TEACHER'S GUIDE

This teacher's guide contains six lessons for use with students in grades 9 to 12. These lessons help students better understand the nature of the various forensic disciplines (anthropology, archaeology, botany, entomology, DNA analysis, isotope analysis, and general forensics) as they think critically about authentic situations developed with the assistance of experts. Students learn to apply the skills used by forensic specialists to observe, recover, analyze, identify and explain evidence.

For an overview of the lessons, see the "Curriculum Connections" chart. To view 'Bonus Material' that provides significantly more details of real forensic cases, go to http://www.sfu.museum/forensics/eng/pg_media-media_pg/professeur-pdfs-teachers/

LESSON 1: WHAT IS YOUR 'FORENSIC POTENTIAL'?   P.2

In this career-oriented lesson students examine their 'forensic potential'. if they were to consider a career in forensics, which of six fields (forensic botany, forensic archaeology, etc.) would most suit their skills, interests, and personality?
Grades 9 – 12

LESSON 2: THE MYSTERY SKULL   P.11

Students learn that many fields and techniques (anthropology, archaeology, botany, geoscience, biology) are used collaboratively by forensic scientists when they investigate suspicious events. Students take on the roles of various forensic specialists investigating a "mystery skull."
Grades 9 – 12

LESSON 3: INSECT INFORMANTS   P.23

Students are introduced to some methods of forensic entomology, the use of insects to investigate crimes. They will work in groups to connect details from an actual investigation to their previously summarized information.
Grades 10 – 12

LESSON 4: WAS THE BODY MOVED?   P.34

Students become familiar with tools used in forensic botany and with the role of expert witnesses in Canadian courts.
Grades 9 – 12

LESSON 5: TSUNAMI VICTIM SEARCH   P.46

Students learn that forensics apply not only to criminal cases but to mass fatalities as well. Students attempt to identify the body of a missing person based on details provided by the person's mother from the identification records of 12 potential matches.
Grades 11 – 12

LESSON 6: FIND THE FLAWS   P.56

Students learn about the investigative and reporting techniques used by forensic archaeologists.
Grades 9 – 12

LESSON 1: What is your 'forensic potential'?

Critical challenge: Identify the forensic science field that would be the most suitable career choice for you and the one that would be the least suitable for you as a potential career in forensics. Create a professional card describing your suitability for this career.

OVERVIEW

In this career-oriented lesson students examine their 'forensic potential'. In other words, if they were to consider a career in forensics, which of six fields (forensic botany, forensic archaeology, etc.) would most suit their skills, interests, and personality? Students match information on various "Forensics profession" cards and with their personal skills, interests and dispositions, to determine the, most likely least likely fit and present a reasoned argument for their selection.

LEARNING OUTCOMES

• appreciate the many different career options within forensics
• reflect on personal dispositions and skills and their suitability for careers in various forensic fields.

PRIOR KNOWLEDGE

• basic understanding of forensics
• knowledge of when various forensic scientists are called upon to investigate

Suggested activities

PREPARATION

• Prepare to display *What is 'forensics'?* (Information sheet #1) on a projector.
• Photocopy one sheet per student of the following:
  – Activity sheets #1a, *Identifying my forensic potential*
  – Activity sheets #1b, *My "forensic profession" card*
  – Activity sheet #2, *Assessing my forensic career decision*
• Photocopy one set per two students:
  – Information sheets #2a and #2b, *Forensic profession cards*

• List the names of the 6 forensic disciplines on the board. (Scramble the list if you are copying them from *What is 'forensics'?* (Information sheet #1).
• Optional: Arrange for students to view videos from the Virtual Museum of Canada website in which forensic scientists describe their profession. See the section entitled, *Introduce "Forensic profession" cards* (below), to determine the best way to incorporate the videos into your lesson.
• [Note: If you choose to show the videos in class, they should be preloaded so they will play right away. To do this, open a new tab or window and load the video before class starts.]
• www.sfu.museum/forensics/eng/pg_media-media_pg/

PRESENT THE CRITICAL CHALLENGE

Explain to students that during this lesson they will find out about the field of forensics. To do this, they will:

• learn, through the use of *Forensic Profession* cards what different skills, abilities and training forensic scientists require, and

• select which forensic discipline most/least suits them as a possible career choice.

DETERMINE MY FORENSIC POTENTIAL

Introduce the term 'forensics'

Invite the students to share what they know about forensics. If they suggest TV shows, ask them why they think people enjoy watching shows about forensics. Invite a volunteer to read *What is 'forensics'?* (Information sheet #1) from the screen or photocopy.

Explain to students that the word 'forensic' comes from the Latin term "forensis" which means "of or before the forum". In Roman times, a criminal charge meant presenting the case before a group of public individuals in the forum. Both the person accused of the crime and the accuser would give speeches based on their side of the story. The individual with the best argument and delivery would determine the outcome of the case. This origin is the source of the two modern usages of the word *forensic* – as a form of legal evidence and as a category of public presentation.
(source: http://www.newworldencyclopedia.org/entry/Forensic_science)

Invite students to describe CSI (criminal scene investigations) scenes they have seen on TV and the role of forensic scientists. Encourage students to draw connections between these examples and the definition of forensics.

Introduce "Forensic profession" cards

Inform students that they will be learning what real forensic scientists have to say about their profession as they review each of the professions in order to select a field within forensics that would be the best fit for them as a career option as well as the one that would be the worst fit.

Refer to the list of forensic fields printed on the board. Instruct students to talk to a partner about what each discipline might involve. Read aloud the descriptions of each career (the paragraph below each of the titles on the forensics profession cards found on Information sheets #2a,b) and invite students to match the name of the field to the description read aloud.

Optional: Arrange for students to view the videos from the Virtual Museum of Canada website in which forensic scientists describe their profession (listed in the section entitled, **Preparation**, above). This could be done either as a class or individually and as part of the lesson or as a supplemental activity.

Ask students which career was the most interesting to them. Discuss the factors to consider in making a career choice. If necessary, provide an example, such as, 'how do you know you might like to be a cook?' Based on the discussion, develop criteria for a good career choice (e.g., suits my interests, skills and personality traits). Suggest to students that personal interest, skills, experiences and personality traits are the source of passion for a career.

Determine 'Forensic potential'

Provide students with a copy of *Identifying my forensic potential* (Activity sheet #1a) and the forensic profession cards (Information sheets #2a,b – one set per 2 students). Instruct students to read each profession card and think about their own skills, interests, experiences and personality traits.

Ask them to fill in the chart, *Identifying my forensic potential* by recording their relevant personal

attributes in each career. Suggest that students should be able to provide evidence for the traits they select. For example, if they pay attention to detail they should be able to provide an example of that attribute. Encourage students to include related or relevant attributes they possess that are not on the forensic profession cards.

When students have completed reviewing each card and recording their personal attributes instruct them to select their most and least suitable forensic science career keeping in mind the criteria for a good career choice.

Create a "Forensic profession" card

Provide students with a copy of *My "Forensic profession"* card (Activity sheet #1b). Based on the notes they made to arrive at their most suitable forensic career (see *Identifying my forensic potential*), ask students to fill out their own personal *"Forensic profession"* cards. Discuss with students what makes an effective professional card. During the discussion introduce the criteria (e.g. original information, relevant, accurate information). Inform them that they will use the criteria found in *Assessing my "forensic profession"* card (Activity sheet #2) to guide the creation of their profession card.

Assessment

Distribute or display the charts in *Assessing my forensic career decision* and *Assessing my "forensic profession"* card (Activity sheet #2). Ask students to use these charts to assess their ability to:
• make a sound career choice in forensics
• create an informative, relevant *"Forensic profession"* card
Invite them to record their self-assessment and hand it in to you.

Extension activities
• Arrange for students to graph the best and worst career choices for the class.
• Introduce misconceptions of forensics. Forensics has become a very popular topic on television in recent years. However, despite its depiction of seemingly real events, TV shows often convey misleading information about forensics. Examples of these misconceptions include: police can use fingerprints to find anyone who commits a crime; lab reports only take a few hours; a DNA sample from a crime scene always identifies the criminal. Show the video clip illustrating the CSI effect (e.g. http://cnettv.cnet.com/csi-effect/9742-1_53-50034131.html). While watching the video, ask students to think about the misleading information TV shows portray about CSI work.

REFERENCES
• The etymology of the word 'forensic': http://www.newworldencyclopedia.org/entry/Forensic_science
• The 'CSI Effect' video clip - http://cnettv.cnet.com/csi-effect/9742-1_53-50034131.html
• www.sfu.museum/forensics/eng/pg_media-media_pg/

TERMS:

archeology	discipline
anthropology	DNA
botany	entomology
curator	forensic

What is 'forensics'?

Strictly speaking forensics means *related to the courts of law*. For forensic scientists, it means:

- identifying people's bodies,
- collecting evidence, and
- going to court to testify using your expertise in a specific field, e.g. bugs, bones, plants, etc.

'Forensics' actually has many meanings, but the main ones involve **identification** and *criminal investigation*.

Forensic Botanist	Forensic Identification Specialist	Curator
Forensic botanists review the plant evidence of a crime scene to determine several things, e.g. what time of year burial may have taken place or if the vegetation has been disturbed. They can also use botanical information to establish if the body has been moved.	Forensic Identification Specialists are police officers whose function is to search the crime scene for evidence. The FI specialist will document the scene, search for evidence, such as fingerprints, footprints, tire tracks, etc., and present this evidence in court as an expert witness.	Curators are responsible for developing/ managing a museum's collection. They may have a background in history, archaeology, or other disciplines. Some have an interest in forensic sciences and can use their knowledge to assist the police in a variety of ways, such as the recovery of remains.
Special skills and/or abilities	**Special skills and/or abilities**	**Special skills and/or abilities**
experience in plant identification methods, good communication skills	ability to recognize patterns, patience, persistence, attention to detail, confidence, strong stomach, problem solving, physical and mental endurance	attention to detail, knowledge of conservation and preservation of materials, an ability to connect the dots, ability to memorize large amounts of data, can maintain strict confidentiality, a team player
Personal interests linked to your work	**Personal interests linked to your work**	**Personal interests linked to your work**
photography and outdoor skills, interest in travel and reading, love of learning	mysteries (books, movies, etc.), fitness (stress relief and physical), public speaking (in court), reading	an interest in any science, general inquisitiveness
Background education, training, and life experience related to this career	**Background education, training, and life experience related to this career**	**Background education, training, and life experience related to this career**
a master's degree and a PhD in plant science (to be a consultant), adaptability (each case is different), broad environmental education	science degree, criminology or forensic program, exposure to death/trauma, knowledge of the Canadian legal system	a master's degree and a PhD, forensic courses, cross-cultural experience, camping and bush skills
Personal traits that could be problematic	**Personal traits that could be problematic**	**Personal traits that could be problematic**
fear of court appearance, fear of public speaking	stubbornness, being indecisive, likes shortcuts - impatient, arrogance, easily swayed by others, not a team player	impatience, serious allergies, weak stomach, highly emotional

Forensic Archaeologist

Forensic archaeologists recover and interpret human remains and material evidence from burial grounds for law enforcement and other legal agencies. They are called as scientific witnesses to courts of law, and they also investigate crimes related to mass graves from armed conflict.

Special skills and/or abilities

flexibility, honesty about scientific limits and personal abilities, sound judgment, deductive reasoning

Personal interests linked to your work

curiosity, being conscientious

Background education, training, and life experience related to this career

a minimum of a Master's degree in archaeology, 40% academic training & 60% practical experience, solid foundation in sciences, living in different places is helpful, mentorship by experienced forensic practitioners

Personal traits that could be problematic

egoism, over-confidence, misconception of role (e.g., "out to get the 'bad guys'", partisanship)

Forensic Entomologist

Forensic entomologists study insects at crime scenes and how they live off dead humans and non-human animals. They can estimate how long human remains have been undetected, as well as have an idea about the cause of death and tell whether or not the body has been moved after death.

Special skills and/or abilities

strong stomach, a background in the classification of organisms, a like of insects

Personal interests linked to your work

insects, biology in general including taxonomy, criminology, an understanding of other forensic sciences

Background education, training, and life experience related to this career

a biology degree with a strong insect focus including taxonomy, a Masters of Science in biology, a PhD specializing in forensic entomology, a forensic science certificate

Personal traits that could be problematic

impatience (casework involves a lot of waiting to do your share of the crime scene work), laziness, not loving the work, only doing it because it's popular

Forensic Anthropologist

Forensic anthropologists help identify deceased individuals from remains that are heavily damaged or decayed. They use their expertise to determine the sex, age, height, and ancestry of the deceased. They can also offer insight on trauma or disease affecting the remains.

Read more: What Is a Forensic Archaeologist? | eHow.com http://www.ehow.com/facts_5933338_forensic-archaeologist_.html#ixzz0qkAXcWav

Special skills and/or abilities

a desire to keep up to date with the latest developments of the discipline because they change constantly, being very precise, give attention to detail

Personal interests linked to your work

an interest in human beings, interests in diversity and biology

Background education, training, and life experience related to this career

a degree in Anthropology/Biology, field school/summer school experience, work with medical examiner's office or Coroner or forensic team, Master's and PhD in Physical/Forensic Anthropology

Personal traits that could be problematic

closed mindedness, impatience, taking things personally

Identifying my forensic potential

	My skills/abilities	My interests	My life experiences	My personality traits
Forensic botanist				
Forensic identification specialist				
Museum curator				
Forensic archeologist				
Forensic entomologist				
Forensic anthropologist				

My **most suitable** forensic scientist career is:

Because:

My **least suitable** forensic scientist career is:

Because:

Criteria for a good career choice:
It suits my skills, interests, experiences and personality.

