evidence may also show that the body has been moved to a second site after death, or that the body has been disturbed at some time, either by animals, or by the killer returning to the scene of the crime.” (Introduction)

Forensic Geology

American Geological Institute (AGI). *Geotimes: Earth, Energy and Environment News*:

<<http://www.geotimes.org>>

The collection of crime scene evidence related to the geosciences is an underappreciated source of cross-curricular linkages for science educators. Here is a comprehensive source of resources to capture interest in the role of earth as evidence.

Sarah Andrews. Forensic Geology: <<http://www.sarahandrews.net>>

Sarah Andrews is a geologist who has written nine novels as well as short stories that follow fictional forensic geologist Emma Hansen. Provides solid science and excellent role-modelling for young women aspiring to the fields of the geosciences.

Forensic Science

The Canadian Society of Forensic Science (CSFS): <<http://www.csfs.ca/>>

“The Canadian Society of Forensic Science (CSFS) is a non-profit professional organization incorporated to maintain professional standards, and to promote the study and enhance the stature of forensic science. Membership in the society is open internationally to professionals with an active interest in the forensic sciences. It is organized into sections representing diverse areas of forensic examination: Anthropology, Medical, Odontology, Biology, Chemistry, Documents, Engineering and Toxicology.” (Home page)

Forensic DNA Consulting. Forensic Science Timeline: <<http://www.forensicdna.com/>>

Click on to Forensic Scene Timeline. You will need to set up a free online account by providing your name and a valid email address.

Forensic Science Web Pages: <<http://home.earthlink.net/~thekeither/Forensic/forsone.htm>>

These web pages were created to provide the layperson with an easy understanding of what forensic science entails, with brief explanations of some of the main disciplines within Forensic Science.

Forensic Services

U.S. Department of Justice. Federal Bureau of Investigation (FBI). *Handbook of Forensic Services*: <<http://www.fbi.gov/hq/lab/handbook/intro.htm>>
<<http://www.fbi.gov/hq/lab/handbook/forensics.pdf>>
“The purpose of the *Handbook of Forensic Services* is to provide guidance and procedures for safe and efficient methods of collecting and preserving evidence and to describe the forensic examinations performed by the FBI Laboratory.” (Introduction)

Handwriting and Forensic Analysis

Courtroom Television Network LLC. Court TV’s Crime Library:
<<http://www.crimelibrary.com/forensics/literacy>>
Enter the term “handwriting” in the search engine that appears at this site.

Mummification

Mummy Tombs. Mummymaking Methods:
<<http://www.mummytombs.com/egypt/methods.htm>>
The National Center for Supercomputing Applications (NCSA). Visualization Division.
Cyber Mummy: <<http://archive.ncsa.uiuc.edu/Cyberia/VideoTestbed/Projects/Mummy/mummyhome.html>>
Public Broadcasting Service (PBS). WGBH Educational Foundation. Nova Online.
Mummies of the World: <<http://www.pbs.org/wgbh/nova/peru/mummies>>
---. Reading the Remains: <<http://www.pbs.org/wgbh/nova/icemummies/remains.html>>

Mysteries

MysteryNet: The Online Mystery Network: <<http://www.mysterynet.com>>
Online solvable mysteries.

Osteology (Bone Science)

The eSkeletons Project: <<http://www.eskeletons.org/>>
The eSkeletons Project website enables you to view the bones of a human, gorilla, and baboon, and to gather information about them from the osteology database.
Pearson Education, Inc. Bone Review:
<<http://occawlonline.pearsoned.com/bookbind/pubbooks/mariebhap/chapter7/custom4/>>
Pictures and quizzes of bones of the human skeleton.
Simon Fraser University Museum of Archaeology and Ethnology:
<<http://www.sfu.ca/archaeology/museum/alpha/search.htm>>
This site outlines the numerous ways that bones and bone fragments reveal the past.
Spoilheap. Human Bones: <<http://www.spoilheap.co.uk/hsr.htm>>

Recovery of Shredded Documents

Webcom Pty Ltd. Chris Anderson & Co Pty Ltd. The Recovery of Shredded Documents:
<<http://www.docexam.com.au/images/shred.htm>>

Trajectory Motion Calculations

The Shodor Education Foundation, Inc. Forensic Science. Stapleton’s Fall:
<<http://www.shodor.org/succeed/forensic/fall.html>>
Fall from window scenario involving trajectory motion calculations. The scenario is from Chain of Evidence by Ridley Pearson.