My "forensic profession" card

Special skills and/or abilities

Personal interests linked to this career

Background education, training, and life experience related
to this career

Personal traits I possess that may be desirable in this career

Forensic field: _____

(headshot sketch)

Name: _____

Assessing my forensic career decision

	Accomplished	Good	Basic	In progress
Suits my skills, interest and personality	My career decision clearly matches my skills, interests experiences and personality.	My career decision matches several of my skills, interests, experiences and personality traits.	My career decision matches a few of my skills, interests, experiences and personality but I'm not sure if it is the best career for me.	I need help deciding which career I should choose.
Evidence				

Assessing my "forensic profession" card

	Accomplished	Good	Basic	In progress
Original information	I extended the information provided in the example and thought of original information to effectively describe my qualities.	I used ideas closely related to the example but I thought of some original information to describe my qualities.	I used some of the information on the example and also thought of a few original ideas.	I copied the information from the professional card example without adding any original information.
Evidence				
Relevant, accurate information	My profession card contains a lot of relevant, detailed information about me and explains why I am suited to the profession. I can provide examples to support the accuracy of the details.	My profession card reveals obvious, relevant information about me that is related to the profession. I can provide some examples to support the accuracy of the details.	My profession card reveals some information about me but it may completely relevant to the profession. I can provide a few examples to support the accuracy of the details.	I need help thinking of information for my profession card.
Evidence				

LESSON 2: The Mystery Skull

Critical challenge: Which of three people most closely matches the "mystery skull"?

OVERVIEW

In this critical challenge, students learn that many fields and techniques (anthropology, archaeology, botany, geoscience, biology) are used collaboratively by forensic scientists when they investigate suspicious events. Students take on the roles of various forensic specialists investigating a "mystery skull." In expert groups, students study and report forensic information about the skull. Based on this information, students assemble in home teams to choose one among three people as the most likely origin of the skull.

LEARNING OUTCOMES

- develop awareness of collaborative work by forensic scientists
- make inferences based on scientific data
- use criteria to reach and justify a conclusion

PRIOR KNOWLEDGE

- basic understanding of forensics
- general knowledge about the migration of early Asian populations into North and South America
- general knowledge about prehistoric lifestyles

Suggested Activities

PREPARATION

- Organize students into home groups of 5 or 6 in preparation for the activity. (Alternatively, have students work independently or with a partner.)
- Photocopy one sheet per student of the following:
  - Information sheet #1, *Skull Photographs*
  - Activity sheet #1, *Analyzing the Evidence*
  - Activity sheet #2, *Making a Decision*
  - Activity sheet #3, *Assessing Conclusion and Justification*
- Photocopy one sheet per team:
  - Information sheets #2, *Expert Reports* (If students will not be working in teams, make one photocopy for every student.)
- Prepare to display Information sheet #1, *Skull Photographs*, on a projector or via an alternative means.
- Read Information sheets #2, *Expert Reports*, and decide if your students will need additional background information to help them understand the science concepts. If so, decide how they will access on-line resources such as those provided in the references.

CREATE MINDSET

Invite students to imagine that a skull with pieces of skin and hair attached has been found in the attic of an old house. The current owner of the house has no idea where the skull came from so a forensic team has been asked to investigate. Display Information sheet#1, *Skull Photographs*, on a projector or via an alternative means. Indicate that this challenge was adapted from an actual case. Details have been changed.

INTRODUCE THE CRITICAL CHALLENGE

Present the Critical Challenge: *Which of three people most closely matches the "mystery skull?"* Explain to students that their task is to determine the origin of the skull. Suggest that students will need to draw on what they have learned about forensic science and use collaboration skills as different forensic experts to solve this mystery.

IDENTIFY THE MYSTERY SKULL

Divide the class into home teams

Organize students in home teams of 5 or 6. Invite teams to briefly brainstorm possible ways to investigate the skull, based on what they have learned about forensic science, and share their ideas with the class. Connect these ideas to the roles of different forensic scientists.

Send team members to expert groups

Explain that each team member will become part of an expert group that will analyze a different forensic report. In their expert groups, students will work together to summarize, in their own words, the investigation method used and the results of the investigation. Their task is to bring this information back to their home team.

Assign each group member a letter: A, B, C, D, E. If the team has more than 5 members, assign 2 members the same letter. Using the assigned letters, send one (or two) members of each home team to meet with an expert group as follows:

A – Forensic Archaeologists
B – Forensic Biologists
C – Forensic Geoscientists
D – Forensic Botanists
E – Forensic Anthropologists

Distribute Activity sheet #1, *Analyzing the Evidence*, and draw students' attention to the two columns: "Method(s)" and "Clues and Conclusions." Clarify that each method should be explained and that the clues and conclusions should include all information provided by the scientist. Encourage students to add their own conclusions from the evidence. For example, the forensic anthropologist's report mentions notching on some teeth. What type of activity might create notches? (using teeth to cut threads or twine) Who might do this activity? (usually women, possibly men making nets) Emphasize the importance of working together to ensure that all "experts" understand the report. (If you have decided to include additional background information for this part of the activity - see **Preparation** - instruct students how to access it now.)

Suggest that "experts" plan and rehearse their home group presentations with each other. Inform students that they will be given approximately 20 - 25 minutes to complete this activity.

Return to home teams and share

Instruct students to return to their home teams and to take turns sharing details of "Method(s)" and "Clues and conclusions about the skull" from each expert report. Each student should add the details from other reports to his or her own chart. Encourage students to ask questions of each other to clarify the information. When students have completed the chart, invite groups to share their conclusions with the whole class.

Introduce the three profiles

Invite students to imagine that news of their investigation has become public and a local museum has claimed the skull as part of a collection that went missing several years ago. Before its disappearance, the skull was being prepared for inclusion in a display on prehistoric human life. Museum staff had drafted profiles of three fictional prehistoric people but had not yet decided which profile to use. Now, armed with information from the current investigation, students must decide: which profile best matches the skull?

Provide each student with a copy of Activity sheets #2a and #2b, *Making a Decision*. Explain that their task is to decide which prehistoric person most closely matches the data on their *Analyzing the Evidence* sheet. Emphasize that the profiles are fictional and there may be more than one good choice. Also note that some descriptions presented in the profiles may not correspond with any available expert evidence. Encourage students to draw a simple timeline to compare birth and death dates of the prehistoric people. Can any of the profiled individuals be eliminated because of date of death? Food? Region? Explain that students will be assessed on their use of evidence to reach and justify their conclusion. Ensure that students understand the distinction between "supporting evidence" and "contrary evidence" by giving an example such as, "Jack is a nice person", where supporting evidence would be that Jack hugs his mother every morning and contrary evidence would be that he sometimes kicks his dog. Draw students' attention to the rating scale from weak (+) to very strong (+++) and invite them to rate the strength of the supporting and contrary evidence about Jack. Ask for more examples of evidence that is supporting or contrary and weak or strong. Direct students to work independently or with a partner to complete the chart. Students should independently write a paragraph to explain and justify their conclusion.

ASSESSMENT

Assess students' responses as recorded in their *Making a Decision* table and final paragraph, using Activity sheet #3, *Assessing Conclusion and Justification*. According to this rubric the assignment is assessed on three criteria:
• Accurate recording of facts and implications
• Plausible conclusion
• Well-reasoned justification

Extension Activities

• Arrange for students to share their choice with a partner who was not in their home team.

• Ask students to list other evidence that would help them make a more definitive choice.

• www.sfu.museum/forensics/eng/pg_media-media_pg/

REFERENCES

Radiocarbon dating: http://science.howstuffworks.com/environmental/earth/geology/carbon-141.htm

Loess soil: http://www.edu.pe.ca/southernkings/loesssp.htm

Mass spectrometry: http://en.wikipedia.org/wiki/Mass_spectrometry

DNA forensics: http://www.ornl.gov/sci/techresources/Human_Genome/elsi/forensics.shtml#3

Pollen analysis: http://forensicarchaeology.org/ (Click on Palynology.)

Dental clues: http://en.wikipedia.org/wiki/Forensic_odontology

TERMS:

archaeology

anthropology

geosciences

radiocarbon dating

isotope analysis

botany

DNA

forensic

Skull Photographs

Expert Reports

EXPERT A: FORENSIC ARCHAEOLOGIST

Radiocarbon Dating

This method is based on measuring two isotopes (atomic forms) of carbon in a plant or animal: rare, radioactive Carbon-14 and common, stable Carbon-12. As long as a plant or animal is alive, its ratio of C-14 to C-12 matches the ratio in the atmosphere. This relationship occurs because both forms of carbon are constantly being replaced when plants absorb carbon during photosynthesis, the process of making food from sunlight and carbon dioxide. The same C-14/C-12 ratio is preserved when animals eat plants. After death, however, C-14 breaks down without being replaced. The ratio of C-14 to C-12 changes at a predictable rate, with half the C-14 disappearing after a "half-life" of about 5700 years. In other words, because C-14 decays, we can estimate the length of time since the organism died based on the changes in the C-14/C-12 ratio. If the ratio is one-half the atmospheric ratio, we can conclude that the organism died approximately 5700 years earlier. To find out the age of the skull, I sent one of the vertebrae (pieces of the backbone) that had separated from the neck to a specialized lab for radiocarbon dating. The results show that the owner of this skull died between 4730 and 4850 years ago. The confidence level for this range is 95%. In other words, 95% of samples tested would fall within the time range of 4730 to 4850 years ago.

DNA analysis

I used DNA analysis to analyze the piece of skin attached to the skull. This method allows us to look for distinctive patterns in the genetic material (DNA or deoxyribonucleic acid) of any living, or once living, thing. The tests showed that the skin is not human. Rather, it comes from a goat.

EXPERT B: FORENSIC BIOLOGIST

Isotope Analysis

I sent samples from a vertebra (piece of backbone) that was loosely attached to the skull to a specialized lab for isotope analysis. This technique measures and compares the ratios of two stable isotopes (forms) of carbon: carbon-12 (most common) and carbon-13 (rare). (Radioactive carbon-14 is not used in this analysis.) Depending on how much carbon-13 they absorb during photosynthesis (the process plants use to make food from sunlight and carbon dioxide) different species are known as C3 or C4 plants. C3 plants include most temperate climate species, including wheat, rice and most types of trees. C4 plants originated in hot, sunny areas and were used in early agriculture. This group includes sugar cane, maize (corn) and sorghum. When humans and other animals eat C3 or C4 plants, the carbon-13/carbon-12 ratios persist and we can often gain important information about their diet and living conditions.

The isotope analysis on bone gelatin from the vertebra (the backbone) associated with this skull indicates that the diet of this person was largely based on foods from C4 plants.

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EXPERT C: FORENSIC GEOSCIENTIST

Sediment Analysis

I examined five pieces of sediment from the temporal fossa (the shallow indentations on each side of the skull). Analysis under a microscope showed that they included soft, powdery silt combined with plant fibres, rodent feces and crushed fish scales. The mineral component resembles loess, a type of soil formed when wind-blown dust is deposited in blankets that can be over 100 metres deep. In some areas of northern China, South America and the southern United States, thick loess deposits cover hundreds of square kilometres. Loess tends to form tall cliffs that often hold natural or human-made caves. (See loess map below.)

distribution of major loess deposits on Earth

EXPERT D: FORENSIC BOTANIST

Pollen Analysis

I used a microscope to analyze pollen grains found in plant and soil samples from the nose and eye area, plus the temporal fossa (the shallow indentations on the sides of the skull). Because the pollen from each type of plant has a distinctive size and form, I was able to compare these grains to known samples and identify the plants they came from.

Pollen of the Chenopodiaceae/Amaranthaceae family dominates the samples. This group of plants is typically found in poor, dry or even salty soils – in deserts, prairies and along the seashore. I found clumps of pollen from grass, sage, sunflowers and onions.

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EXPERT E: FORENSIC ANTHROPOLOGIST

Dental analysis

Fortunately, the skull has a nearly complete set of teeth that provides us with many clues. The first thing I noticed in my examination was the pattern of wear on the molars. These back teeth are very flat and worn down. Also, there is noticeable notching on the right canine tooth, and notching to a lesser extent on the left canine.

The incisors show some "shoveling" – a scooping out on the tongue side that is usually found in people of Asian or aboriginal American ancestry. Also, the molars lack the Carabelli's cusp, an additional bump that is most commonly found on the teeth of people of European descent.

Age and sex for the skull have not yet been determined.

Analyzing the Evidence

Expert	Methods	Clues and conclusions about the skull
A		
B		
C		
D		
E		

Making a Decision

Which prehistoric person – Anu, Spakwa or Qara – is the most likely match for the mystery skull? Record each piece of evidence in the appropriate column. Next to each piece of evidence, rate its strength using stars (* weak evidence, *** strong evidence). State and justify your conclusion about the most likely identity of the skull.

Anu	Experts' supporting evidence	Experts' contrary evidence
- Male, born about 4830 years ago, died of pneumonia around age 47.		
- lived in what is now the Rocha region of Uruguay		
- his people planned towns and constructed large earth mounds that were probably used for burial and ceremonial purposes		
- family grew corn, squash and beans near their home		
fished in the ocean using large nets		
Anu	**Experts' supporting evidence**	**Experts' contrary evidence**
- Female, born about 4760 years ago, died in childbirth around age 21		
- lived in a cave on the banks of the Mississippi River (present-day Louisiana)		
- lived with clan of approximately 300 people		
- her people had started to sow seeds and harvest crops such as maize and sunflowers		
- made pottery and baskets to hold foods and tools		

Qara	Experts' supporting evidence	Experts' contrary evidence
- female, born about 4680 years ago, died of starvation around age 32		
- lived in area now known as Inner Mongolia region of northern China		
- nomadic lifestyle with about 30 members of extended family plus domesticated horses and other animals		
- diet largely based on meat and milk products		
- used animal hides and wool to make clothes and portable homes called yurts		

Conclusion and reasons:

Assessing Conclusion and Justification

	Accomplished	Good	Basic	In progress
Accurate recording of facts and implications	Includes all relevant facts; recognizes subtle implications of evidence	Includes most relevant facts; recognizes obvious implications of evidence	Includes some relevant facts and directly stated evidence	Includes few or no relevant facts; some evidence is inaccurate or misunderstood
Plausible conclusion	Matches all relevant facts; astutely assesses relative strength of supporting and contrary evidence	Matches most relevant facts; reasonably assesses relative strength of supporting and contrary evidence	Matches some relevant facts; vaguely assesses strength of evidence	Matches few or no relevant facts; does not weigh strength of evidence
Well-reasoned justification	Defends choice with sophisticated logic; thoroughly accounts for supporting and contrary evidence	Defends choice with solid logic; accounts for most supporting and contrary evidence	Defends choice with weak logic; accounts for some aspects of supporting and contrary evidence	Defense of choice is illogical; ignores supporting and contrary evidence
Comments				

LESSON 3: Insect Informants

Critical Challenge: Design three effective exhibit boards to support a forensic entomologist's testimony about the estimated date of a victim's death.

OVERVIEW

In this critical challenge, students are introduced to some methods of *forensic entomology,* the use of insects to investigate crimes. They will work in groups to connect details from an actual investigation to their previously summarized information. As a class, students determine criteria for "an effective visual representation" before designing a set of three exhibit boards supporting the forensic evidence.

LEARNING OUTCOMES

- understand methods used by forensic entomologist
- appreciate the value of entomology as a forensic science
- enhance the ability to locate key information in complex texts

PRIOR KNOWLEDGE

- basic understanding of forensics
- familiarity with insect life cycles

Suggested Activities

PREPARATION

- Photocopy one sheet per student of the following:
  - Information sheet #1, *Forensic Entomology Article*
  - Information sheet #2, *An Actual Investigation by Dr. Gail Anderson*
  - Activity sheet #1, *Gathering the Information*
  - Activity sheet #2, *Self-Evaluation of Exhibit Boards*
  - Activity sheet #3, *Assessing Exhibit Boards*
  - Activity sheet #4, *Assessing Self-Evaluation*

- Option: Prepare to show a video that features the work of an entomologist (e.g. the first 9 minutes of CBC Nature of Things, *Bugs, Bones & Botany: The science of a crime*. Dr. Gail Anderson and her work are featured in the first segment of the program.; Note: Some images may be disturbing for students: http://www.cbc.ca/video/#/Shows/The_Nature_of_Things/2009-10/   Search for: Bugs, Bones & Botany
- www.sfu.museum/forensics/eng/pg_media-media_pg/
- [Note: If you choose to show the videos in class, they should be preloaded so they will play right away. To do this, open a new tab or window and load the video before class starts.

CREATE MINDSET

Invite students to share what they already know, if anything, about forensic entomology. Clarify that although the term applies to any use of insects in legal investigations, it most often refers to using insects to determine the postmortem interval, or the time that has passed since a *suspicious* death.

Explain to students that in this challenge, they will examine an actual investigation conducted by Dr. Gail Anderson, a forensic entomologist at Simon Fraser University in British Columbia.

Option: Show a video (like the one suggested in the **Preparation** section) featuring the work of an entomologist. Ask students to watch for specific methods that might be used in an investigation.

INTRODUCE THE CRITICAL CHALLENGE

Explain that forensic scientists are often called into court to act as expert witnesses. In addition to their verbal testimony, witnesses may use visual representations such as exhibit boards (similar to large posters) or electronic technology such as PowerPoint. The impact of an expert's testimony is enhanced through the use of effective visual representations. Explain that students will create letter-size (8.5 x 11) mock-ups of three full-scale exhibit boards. The boards will support a forensic entomologist's testimony about the estimated date of a victim's death as described in *An Actual Investigation* information sheet.

SESSION ONE

Summarize the information

Invite students to share with the class any methods they are familiar with or those observed during the video. Distribute Information sheet #1, *Forensic Entomology Article*, and explain that this article by Dr. Anderson describes in detail some of the forensic entomology methods used in investigations. Also distribute Activity sheet #1, *Gathering the Information*. Instruct students to highlight or underline key pieces of information in the article and summarize those ideas, in their own words, in the first column of the chart. Refer to the example given and consider modeling another example before students begin working on their own. Clarify the meaning of "point form" (i.e., concise, no unnecessary words, phrases rather than complete sentences, separate bullet for each piece of information) and remind students to use their own words rather than copying directly from the article.

When students have completed the first column of the chart, suggest they exchange pages with another student and discuss similarities and differences between their two summaries. As a whole class, share key points and ensure that students have understood the article.

Introduce the case

Distribute Information sheet #2, *An Actual Investigation by Dr. Gail Anderson,* and invite students to read the description of an actual forensic case. When students have finished reading the case, ask them to return to the *Gathering the Information* chart and enter important case details in column two, beside any related points in column one.

Review the Critical Challenge: *Design three effective exhibit boards to support a forensic entomologist's testimony about the estimated date of a victim's death*. Inform students that exhibit boards provide the judge and jury with relevant background information about forensic methods as well as details of a particular case. Invite them to review columns one and two on their *Gathering the Information* charts and discuss with a partner which pieces of information might be included on the exhibit boards. Suggest that students select information that requires clarification or explanation, and is critical to the testimony.

Encourage students to brainstorm ways to convey the information (point form lists, diagrams, drawings, etc.), and to record these in column three on the chart.

Establish criteria for effective displays

Display samples of information posters or online examples and ask students to consider what makes each exhibit board effective. (For samples of exhibit boards, go to a site such as: http://www.bydesignlegal.com/samples.html or locate other examples illustrating effective visual displays, e.g. textbook covers, posters, etc.).

Invite students to work in small groups to brainstorm criteria for an effective visual representation for courtroom purposes. Share ideas as a class and work together to agree on three or four criteria. Alternatively, suggest specific criteria to students, such as being concise, comprehensive, convincing and carefully presented. As illustrated below, draw a T-chart on the board or overhead and ask students to suggest possible techniques for achieving each of the agreed-upon criteria.

Criteria	Techniques
Comprehensive	Include relevant data and specialized knowledge Provide background information to enhance understanding
Concise	Omit unnecessary words, use point form and illustrations/diagrams to convey information
Convincing	Support and clarify testimony. Convey main ideas in a powerful way.
Carefully presented	Purposefully plan and apply colour, layout, illustrations

Discuss criteria that may seem to be contradictory. For example, how can a board be concise and also comprehensive? *(By including only important, relevant facts, using diagrams, and so on.)*

Design the boards

Direct students to begin draft plans for their exhibit boards using their *Gathering the Information* charts plus the criteria and techniques recorded in their notebooks. Clarify whether the task will be completed independently or with a partner. Provide time in class for students to begin work on their exhibit boards and/or assign the project as homework. You may want students to submit drafts of the boards for your review and feedback prior to final completion.

SESSION TWO
View the exhibit boards

Invite students to post their exhibit boards around the classroom. Allow time for a "gallery walk" during which students view all the boards. Suggest that they look for evidence of the agreed-upon criteria in each set of boards. You may want to assign partners who will give each other informal feedback.

ASSESSMENT
Students' self-evaluation of the exhibit boards

Provide each student with a copy of Activity sheet #2, *Self-Evaluation of Exhibit Boards*. In the left-hand column, ask students to record the four criteria you created as a class (in the section **Establish criteria for effective displays** above), or use the criteria provided in the T-chart (above): comprehensive,

concise, convincing, carefully presented. Explain that your assessment of their work will be based on the exhibit boards and thoughtful completion of the self-assessment task.

Teacher assessment

Assess students' projects using Activity sheet #3, *Assessing Exhibit Boards*. According to this rubric, the work is assessed on four criteria:

• comprehensive

• concise

• convincing

• carefully presented

Assess students' self-evaluations (presented in Self-Evaluation of Exhibit Boards) using Activity sheet #4, Assessing Self-Evaluation. According to this rubric, the work is assessed on two criteria:

• strengths and weakness for each criterion

• useful ideas for improvement

Extension activities

Invite students to find out how Dr. Anderson's work helped convict black bear poachers:
http://www.thefreelibrary.com/Fly+witness-a019986894

REFERENCES

• Anderson, Gail S. (retrieved August 24, 2010 from this source) http://www.sfu.ca/~ganderso/forensicentomology.htm

• (Adapted sections from the article were used in this lesson.)

• Anderson, G.S. 2000 Minimum and maximum development rates of some forensically important Calliphoridae (Diptera), *Journal of Forensic Science,* Vol. 45(4), pp. 824-832. (retrieved from: http://www.clt.uwa.edu.au/__data/page/112507/fse07_forensic_entomology.pdf)

• By Design Legal (Sample exhibit boards.)

• http://www.bydesignlegal.com/samples.html

• CBC, The Nature of Things (July 2010) *Bugs, Bones and Botany: the Science of Crime*

• http://www.cbc.ca/video/#/Shows/The_Nature_of_Things/2009-10/ID=13922: 77696

• "Fly witness", An article in which Dr. Anderson's work helped convict black bear poachers:

• http://www.thefreelibrary.com/Fly+witness-a019986894

• www.sfu.museum/forensics/eng/pg_media-media_pg

TERMS:

entomology
successional
decomposition
pupae
larvae
instar
maggot

Forensic Entomology Article

(Adapted from Anderson, G. S. FORENSIC ENTOMOLOGY: THE USE OF INSECTS IN DEATH INVESTIGATIONS)

Among the tasks tackled by a forensic entomologist is the analyses the insects on or inside a corpse to determine how much time has passed since the person died. In addition to carefully collected insect samples, the entomologist uses information such as the environment at the crime scene, the cause of death and the average temperature in the area, to produce an accurate estimate.

There are two main methods used to analyze the insects from a body:

1. successional waves of insects

2. maggot age and development

Method 1 is most useful when the person has been dead from a few weeks up to a year or sometimes more. It works because human bodies change as they decompose. Some types of insects are attracted to the earliest stages of decomposition while others arrive on the scene much later. Because insects typically inhabit a corpse in predictable "waves" of different species, forensic entomologists can use the presence of a particular type of insect to estimate the time of death.

Method 2 can give a date of death accurate to a day or less, or to a range of days using the age and developmental stage of immature blowflies (or maggots). As tissues of the corpse decompose, the remains go through rapid physical, biological and chemical changes, and different stages of the decomposition are attractive to different species of insects. Certain species of insects are often the first witnesses to a crime.

Blowflies are common insects that are attracted to a corpse very soon after death and are usually the first to arrive. They lay their eggs on the corpse, usually in a wound if present or, if not, in any of the body's natural openings. The eggs hatch and the immature insects go through various stages of development at predictable times.

This time period is affected by the availability of food and the temperature. In the case of a human corpse, food availability is not usually a limiting factor, so temperature is the strongest influence. Since insects are "cold blooded," their development is extremely temperature dependent, that is, the warmer the temperature, the faster rate of development, and *vice-versa*.
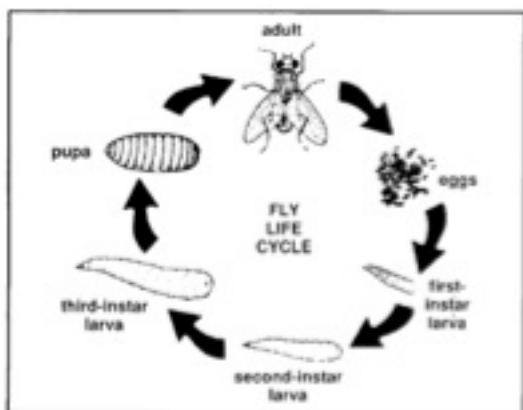
Figure 1. The developmental stages of a blowfly

Rates of development for Calliphora vicina, a species of blowfly
[inserted from another source by the same author]

	15.8 °C		20.7 °C		23.3 °C	
	Time to reach stage (hours)		Time to reach stage (hours)		Time to reach stage (hours)	
Stage	Min	Max	Min	Max	Min	Max
1st instar	40.6	44.4	20.9	23.6	21	22
2nd instar	94.3	103.3	52.3	52.3	45	45
3rd instar	135.7	158.7	78.3	95.3	77	77
Prepupal	233.7	246.7	127.9	145.3	145	159.5
Pupal	382.3	392.3	245.7	356.9	264	270
Adult	775	917	486.2	647.8	468.5	624.5

The above data has been adapted from: Anderson, G.S. 2000 Minimum and maximum development rates of some forensically important Calliphoridae (Diptera), Journal of Forensic Science, Vol. 45(4), pp. 824-832, and simplified for this lesson. (taken from http://www.clt.uwa.edu.au/__data/page/112507/ fse07_forensic_entomology.pdf)

An analysis of the oldest life stage of blowfly on the corpse and the temperature of the region in which the body was discovered leads to a day or range of days for the *'time since death'*. For example, if the oldest insects are 7 days old, then the deceased person has been dead for at least 7 days. This method can be used only until the first adults begin to emerge, in which case dark pupae are present. After that, it is not possible to determine which generation of flies is present. In this case, the time of death must be determined using the second method, that of insect succession.

An Actual Investigation by Dr. Gail Anderson

(Adapted from Anderson, G. S.
FORENSIC ENTOMOLOGY: THE USE OF INSECTS IN DEATH INVESTIGATIONS)

Human remains were found in mid October. The death was due to gunshot wounds to the head. The upper portion of the body was almost skeletonized (reduced to skeleton), but the lower area, clad in tight clothes, appeared almost fresh. There were several large maggot masses on the corpse that generate their own heat for a while due to the frenzied activity. The temperature of the largest maggot mass was 20 degrees C, even after the body had been refrigerated at 4 degrees C for two hours. All sizes of larvae were collected and three pupae. (Refer to the insect life cycle above to see these stages). These were pale in colour so had only just pupated (become pupae). No puparia (the rigid outer shell that covers some pupae) were found. The mean temperature at the death site was 15 degrees C.

Two species of blowfly (a type of fly) emerged, *Calliphora vomitoria* and *Phormia regina*. Both are common species that are amongst the first to arrive on a corpse. The oldest stage of *Calliphora vomitoria* collected was just entering the prepupal stage of the third instar (the last stage before the larva turns into a pupa). This was determined from size, number of spiracular slits (breathing holes), date of pupation and behaviour. At the temperature of the death site, 15 degrees C, *Calliphora vomitoria* takes a minimum of 9.3 days to reach the beginning of the prepupal stage of the third instar. So these insects were a minimum of 9 days old when collected on 12 October, meaning that they were laid as eggs on or before 4 October. As there was blood at the scene, the insects probably arrived very soon after death. Therefore death must have occurred on or before 4 October.

Using the same techniques for *Phormia regina*, the oldest specimens of which were in the pupal stage when collected, it was calculated that *Phormia regina* eggs were laid no later than 3 October. Therefore, using the two insects together, it can be shown that death occurred on or before 3 October.

Gathering the Information

Key information from the article	Key points from the actual investigation	Ideas to include on the exhibit boards
- insects show time since death		

Self-Evaluation of Exhibit Boards

In the left-hand column, write the four criteria for an effective visual representation. In the middle and right-hand columns, describe specific features of your project that meet the criteria and any features that could be improved.

Criteria	Features that meet the criteria	Ideas for possible improvement

Assessing Exhibit Boards

	Accomplished	Good	Basic	In progress
Comprehensive	Includes all key ideas about case and related science concepts	Includes most key ideas about case and related science concepts	Includes some key ideas about case and related science concepts	Few or no key ideas included about case and related science concepts
Concise	Very tightly focused on relevant points; no extraneous words or details	Focused on relevant points; few extra words and details	Some parts lack focus; many irrelevant words and details	Unfocussed; many irrelevant words and details
Convincing	Explanations show knowledge and insight; strongly support and clarify testimony	Explanations show knowledge and support testimony	Explanations show some knowledge; weak support for testimony	Explanations show lack of knowledge; may undermine testimony
Carefully presented	Carefully designed and presented with excellent use of colour, layout and illustrations	Carefully presented; good use of colour, layout and illustrations	Some care taken with presentation; parts may be untidy or poorly displayed	Presentation shows little care; overall effect is untidy and hard to read/view
Comments				

Assessing Self-Evaluation

	Accomplished	Good	Basic	In progress
Identifies strengths and weaknesses	Thoughtfully identifies strengths and weaknesses in relation to each criterion	Identifies strengths and weaknesses in relation to criteria	Identifies some strengths and weaknesses in relation to criteria	Only weakly related to criteria
Offers ideas for improvement	Includes highly appropriate and constructive ideas for improvement	Describes some appropriate ideas for improvement	Ideas for improvement are vague or inappropriate	No ideas for improvement
Comments				

LESSON 4: Was the Body Moved?

Critical Challenge: As a member of the jury, decide which of four pieces of evidence presented by a forensic botanist is most convincing.

OVERVIEW

In this critical challenge, students become familiar with tools used in forensic botany and with the role of expert witnesses in Canadian courts. They read a fictional news article about a murder case and re-enact a court session, or simply read a transcript, in which a forensic botanist provides testimony supporting the allegation that the victim's body was moved after the murder occurred. Students record details and assess the strength of the evidence represented by four exhibits presented by the botanist. They also judge the plausibility of alternative explanations for the evidence that do not imply that the body was moved. After comparing the four exhibits, students decide which one offers the most convincing evidence that the body may have been moved, and justify their reasons for selecting it over the others.

LEARNING OUTCOMES
- develop awareness of the work of forensic botanists
- use criteria to form and justify a conclusion

PRIOR KNOWLEDGE
- general understanding of forensic science
- familiarity with the roles of judge, jury, Crown Counsel and Defense Counsel in the Canadian criminal justice system

Suggested activities

PREPARATION
- Photocopy one sheet per student of the following:
  - Information sheets #1a and #1b, *Details of the Case and Testimony*
  - Information sheet #2, *Courtroom Evidence*
  - Activity sheet #1, *Analyzing the Evidence*
  - Activity sheet #2, *Choosing the Most Convincing Exhibit*
  - Activity sheet #3, *Assessing the Analysis*
  - Activity sheet #4, *Assessing Choice and Justification*
- Prepare to display the evidence in Information sheet #2, Courtroom Evidence, on a projector or via an alternative means.
- Prepare to display a webpage showing the 'Biogeoclimatic zones of British Columbia' (e.g. http://www.for.gov.bc.ca/hfd/library/documents/treebook/biogeo/biogeo.htm) on a projector or via an alternative means.
- If you intend to re-enact the court session:
  - Set up "court" furniture at front of classroom. The Judge sits at the front, behind a table. The two lawyers (Crown Counsel and Defense Counsel) sit at separate tables facing the judge and the court

clerk sits in front of the judge, facing the lawyers. The jury sits on one side. John Doe, the accused, sits on the other side of the room, facing the jury.

- Choose students for each role: forensic botanist Rhonda Brown, Defense Counsel, Crown Counsel, judge, court clerk, accused. The remainder of the class will comprise the "jury". Provide time for students with reading roles to practice the script.

PRESENT THE CRITICAL CHALLENGE

Explain that this is a fictional case in which a forensic botanist is acting as an expert witness. Clarify the following terms:

- **forensic botanists** are scientists who apply their scientific knowledge of plants, pollen, seeds, and all floral and botanical organic matters to legal investigations.
- **expert witnesses** are qualified individuals whose specialized knowledge and skills, gained from training, experience, and education, require them to testify in a court case. Expert witnesses are expected to be objective and unbiased. They should explain technical information clearly and succinctly, provide supporting data, and avoid speculating on larger issues related to the case.

Distribute Information sheets #1a and #1b, *Details of the Case and Testimony*. Invite a volunteer to read the Introduction aloud to the class. Clarify details of the article with the class. Ensure that students have located Vancouver and Merritt on the small map (located on Information sheet #1a) to understand the logistics of driving from one city to another. Also, draw students' attention to the different ecosystems of the areas where each city is located.

DECIDE WHICH EVIDENCE IS THE MOST CONVINCING

Prepare for jury role

Explain to students that in this segment of a mock trial their task is not to decide the guilt or innocence of the accused, or even to decide that the body most certainly was moved, but simply to decide which exhibit is most convincing—that is, provides the strongest and most plausible evidence that the victim's body *may* have been moved after death. Encourage students either to take notes while listening to the testimony or to listen to the testimony and then review the transcript for key ideas.

OPTIONAL: Present court re-enactment

If you chose to re-enact the court scene, encourage students with speaking roles to read slowly and with expression. Direct jury members to listen quietly, without comment.

Review the ecosystems map

Display the 'Biogeoclimatic zones of British Columbia' (e.g. http://www.for.gov.bc.ca/hfd/library/documents/treebook/biogeo/biogeo.htm) and invite students to explore those zones that are relevant to the case.

Analyze supporting evidence

Distribute Activity sheet #1, Analyzing the Evidence. Encourage students to refer to their notes and the Details of the Case and Testimony to find specific, concrete details of each exhibit that support the allegation that Jane Doe's body was moved after her death. Instruct students to record the evidence in

the middle column and to rate the strength of this evidence on a scale from strong to weak. Evidence is strong if there are trustworthy facts, ideally several pieces of information that directly support the conclusion.

Analyze alternative explanations

Instruct students to use the right-hand column on *Analyzing the Evidence* to describe alternative explanations to the one presented by the expert witness, including those suggested by the Defense Counsel and their own alternative explanations for the evidence presented in the exhibits. Direct students to rank the plausibility of each alternative explanation, considering whether the explanations are reasonable in light of other available information and realistic to expect that things might actually happen this way.

Choose the most convincing exhibit

Invite students to refer to their work on *Analyzing the Evidence* to help them choose the exhibit offering the most convincing evidence that the body may have been moved after death. (Even if students believe that the body wasn't moved, they must still identify the one that provides the strongest case that it could possibly have been moved.) Present the following criteria for a convincing exhibit:
• provides strong supportive evidence for the conclusion
• is not discredited by other highly plausible explanations that suggest a different conclusion.

Arrange for students to work individually or with a partner to complete Activity sheet #2, *Choosing the Most Convincing Exhibit*. Ask students to indicate their choice, to provide reasons for choosing it and reasons why other choices are somewhat believable, and to justify why their choice is the most convincing. Remember that the most convincing exhibit is **very strong** in supportive evidence and there is **little plausibility** to any alternative explanations.

ASSESSMENT

Assess students' analysis of the evidence and alternative explanations using Activity sheet #3, *Assessing the Analysis*. According to this rubric the assignment is assessed on two criteria:
• identifies relevant and important details
• offers justifiable ratings.

Assess students' justification for the most convincing exhibit using Activity sheet #4, *Assessing Choice and Justification*. According to this rubric the assignment is assessed on three criteria:
• identifies evidence for the choice
• identifies evidence for other choices
• offers a plausible justification.

Extension activities

- Invite students to brainstorm questions they would like to ask the expert witness in this case. Encourage them to think of other evidence that would be helpful for reaching a verdict in this case.
- Using this critical challenge as a model, ask students to create a new crime scenario and expert witness testimony based on plants and ecosystems in the local region.
- www.sfu.museum/forensics/eng/pg_media-media_pg/

REFERENCES

- Cannings, Richard and Cannings, Sydney (2004) *British Columbia: A Natural History.* Vancouver: Greystone Books.
- Parish, Roberta. (1994) *Tree Book: Learning to Recognize Trees of British Columbia.* Victoria, BC: Ministry of Forests (available for download from Ministry website).
- Biogeoclimatic zones of British Columbia:
- http://www.for.gov.bc.ca/hfd/library/documents/treebook/biogeo/biogeo.htm
- *'Ecosystems: Managing Tomorrow's Forests'* video: http://www.for.gov.bc.ca/hre/becweb/Photos/ECOSYSTEMS%20video.wmv (found at http://www.for.gov.bc.ca/hre/becweb/index.html)
- www.sfu.museum/forensics/eng/pg_media-media_pg/botanique-botany/video/

TERMS:

botany
ecosystem
expert witness
DNA
forensic botanist

Details of the Case and Testimony

INTRODUCTION

At 5 p.m. on Saturday, May 5, the body of Jane Doe, a 28-year-old Vancouver resident, was discovered in the coastal rainforest near Vancouver, B.C. The deceased woman was dressed in a fleece jacket, jeans, hiking boots and a wool cap. The coroner's report shows that Doe died approximately 24 hours before her body was discovered and that she had been strangled. Doe's ex-husband, John Doe, has been charged with murder.

John Doe's lawyer argues that his client could not have carried out the crime as he was seen in Merritt, B.C. at the time of the murder. Merritt is a small city in the dry southern interior of B.C., about a four-hour drive from Vancouver. Crown Counsel (the prosecution lawyer against John Doe) claims that John Doe could have killed his ex-wife in the Merritt area late Friday afternoon and then driven to Vancouver where he left her body in the rainforest.
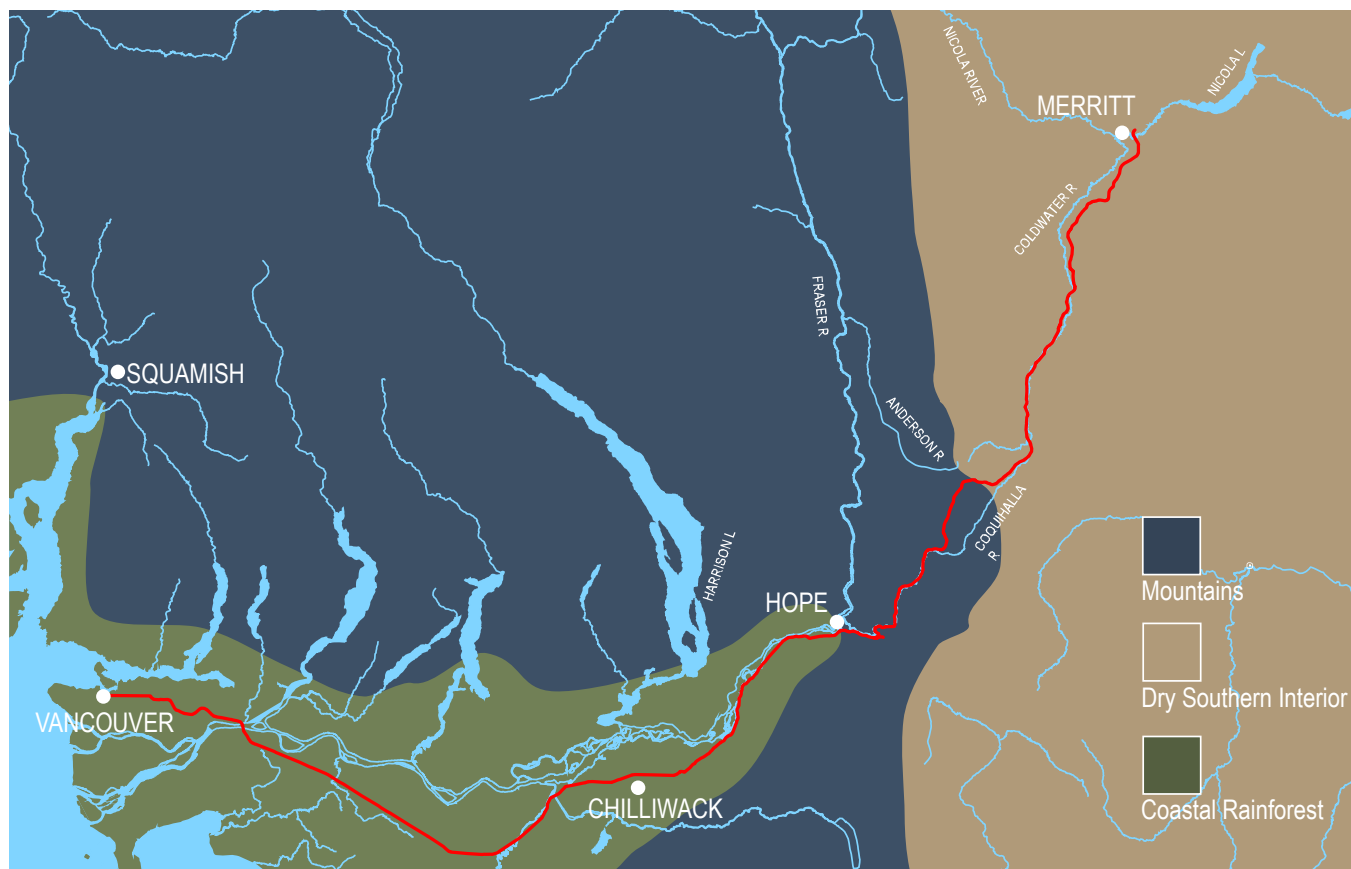
A forensic botanist has been called by Crown Counsel to help answer the question: was Jane Doe killed near the spot where her body was found - or was she killed somewhere else and then moved? Although the answer to this question will not prove John Doe's guilt or innocence, it will provide important information for the jury to consider.

COURT TRANSCRIPT

CC = Crown Counsel (court lawyer against John Doe)
DC = Defense Counsel (lawyer for the accused, John Doe)
J = Judge
RB = Ms. Rhonda Brown, forensic botanist
Also present: accused, court clerk, members of the jury

*Note: The expert witness has been called and sworn-in. Crown Counsel opens the direct
examination, which is followed by Defense Counsel's cross-examination.*

CC: I would like to submit Exhibit A. Ms. Brown, please describe this exhibit. [View the Courtroom Evidence images .]
      (After introducing each exhibit, CC hands it to the court clerk who "records" it and then hands it to the judge.)

RB: Exhibit A is enlarged images of microscopic grains of pollen found on the victim's clothing. Pollen grains from different types of plants are highly distinctive. They are often carried in the wind and can cover a person's clothing without being noticed. The pollen found on the victim's clothing included that of pine and cactus, two species that are native to the dry southern interior, and are not found in the coastal rainforest.

CC: I would like to submit Exhibit B. Ms. Brown, please describe this exhibit.

RB: Exhibit B was found under the victim's T-shirt, between her shoulder blades. It's a needle cluster from a Pondersosa pine tree. The Ponderosa pine grows in dry, open regions of the southern BC interior. The brown colour and brittleness of the needles indicates that they had probably fallen from the tree and were lying on the ground at the time they became attached to the victim.

CC: I would like to submit Exhibits C and D. Ms. Brown, please describe these two exhibits.

RB: Exhibit C and D are plant material taken from the hair on the back of the victim's head. Exhibit C contains small grass fragments and Exhibit D is a few Douglas-fir needles. The grass was identified by DNA analysis as Bluebunch Wheatgrass. In BC, this species is found in the southern interior grasslands.

CC: What conclusion do you reach from these pieces of evidence?

RB: The plant material found on the victim's body, and the location of the pieces on her back and in her hair, are consistent with her moving – or being dragged – feet-first, on her back, somewhere in the southern interior region around the time of her death.

CC: Thank you. I have no further questions.

J: Counsel for the defense may question the witness.

DC: Ms. Brown, you mentioned that Exhibit D includes Douglas-fir needles. Don't Douglas-fir trees grow on the west coast, including the area where the victim's body was found?

RB: Yes, Douglas-firs are very common in the coastal forests. However, there are two varieties of Douglas-fir - one grows on the coast and one grows in the interior. The needles of the interior variety of Douglas-fir have a bluish

tinge compared to the coastal trees. Exhibit D includes needles from both varieties of Douglas-fir.

DC: Ms. Brown, is it true that pollen grains are extremely long-lasting and have even been used by archaeologists to identify remains that are thousands of years old?

RB: Yes, that's true.

DC: So, the pollen grains found on the victim's clothing could have been there for a long time – perhaps days or weeks?

RB: Yes, they could have been.

DC: You mentioned that the Ponderosa pine needles had been dead for some time. Is it not possible that the killer collected these needles and deliberately placed them on the victim's body in the west coast forest in an attempt to confuse the investigation and pin the blame on the accused?

RB: I suppose that's possible.

DC: I have no further questions, Your Honour.

J: (to RB) You may step down.

Courtroom Evidence

EXHIBIT A: POLLEN GRAIN IMAGES (HIGHLY MAGNIFIED)

Pine Pollen
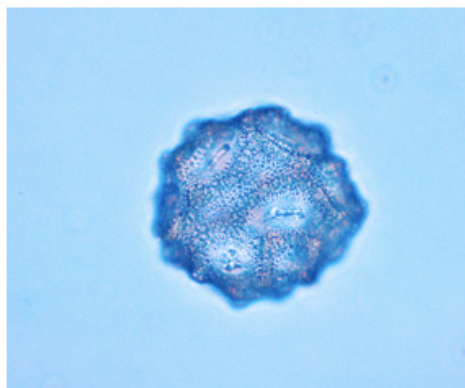
Cactus Pollen

EXHIBIT B: PINE NEEDLES

Ponderosa Pine

EXHIBIT C: GRASS FRAGMENTS & EXHIBIT D: DOUGLAS-FIR NEEDLES

C: Bunchgrass
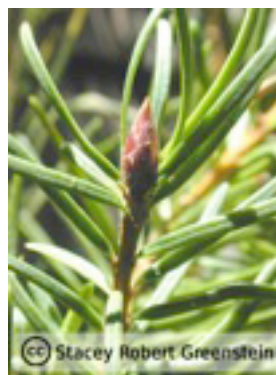
D: Douglas-fir needles

Analyzing the Evidence

Record details for each exhibit that support the suggestion that Jane Doe's body was moved after her death. Rate the strength of the evidence as Strong (S), Medium (M) or Weak (W). Identify alternative explanations for the evidence that suggest that the body was NOT moved after death. Rate the plausibility of each alternative explanation as Very Plausible (VP), Somewhat Plausible (SP) or Not Plausible (NP).

Exhibits	Evidence supporting the conclusion that the body was moved after her death	Alternative explanations suggesting that the body was NOT moved after her death
A: Pollen Grains	S M W	VP SP NP
B: Pine needles	S M W	VP SP NP
C: Grass fragments	S M W	VP SP NP
D: Douglas-fir needles	S M W	VP SP NP

Choosing the Most Convincing Exhibit

Justify which of the four exhibits provides the most convincing evidence that the body might have been moved. A convincing exhibit will be more **strongly supported** and have **low plausibility of alternative explanations.**

I think Exhibit A   B1   B2   C (circle one) provides the most convincing evidence that the body might have been moved because

Some of the other Exhibits are believable because

In light of all the evidence, I chose Exhibit A   B1   B2   C (circle one) over the others because ...

Assessing the Analysis

Use this rubric to assess each student's response to Activity sheet #1, Analyzing the Evidence.

	Accomplished	Good	Basic	In progress
Identifies relevant and important details	Identifies the most important and relevant details.	Identifies relevant details including most of the important ones in the documents.	Identifies some relevant details, but important ones are omitted.	Identifies few relevant details.
Offers justifiable ratings	All ratings are highly justifiable in light of the evidence.	Most ratings are clearly justifiable in light of the evidence.	Generally the ratings are somewhat justifiable in light of the evidence	Most rating ratings are not justifiable given the evidence.
Comments				

Assessing Choice and Justification

Use this rubric to assess each student's response to Activity sheet #2, *Choosing the Most Convincing Exhibit*.

	Accomplished	**Good**	**Basic**	**In progress**
Identifies evidence for the choice	Identifies the most important evidence for the choice.	Identifies most of the important evidence for the choice.	Identifies some relevant and important evidence for the choice.	Identifies no relevant evidence for the choice.
Identifies evidence for other choices	Identifies the most important evidence for other choices	Identifies most of the important evidence for other choices	Identifies some relevant and important evidence for other choices	Identifies no relevant evidence for other choices
Offers a plausible justification	Offers a highly plausible justification of why the selected choice is the most reasonable.	Offers a clear justification of why the selected choice is the most reasonable.	Offers a somewhat plausible justification of why the selected choice is the most reasonable.	Offers an implausible justification of why the selected choice is the most reasonable.
Comments				

LESSON 5: Tsunami Victim Search

Critical challenge: Drawing on the records of 12 victims of a tsunami disaster, rank order the three most likely matches with the description of the missing daughter of Esther Yang Brewer.

OVERVIEW

In this lesson, students learn that forensics apply not only to criminal cases but to mass fatalities as well. Students attempt to identify the body of a missing person based on details provided by the person's mother from the identification records of 12 potential matches. To begin, students work in pairs to review summary data from four of the potential matches, looking to see which of these victims mostly closely fits with the description of the missing person. Joining in a team with students who have examined the other eight victim records, each team presents it conclusions about the most likely match. Individually, students rank order the three prime matches and prepare a brief written justification for their choice of the most likely match with the missing person. Students share their conclusions with the rest of the class.

LEARNING OUTCOMES

• identify physical features that make us unique
• distinguish between bodily features we can change and ones we cannot change
• interpret clues when analyzing data

PRIOR KNOWLEDGE

• basic understanding of forensics
• an introductory knowledge of natural disasters and mass fatalities
• basic understanding of what forensic anthropologists do

Suggested activities

PREPARATION

• Photocopy one set per student pair of the *'Missing Person' Package* below:
  - Information_sheets_#1.pdf, *Antemortem Record: Teresa Brewer*
  - Information sheet #2, *Postmortem Records*
• Photocopy one sheet per student of the following:
  - Activity sheets #1a and #1b, *Identifying Potential Matches*
  - Activity sheet #2, *Selecting the Most Likely Match*
  - Activity sheet #3, *Assessing the Conclusions*

Introduce the lesson

Explain to students that they will:
• act as forensic experts involved in the identification of human remains following a natural disaster, and
• follow procedures involving a realistic, but fictional scenario in which a mother is trying to locate her missing daughter.

Introduce criteria for identification

Help students understand how forensic experts identify individuals by inviting them to imagine that one of the staff members at your school is believed to be a thief. They must decide whether or not the clues you provide suggest that you could actually be the thief. Write the following four headings on the board:
• Features that clearly eliminate me as the thief
• Features that suggest I might not be the thief
• Features that suggest I could be the thief
• Features that clearly match me and the thief

Provide students with five or six clues about the mystery thief (e.g., is male [or female], has dark [light] hair, is over 20 years old, is right-handed, left behind keys to your school). After each clue, ask students to determine under which category each feature belongs. Include easily changed features (such as a hair colour different from your own) or very common features (such as height) to illustrate that some clues are inconclusive. Provide other clues that refer to features that are unique (e.g. a space between two front teeth known as a diastema) or unusual (e.g. a distinctive tattoo) to illustrate the idea of positive identification.

Conclude this part of the activity by informing students that there are only two types of physical features that can positively identify us – dental records and fingerprints. All other physical features of the body can change or can be similar to other people.

Introduce the scenario

Inform students that there has been a tsunami off the coast of Thailand. Several thousand people have drowned or gone missing as a result. Esther Yang Brewer has traveled from Canada to Bangkok to try to find her daughter who was visiting Thailand at the time of the tsunami. When Esther arrives at the airport, she is confronted with a 'living board' where people have posted photos of their loved ones in the hopes that someone has seen the missing person. She hangs a photo of her daughter, Teresa Brewer, on the board.

In other parts of Thailand, photos of recovered bodies are displayed on 'death boards' hanging outside three temporary morgues. In many cases it is difficult to recognize the bodies, so family members must often look for identifiable features, such as familiar jewelry or tattoos.

Esther is directed to the Canadian embassy where she fills in an antemortem record, with the assistance of family liaison officers, to aid in locating and identifying her daughter's body in case she has been killed in the tsunami.

In the meantime, the Red Cross, military personnel and civilian agencies continue to try to locate and identify the human remains of tsunami victims. They have been working to build a database of records for use in the identification process. Based on the description provided by Esther, these officials have assembled a summary chart of the records of 12 potential matches with her daughter.

Organize students into teams

Invite students to work in teams of six to analyze the chart of 12 victims' postmortem records (see the *Postmortem Records* – Information sheet #2). Explain that each student pair within a team will examine four records from the list of 12:

Student pair A – Records #1-4
Student pair B – Records #5-8
Student pair C – Records #9-12

Identify potential matches

Provide student pairs with the '*Missing Person' Package* (one set per 2 students). Inform them that it contains all the documents they require to make a decision about which of their four assigned victim records (see Information sheet #2) best matches the description of Teresa Brewer given by her mother (see Information sheets #1, *Antemortem Record: Teresa Brewer*).

Ask students to select the "best match" by deciding which record has the most features that best fit the missing person's description and no features that eliminate the person.

To assist students in this task, distribute Activity sheet #1a and 1b, *Identifying Potential Matches*.
Ask them to review the nine features (displayed in columns) provided for each of **their** four potential matches. Using the description provided by Teresa's mother, (see *Antemortem Record: Teresa Brewer*), ask students to determine the degree of match for every feature between their four assigned individuals and the missing person. Ask students to indicate their assessment of the match for each feature by placing a check mark in the appropriate box and to explain their reasoning on *Identifying Potential Matches*. Instruct student pairs to put a large star next to the record number of their 'best match' once the chart is complete. (If two victims' records are seen to match equally, direct students to star both possibilities.)

Display Activity sheet #3, *Assessing the Conclusions* rubric, and discuss the expectations for this initial assignment: (1) identify the most significant details from the missing person's description, and (2) offer reasonable conclusions about the extent to which each of the nine features conclusively eliminates or fits the missing person and offers plausible reasons for these assessments.

Share conclusions with the rest of the team

Direct the three student pairs in each team to combine together to discuss all 12 records of human remains. Invite each pair to present its 'best match' explaining the factors used to make this decision. Encourage other team members to take notes on the chart in Activity sheet #2, *Selecting the Most Likely Match*, since they will be using this information to determine a best match overall. If teams present more than one match, instruct all team members to listen carefully to each rationale and choose the one they feel is the best match.

Rank order the possible matches

Ask students independently to rank order the three best matches presented by their team. Invite them to present their results and rationale for their ranking in paragraph form on Activity sheet #2. Display Activity sheet #3, *Assessing the Conclusions* rubric, and discuss the expectations for the final assignment based on the criteria. Remind students to explain how Teresa's changeable and unchangeable features came into play in their decision.

NOTE: If there are students who tell you they believe they have better matches than those presented by their team, consider allowing them to compare those. They will likely be more invested in the task.

ASSESSMENT

Assess student's analysis of the potential matches with the missing person using Activity sheet #3, *Assessing the Conclusions*, according to three criteria:

- recognize significant details from the missing person's description;
- assess the extent to which each feature conclusively eliminates or fits the missing person;
- provide a plausible explanation supported by relevant and accurate data for the most likely match.

Note to teachers

Possible answers for this challenge are victim records numbered:

2, 4, 6, 7, 9, 12. Other answers are definitively not possible.

Extension Activities

Arrange for students to carry out the activities of the Virtual Museum's forensic website that pertain to biological profile. www.sfu.museum/forensics/eng/analysez-analyze/profil-profile
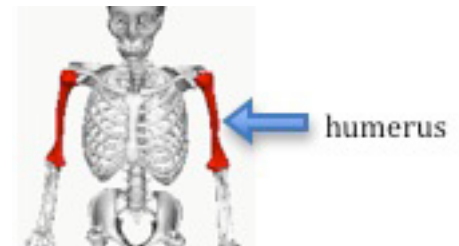
humerus

Math activity: On occasion, forensic anthropologists will estimate a person's stature, or height, based on the length of their bones. In this case we will use the humerus. Invite students to carry out the following steps

Create a mathematical equation that estimates a person's height from the humerus.

> **Step 1:** With a partner's help and metre stick, estimate the length of your humerus (from the knot at your elbow to the knot at your shoulder). Measure your height as well.
>
> **Step 2:** Follow the 3 steps in the diagram below:

1. Place your height along the y-axis.

3. Connect the two points using a straight line.

height (cm)

length (cm)

2. Place the length of your humerus along the x-axis
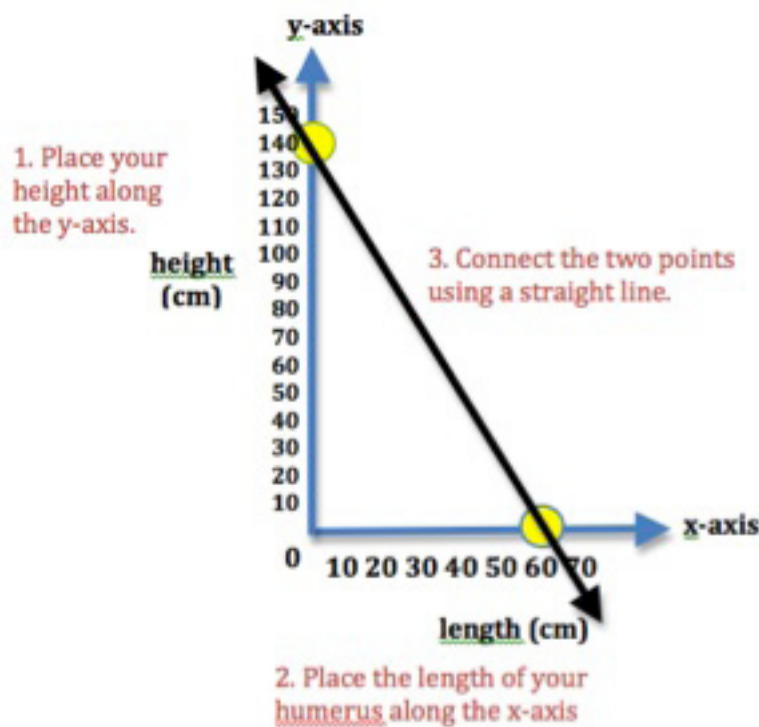
Enter your measurements in the appropriate place on the graph. (Using graph paper will make this task easier.)

Step 3: Create the mathematical formula.
a) Calculate the slope of the line using the following equation:

$$\text{Slope} = \frac{\text{rise}}{\text{run}}$$

An easy way to calculate this is to use your height as the 'rise' value and the length of your humerus as the 'run' value. In other words,

$$\text{Slope (m)} = \frac{\text{your height}}{\text{the length of your humerus}} = \frac{140 \text{ cm}}{65 \text{ cm}} = \textbf{2.15}$$

b) Determine the equation of the line **y = mx + b**, where:
  y = the height of the person,
  m = the slope of the line calculated above,
  x = the length of the person's humerus, and
  b = the y-intercept on a graph of the line.
In our example, **y = 2.15x + 140**

Step 4: Encourage students to try out their equations on each other by calculating height from the length of their humerus. Which students have found the most accurate equation? Invite students to explain why that equation is the most accurate. What happens if you use several students' measurements to create the equation instead of just one? How does the age of your students affect the results?

TERMS:
anthropology
human remains
mass fatality
natural disasters
postmortem

Antemortem Record

Missing Person Number/Code: **226**
(Use unique numbering and include it on associated
files, photographs or stored objects.)

Interviewer name: **J.L. Davies**

Interviewer contact details: **Red Cross, Temporary Morgue, Phuket**

Interviewee(s) name(s): **Esther Yang Brewer**

Relationship with missing person: **Mother**

Contact details

Address: **157 Main Street, Centre City, MB Canada**

Telephone: **(999) 222-5103**   **E-mail:** **eybrewer@myemail.ca**

Contact person for missing person, if different from above: (who to contact in case of news: name/contact details)

David Brewer (father)
phone: 999-222-7785

Annex 2. Missing Persons Form (continued)

MP N°./Code: __226_____ **Missing Persons Data**

A. PERSONAL DETAILS

A.1	Missing person's name	Include surname, father's and/or mother name, nicknames, aliases: **Teresa Brewer Mother: Esther Yang Brewer**				
A.2	Address/Place of residence	Last address & usual address if different from the former: **157 Main Street, Centre City, NB Canada**				
A.3	Marital status	(Single)	Married	Divorced	Widowed	Partnership
A.4	Sex	Male	(Female)			
A.5	If female	Unmarried name:				
		Pregnant	Children	How many?		
A.6	Age	Date of birth: **October 17, 1984**		Age: **21**		
A.7	Place of birth, nationality, principal language	**Shang Hai China, Chinese Canadian, English**				
A.8	Identity document (Main details, N°, etc.)	If available, enclose photocopy of ID **Canadian Passport No. 106695**				
A.9	Fingerprints available?	Yes	(No)	Where:		
A.10	Occupation	**Student**				
A.11	Religion	**n/a**				

B. EVENT
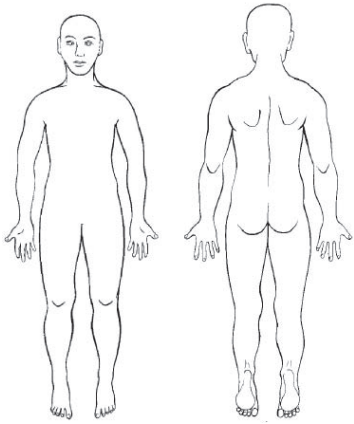
B.1	Circumstances leading to disappearance: (use additional sheet if necessary)	Place, date, time, events leading to disappearance, other victims and witnesses who last saw Missing Person alive (incl. name and address): **Traveling around Indonesia before returning for school in Canada in January; Last email 12/21/04 mentions Phuket, planning to head to the smaller islands in the next couple of days**	
	Has this case been registered/ denounced elsewhere?	Yes (No)	With whom/Where:
B.2	Are other family members missing, and if so, have they been registered/identified?	List name, relationship, status: **n/a**	

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MP N°/Code: __226_____ **Missing Persons Data**

C. PHYSICAL DESCRIPTION

C.1	General description (indicate exact measure, or approximate AND circle the corresponding group)	Height (exact/estimated?): **approx. 155cm**	Short	Average	Tall
		Weight: **~ 50kg**	Slim	(Average)	Fat
C.2	Ethnic group/Skin color	**Asian and Caucasion features/fair skin**			
C.3	Eye color	**brown**			

C.4						
	a) Head hair	Color: **dark brown**	Length: **shoulder**	Shape:	Baldness:	Other:
	b) Facial hair	(None)	Moustache	Beard	Color:	Length:
	c) Body hair	Describe **n/a**				

C.5	Distinguishing features **Physical** e.g. shape of ears, eyebrows, nose, chin, hands, feet, nails; deformities	Continue on additional sheets if needed. Use drawings and/or mark the main findings on the body chart. • **No distinguishing features**
	Skin marks scars, tattoos, piercings, birthmarks, moles, circumcision, etc.	• **pierced ears**
	Past injuries/ amputations include location, side, fractured bone, joint (e.g., knee), and if person limped	• **No significant injuries**
	Other major medical conditions operations, diseases, etc.	• **Celiac's disease**
	Implants pacemaker, artificial hip, IUD, metal plates or screws from operation, prosthesis, etc.	• **n/a**
	Types of medications used at time of disappearance	• **n/a**

53
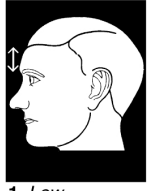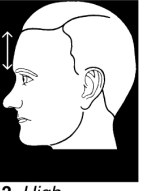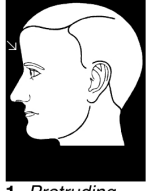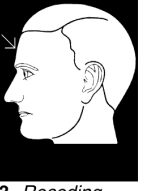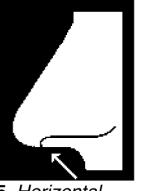
MP N°/Code: **226** _____ **Missing Persons Data**

SILHOUETTE SKETCH

Please choose the appropriate sketches and mark items on D1 and D2

34 | **02 Head form, front (Shape of head from front)**

1 Oval **2** Pointheaded **3** Pyramidal **4** Circular **5** Rectangular **6** Quadrangular

03 Head form, profile (Shape of head from side)
|<->| |<--->| |<----->|

1 Shallow **2** Medium **3** Deep

37 | **01 Forehead - Height/Width**

1 Low **2** Medium **3** High **4** Narrow **5** Medium **6** Wide

02 Forehead - Inclination

1 Protruding **2** Vertical **3** Receding **4** Receding clearly

40 | **03 Nose - Curve/Angle**

1 Concave **2** Straight **3** Convex **4** Turned down **5** Horizontal **6** Turned up

42 | **02 Ear lobes**

1 Not attached **2** Attached

MP N°/Code: 226 _____   **Missing Persons Data**

|		
C.6	**Dental condition** Please describe general characteristic, especially taking into account the following: • Missing teeth • Broken teeth • Decayed teeth • Discolorations, such as stains from disease, smoking or other • Gaps between teeth • Crowded or crooked (overlapping) teeth • Jaw inflammation (abscess) • adornments (inlays, filed teeth etc) • any other special feature **Dental treatment** Has the Missing Person received any dental treatment such as • Crowns, such as gold-capped teeth • Color: gold, silver, white • Fillings (incl. color if known) • False teeth (dentures)-upper, lower • Bridge or other special dental treatment • Extraction Also indicate wherever there is uncertainty (for example, the family member may know that an upper left front tooth is missing, but is unsure which one).	**• normal teeth** **• white teeth** **• a few cavities with silver coloured fillings**

If possible, use a drawing, and/or indicate the described features in the chart below

If the missing person is a child, please indicate which baby teeth have erupted, which have fallen out and which permanent teeth have erupted and use the chart below
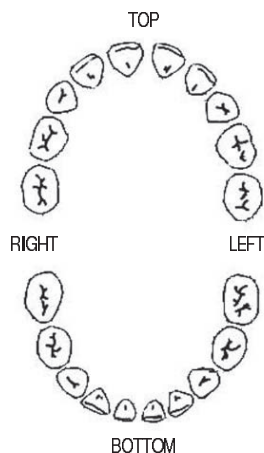
BABY/PRIMARY TEETH   ADULT/PERMANENT TEETH
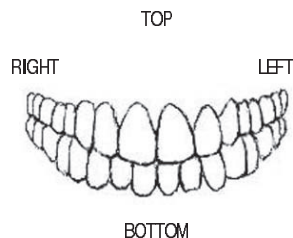
Annex 2. Missing Persons Form (continued)

MP N°/Code: ___226_____ **Missing Persons Data**

D. PERSONAL EFFECTS

D.1	**Clothing** (worn when last seen/at time of disaster)	Type of clothes, colors, fabrics, brand names, repairs: describe in as much detail as possible. **• cotton fabrics, bright colours** **• no special brand name**
D.2	**Footwear** (worn when last seen/at time of disaster)	Type (boot, shoes, sandals), color, brand, size: describe in as much detail as possible. **• sandals, summer shoes** **• size 7 Canadian**
D.3	**Eyewear**	Glasses (color, shape), contact lenses: describe in as much detail as possible. **• n/a**
D.4	**Personal items**	Watch, jewelry, wallet, keys, photographs, mobile phone (incl. number), medication, cigarettes, etc: describe in as much detail as possible. **• watch, gold necklace with heart pendant** **• backpack purse, wallet with photos and money**
D.5	**Identity documents** (which the person was/might have been carrying when last seen/at time of disaster)	Identity card, driving license, credit card, video club card, etc. Take photocopy if possible. Describe the information contained. **• Canadian passport** **• VISA credit card**
D.6	**Habits**	Smoker (cigarettes, cigars, pipes), chewing tobacco, betel nut, alcohol, etc. Please describe, incl. quantity. **• n/a**
D.7	**Doctors, medical records, X-rays**	Give details of doctor, dentist, optometrist, or other. **• has just been diagnosed with Celiac's disease**
D.8	**Photographs of missing person**	If available, enclose photos or copies of photos as recent and clear as possible, ideally smiling (with teeth visible). Also, photos of clothing worn when disappeared. **See attached**

Note: The information collected in this form will be used for the search and identification of the missing person. Its content is confidential and any use outside of the intended context will need explicit consent by the interviewee.

MP N°/Code: __226_____ **Missing Persons Data**

Missing Person: Teresa Brewer

Postmortem Records

Information collected by the forensic pathologist, forensic anthropologist and forensic odontologist

Victim Record #	Age range	Ancestry*	Eye colour	Hair colour	Hair type	Dental traits	Height (cm)	Tattoos, scars, birthmarks	Personal effects	Clothing
1	15-20	African	brown	black	curly	none	150cm	none	none	green bathing suit
2	18-25	Asian	brown	brown hair with red highlights	straight	none	157cm	none	silver chain with opal pendant	grey shirt and white skirt, brown sandals
3	50-60	Asian	hazel	brown	straight	dentures	151cm	surgical scar – right knee	watch, gold necklace, wedding band on left hand ring finger	white and red bathing suit
4	18-25	European	brown	chestnut brown	straight	none	153cm	butterfly tattoo – left hip	watch, silver ring on right hand ring finger	blue shirt and jean shorts
5	40-50	European	blue	blonde	curly	bridge	160cm	none	wedding band on left hand ring finger	black blouse, black pants
6	20-30	European	brown	brown	straight	none	152cm	heart tattoo, back of neck	none	white blouse, multi-coloured skirt, white shoes
7	18-25	Asian	hazel	died blonde	straight	none	153cm	none	Thai necklace	multi-coloured bathing suit and white wrap
8	15-20	African	brown	dark brown	curly	none	157cm	none	watch, gold chain	blue shorts and white t-shirt
9	20-30	European	brown	brown	straight	none	156cm	none	none	yellow t-shirt and yellow skirt
10	30-45	African	green	red	curly	dentures	155cm	birthmark on right inner thigh	gold watch, 2 gold rings on middle and ring finger	red shirt and black shorts, brown sandals
11	20-30	European	blue	blonde with blue streaks	straight	none	155cm	small scar on right shoulder	wedding band on left hand ring finger	black bathing suit
12	18-25	Asian	brown	black	straight	none	154cm	none	2 gold chains, 1 diamond ring on the left middle finger	pastel coloured sun dress

* Note: Due to putrefaction, bloating and liquefaction in tropical climates, it is almost impossible to make out facial features as the body decomposes. Consequently, having a column based on 'Ancestry' is merely for exercise purposes.

Identifying Potential Matches

Feature	Victim record #	Victim record #	Victim record #	Victim record #
Age range	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**
Ancestry	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**
Eye colour	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**
Hair colour	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**
Height (cm)	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**

Identifying Potential Matches

Feature	Victim record #	Victim record #	Victim record #	Victim record #
Wisdom teeth	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**
Tattoos, scars, birthmarks	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**
Personal effects	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**
Clothing	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**	☐ clearly eliminates our individual ☐ may not be our individual ☐ could be our individual ☐ clear match with our individual **Reason:**

Selecting the Most Likely Match

Rank order the three human remains presented by your team in terms of their likely match with Esther Yang Brewer's daughter.

	Victim record #	Victim record #	Victim record #
Features that clearly eliminate our individual			
Features that may not be our individual			
Features that could be our individual			
Features that clearly match our individual			
Ranking #			

MY CONCLUSION

In one or two paragraphs, provide a plausible explanation supported by relevant and accurate data for your choice as the best match with the missing person. (Continue on the back of this page.)

Assessing the Conclusions

Use this rubric to assess student responses on Activity sheet #1, Identifying Potential Matches and Activity sheet #2, Selecting the Most Likely Match.

	Accomplished	**Good**	**Basic**	**In progress**
Identifies significant details	Identifies the most significant details from the missing person's description.	Identifies most of the significant details from the missing person's description.	In some cases, offers a reasonable identification of the flaw(s) present in the report	Requires assistance to identify the flaw(s) present in the report
Assesses implications for conclusive identification	For every feature, offers a very reasonable assessment of the extent to which it conclusively eliminates or fits the missing person.	For most features, offers a reasonable assessment of the extent to which it conclusively eliminates or fits the missing person.	For many features, offers a somewhat reasonable assessment of the extent to which it conclusively eliminates or fits the missing person.	Offers few correct assessments of the extent to which the feature conclusively eliminates or fits the missing person.
Provides plausible explanation for most likely match	Explanation is very plausible and clearly supported by very relevant and accurate data.	Explanation is generally plausible and supported by relevant and accurate data.	Explanation is plausible, but supported with minimal relevant and accurate data.	The explanation is either not plausible or lacks any support from relevant and accurate data.
Comments				

LESSON 6: Find the Flaws

Critical challenge: Considering five techniques used by forensic archaeologists, identify and address the flaws in a fictional police report about a mass gravesite.

OVERVIEW
In this challenge, students learn about the investigative and reporting techniques used by forensic archaeologists. To begin, students apply five archaeological concepts to simple situations and record their results. Next, they assume the role of a forensic archaeologist and assess nine excerpts from a fictional police report about a mass gravesite. Their final task is to identify and explain the nature of the flaws and suggest improvements for each excerpt.

LEARNING OUTCOMES
- develop an appreciation for the investigative techniques used by forensic archaeologists
- recognize when data is unclear, inaccurate, incomplete or unsupported and demonstrate the ability to improve it

PRIOR KNOWLEDGE
- general knowledge about forensic archaeology

Suggested activities

PREPARATION
- Photocopy one sheet per student of the following:
  - Information sheet #1, *Aerial Photo*
  - Information sheet #2, *Police Sketches*
  - Activity sheet #1a and #1b, *Five Forensic Techniques*
  - Activity sheet #2a, #2b and #2c, *Find the Flaw and Fix It*
  - Activity sheet #3, *Assessing the Critique*

Prepare Information sheet #1, *Aerial Photo* for display on a projector or via alternative means.

CREATE MINDSET
Display Information sheet #1, Aerial Photo to the class. Invite students to offer their initial impressions of the image using the 5W's (who, what, where, when, why) and to justify their inferences with evidence from the image. After some initial discussion, explain that this photograph was taken in a war zone where several people had gone missing. Invite students to share what more they notice about the image. Ask how their observations and inferences changed once they received this new information. Explain that the lenses through which we view things affect *what* we see and *how* we see them. In this challenge, students will learn to see and assess excerpts taken from a police report through the eyes of a forensic archaeologist.

Provide the hypothetical scenario

Invite students to imagine that several people have gone missing as a result of violent conflict between two neighbouring villages in a war-torn country. The UN has called in a forensic expert to assess the quality of a report compiled by local police. Inform students that they will take on the role of the forensic archaeologist and evaluate excerpts from the report by considering the proper use of five archaeological techniques. First, students will learn about the techniques, and then identify the flaws and suggest improvements for selected excerpts from that report.

Introduce the forensic techniques

Organize students into groups of three. Provide everyone with a copy of Activity sheet #1a and #1b, *Five Forensic Techniques*. Ask the groups to read and discuss each technique and complete the associated task before moving on to the next technique. Invite students to share their solutions with the class. Alternatively, form five expert groups of students who work together to comprehend and present each of the techniques to the class. Invite non-presenting groups to carry out the task after the presentation, asking the presenters for assistance when needed. (This format will take more time than the one above).

In either case, encourage class members to comment on the suggested answers. Discuss in further detail those techniques that students found particularly challenging.

Carry out the challenge

Provide each student with copies of Activity sheets #2a, #2b and #2c, *Find the Flaw and Fix It*. Explain that the excerpts from a flawed police report are found in the first column and the criteria for expert reporting are listed in the second column. Invite each group to assess the nine excerpts noting that effective reports are *clear, accurate* and *complete*. Encourage students to review all of the techniques as they consider how each excerpt may be flawed, that is, whether they are *unclear, inaccurate* or *incomplete*. Instruct students to identify and explain the nature of the flaws (column 2), and suggest how they can be improved (column 3). Prior to beginning the task, review with them the criteria for assessment found in Activity sheet #3, *Assessing the Critique*.

ASSESSMENT

Assess students' responses recorded in their *Find the Flaw and Fix It* chart using Activity sheet #3, *Assessing the Critique*. According to this rubric the assignment is assessed on three criteria:

• identifies reasonable flaw(s) in each excerpt
• provides a clear, plausible explanation of each flaw
• suggests improvements that are consistent with proper forensic techniques

Extension activities

- Encourage students to learn when to document, collect and disregard items from a crime scene in the following online activity:

  www.sfu.museum/forensics/eng/identifiez-identify/

- Prepare to display the extension activity images on the projector. Ask students to sit in pairs, where one person has his/her back to the screen and is holding a pen or pencil, a blank sheet of paper and has a hard surface to draw on. Ask the other partner to sit facing the screen and to describe what they see. As the scene is being described, invite the students with the paper to draw what they hear. After 5-8 minutes, invite the artists to do the activity again on a second piece of paper, except this time their partners must provide details according to archaeological techniques, e.g. stratigraphy, provenience, etc. When they have finished their second sketch, ask the artists to turn around and compare both their images with the one on the screen. Invite partners to discuss why the scenes are different and why they are similar. How must the descriptions be modified when using the archaeological techniques?

Instruct students to change places, display the second image and repeat the steps above.

www.sfu.museum/forensics/eng/pg_media-media_pg/archaeologie-archaeology/video/

REFERENCES

- Nawrocki S (1996). An Outline of Forensic Archeology. University of Indianapolis Archeology & Forensics Laboratory (http://archlab.uindy.edu).

TERMS:

anthropology
mass graves
provenience
in situ
stratigraphy

Aerial Photo

Police Sketches

1. MASS BURIAL (PLAN VIEW)

Treed area

bulldozed area
- discoloured ground

clearing

Spanish
dictionary

hole: 3m x 3m;
2m deep

shell casings
64°51'24.06" N
94°16'07.75" W

Treed area
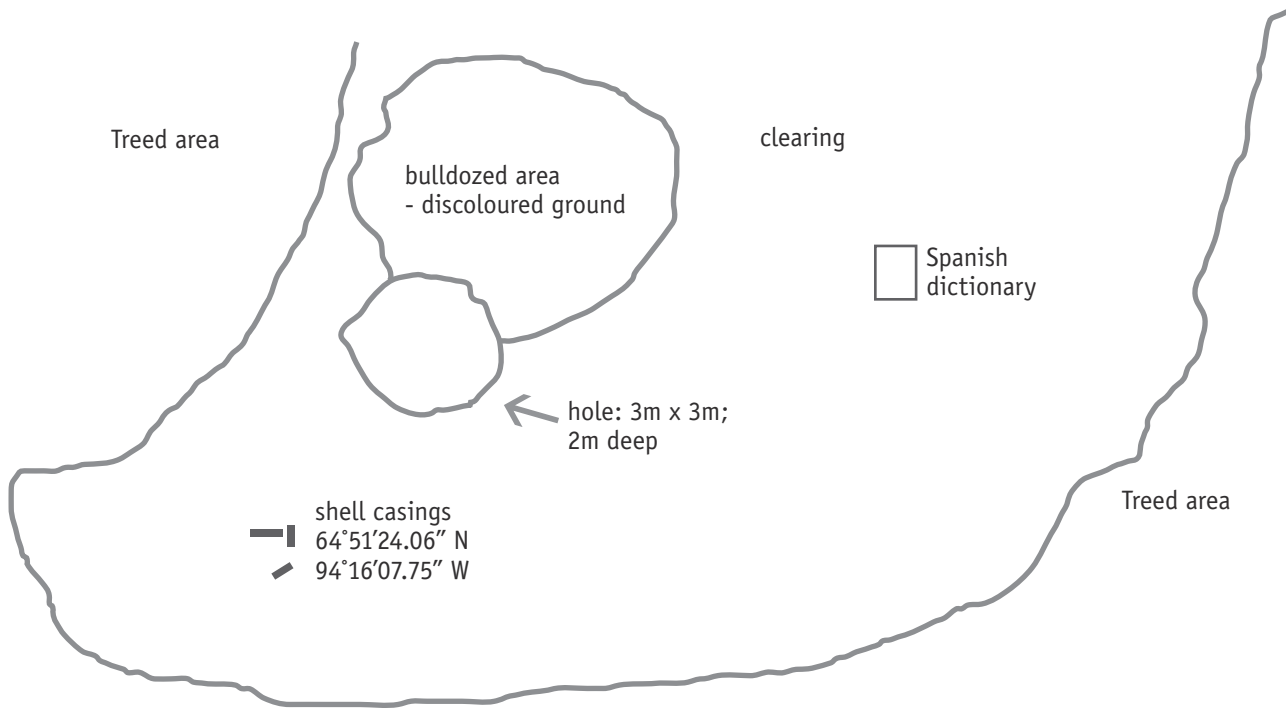
2. STRATIGRAPHY ('SECTION VIEW' OR 'SIDE VIEW')

Police investigation pit

Mass burial site

above ground

below ground
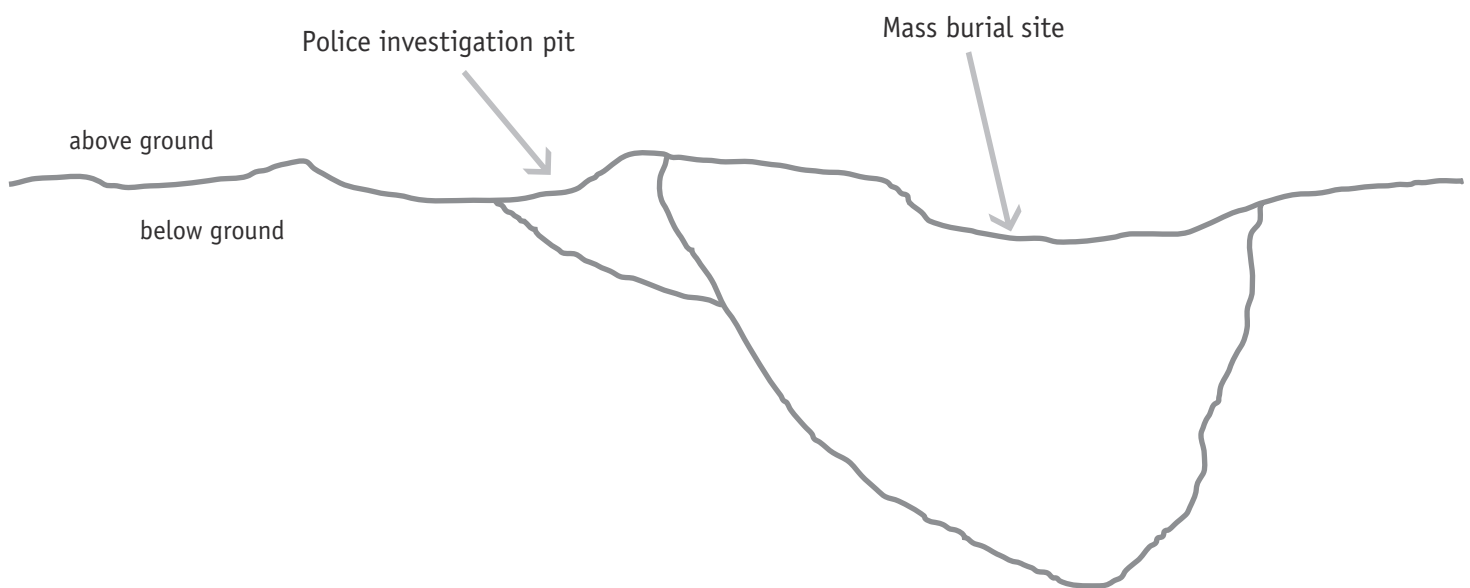
Five Forensic Techniques

1. Attention to stratigraphy

Professional forensic archaeologists study the strata (layers) of a site to figure out the order of events at the scene. Rock, soil, plants, human structures and criminal evidence accumulate over time. In the same way you would find yesterday's shirt near the top of your dirty laundry basket and last week's jeans at the bottom, archaeologists expect to find recently deposited evidence near the top layer of a site and older items in lower positions. Items in the same layer have usually been deposited at the same time. Evidence and layers that seem out of place are often signs that the site has been disturbed. In recording the stratigraphy, a forensic expert:

• is careful to record the precise relationship of the layers of objects (clear),

• ensures that the layers are accurately reported in the correct sequence (accurate), and

• reports the stratigraphy of all pieces of evidence when appropriate (complete).

TASK: *Create a carefully labelled diagram of the layers of the contents inside your desk (or elsewhere in the classroom) and suggest plausible inferences about the reasons for the sequence of the items.*

2. Recording of provenience

Once a site has been excavated, it cannot be restored to its original state. For this reason, forensic archaeologists carefully measure and record the provenience (exact location) of each piece of evidence as it is found. Depending on the size and nature of the site, the archaeologist might use a baseline, grid, aerial photo or other method to map the site and locate each item. Important mapping details include a north arrow, datum, scale, date and author. Unlike regular, 2-dimensional maps, provenience is 3-dimensional, including the surface coordinates and either the height or the depth where an item was found. In some cases, provenience also includes notes about the original source of an item, such as a receipt that can be linked to a restaurant in a certain town. In recording the provenience, a forensic expert:

• is careful to record the precise location of the objects (clear),

• ensures that the distances and positions are accurately reported (accurate), and

• records the provenience of **every** piece of evidence (complete).

TASK: *Create a precisely labelled diagram describing your current location in the classroom that includes measurements and at least four reference points.*

3. Recovery of all evidence

An expert forensic investigation includes careful collection of all the evidence at a scene, not only by the forensic archaeologist but also by an entire team of forensic experts. This recovery includes remains (human body parts and fluids), artifacts (items used by a person) and conditions (such as broken branches or footprints in soil). Because items such as bone fragments and teeth can be extremely small, archaeologists frequently use wire screens to sift the soil and brushes to dust it away. As each piece of evidence is found, the archaeologist numbers it in sequence, takes a photograph and determines whether

it is should be (1) simply documented because there is no further information that it is likely to reveal, (2) documented and collected for more study in the lab, or (3) left alone because it is irrelevant to the case. To document an item, the archaeologist takes detailed notes and photos before allowing it to be put back or collected. In recording the recovered evidence, a forensic expert:

• is careful to record how the pieces of evidence were documented and collected (clear),

• accurately documents precise details of the items (accurate), and

• documents and/or collects all potentially relevant pieces of evidence (complete).

TASK: *The items listed below were found in your classroom early one morning after someone broke into and vandalized your school the previous night. Provide details about how you would treat each object, whether it should be (1) documented, (2) document and collected for further analysis, or (3) left alone because it has no relevance to the case.*

• *chalk*

• *a screwdriver*

• *an iPod*

• *mud on the floor*

• *can of spray paint*

4. Decisions about place

Forensic archaeologists make thoughtful decisions about whether or not a piece of evidence is "in situ" (in its **original** place). To do this, archaeologists look for signs of natural and unnatural disturbances—a natural disturbance would be something that was brought about entirely by the normal forces of nature, and an unnatural disturbance would have been influenced at least partly by some other cause. Uneven ground, burned areas or new plant growth may be an unnatural disturbance if they resulted from someone moving objects into the area from somewhere else. In recording conclusions about the origins of objects, a forensic expert:

• is careful to note precise details of the placement of objects in relation to their surroundings (clear),

• ensures that all relevant disturbances are accurately reported (accurate), and

• includes all potentially relevant details regarding natural and unnatural disturbances (complete).

TASK: *Following a break-in at a neighbouring house, which of the following disturbances most likely indicates that evidence has been moved from its original place and is no longer "in situ"? Provide plausible explanations for your choice.*

• *uneven ground beneath a large tree*

• *broken branches on a shrub beneath your window*

• *paint chips on the ground next to the back shed*

• *paint chips on the ground next to the back door*

5. Limited damage

Careful handing of the evidence is critical. If the remains and artifacts are going to be removed from the site, the expert carefully labels (providing provenience details) and packs them into sturdy containers for shipping. Scratches, breaks and holes in bones and other fragile pieces of evidence can provide crucial information - as long as the damage happened during the original crime, not the current investigation. To limit new damage, a professional archaeologist works slowly and carefully, often using small hand tools such as brushes and trowels rather than bulldozers or other large machines. In recording information about the handling of objects, a forensic expert:

• records details of the methods selected to extract evidence so as not to damage any objects (accurate),

• records the precise details of any damage that may have occurred in the excavation and handling of the objects during the investigation (clear and complete)

TASK: *Carefully describe an efficient extraction method that is not likely to damage potential evidence for each of the following situations:*
• *Looking for a post-it note buried just below the grass in front of a house*
• *Finding a needle in a haystack*
• *Looking for a possible body buried a metre or deeper in a large empty lot*

Assessing the Critique

	Accomplished	Good	Basic	In progress
Identifies the flaw(s) in each excerpt	In every case, offers a very reasonable identification of the flaw(s) present in the report	In the majority of cases, offers a reasonable identification of the flaw(s) present in the report	In some cases, offers a reasonable identification of the flaw(s) present in the report	Requires assistance to identify the flaw(s) present in the report
Provides clear, plausible explanations	In every case, provides very clear and plausible explanations for the identified flaws	Consistently provides clear and plausible explanations for the identified flaws	Provides some plausible explanations for the identified flaws	Requires assistance to provide clear and plausible explanations for any of the identified flaws
Suggests improvements consistent with proper forensic techniques	In every case, suggests solutions to the flaw that are clearly consistent with proper forensic techniques	In the majority of cases, suggests solutions to the flaw that are consistent with proper forensic techniques	In some cases, suggests solutions to the flaw that apply proper forensic techniques	Requires assistance to apply proper forensic techniques to the flaw
Comments				

Find the Flaw and Fix It

Check off any flaws that you notice for each excerpt (or sketch) and explain why the excerpt (or sketch) is flawed.

Applying appropriate forensic techniques, tell how to improve the information that is recorded in the excerpt using examples.

Excerpt from the police report

Find the flaws in sketch #1 entitled, 'Mass burial' on Information sheet #2.

Flaws

- [ ] Vague/unclear
- [ ] Inaccurate
- [ ] Incomplete
- [ ] Not supported
- [ ] Other

"There was a fairly large hole, about the size of a car, on the edge of the forest. See the labeled diagram, 'Mass burial'."

Flaws

- [ ] Vague/unclear
- [ ] Inaccurate
- [ ] Incomplete
- [ ] Not supported
- [ ] Other

"A piece of green Rebel clothing was found 10m from the hole."

Flaws

- [ ] Vague/unclear
- [ ] Inaccurate
- [ ] Incomplete
- [ ] Not supported
- [ ] Other

Excerpt from the police report

"A Spanish dictionary containing the name Olga was sitting on top of the tree stump directly North of the hole. See sketch #1 entitled, 'Mass burial'."

"Shell casings used by the Rebels were found at these coordinates: 64°51'24.06" N 94°16'07.75" W"

Find the flaws of sketch #2 entitled, 'Stratigraphy' on Information sheet #2.

Check off any flaws that you notice for each excerpt (or sketch) and explain why the excerpt (or sketch) is flawed.

Applying appropriate forensic techniques, tell how to improve the information that is recorded in the excerpt using examples.

Flaws

☐ Vague/unclear
☐ Inaccurate
☐ Incomplete
☐ Not supported
☐ Other

Flaws

☐ Vague/unclear
☐ Inaccurate
☐ Incomplete
☐ Not supported
☐ Other

Flaws

☐ Vague/unclear
☐ Inaccurate
☐ Incomplete
☐ Not supported
☐ Other

Excerpt from the police report

Check off any flaws that you notice for each excerpt (or sketch) and explain why the excerpt (or sketch) is flawed.

Applying appropriate forensic techniques, tell how to improve the information that is recorded in the excerpt using examples.

"A mechanical excavator uncovered several sets of human remains. A number of the bones were broken."

Flaws

- [ ] Vague/unclear
- [ ] Inaccurate
- [ ] Incomplete
- [ ] Not supported
- [ ] Other

"An engraved watch found on one of the bodies identifies the victim as J. T. Philippe."

Flaws

- [ ] Vague/unclear
- [ ] Inaccurate
- [ ] Incomplete
- [ ] Not supported
- [ ] Other

"The following items were put into a sterile bag, labeled 'Evidence', sent to the police station and sealed: shell casing, bone, green cloth, dictionary."

Flaws

- [ ] Vague/unclear
- [ ] Inaccurate
- [ ] Incomplete
- [ ] Not supported
- [ ] Other