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Grade Six

Evidence and Investigation

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Evidence and Investigation

Before You Begin

This unit provides a stimulating and challenging exploration of how forensic scientists examine the evidence at crime scenes to help them discover the truth. What happened? When did it happen? Where did it happen? How did it happen? Who did it? Why did it happen?

In this unit, students develop inquiry skills as they gather evidence, examine it closely, make predictions and inferences, hypothesize, experiment with different substances, and interpret their findings in order to solve problems. They also become more aware of the importance of proper care and handling of materials in the pursuit of explanations for clues to their mystery. These forensic science activities offer students the opportunity to use different scientific techniques to draw conclusions from evidence. At the same time, the students become more aware of the many scientific careers that aid in criminal investigations, and the technology utilized to solve forensic problems.

Topic D: Evidence and Investigation

(Suggested time: 4-6 weeks)

This unit makes a great opener for the school year but could be taught at any time of year. The autumn weather is helpful for the lessons concerning footprints and cast impressions; however, the spring months can serve this purpose too. As an integrated exercise, schedule 4 to 6 weeks to complete this unit, allowing time to incorporate language learning, drama, health and science time. The science component requires 20-30 hours of class time. You may wish to ask parents to donate some of the materials you will need or be guest speakers. If you intend to create cast impressions for a mystery centre, contact a bicycle repair shop to obtain old tires from a variety of bikes. You can also collect soil samples from different areas of the city and community to conduct the soil identification activities.

Microscopes are invaluable tools in this unit, giving students an opportunity to examine certain types of evidence in detail. If the students have not used microscopes or made slides previously, you may need to incorporate several lessons into this unit. In *Explorations in Science, Level 5, It's a Small World* there are several activities that introduce students to the care and handling of microscopes and how to make their own slides.

Background Information

Imagine you are hot on the trail of a fugitive jewel thief. You come across a clearing in the woods where the remains of a campfire are still smouldering. What type of evidence will indicate if the person you are after was at the campsite and how can you tell if you are gaining on your quarry?

The work of an investigator requires alert senses, a deductive mind and knowledge of how evidence can and cannot be used to establish a fact. Let's look at the usefulness of various forms of evidence. In general, the more individualized evidence is the more powerful it is. Take the smouldering campfire in the above case. It indicates one or more people were at the site very recently, but it can't tell you specifically who. A clear shoe print found in the dirt at the campsite might prove to match the sole pattern on a brand of runners you know the culprit is wearing, but thousands of other people wear the same brand. Your shoe print is *circumstantial* or class evidence. What you need in order to establish your fugitive was present on the site is *conclusive* or *individual* evidence. (Shoe prints can be individual evidence if they have scratches or nicks on them.)

Many clues provide individual evidence. Fingerprints, footprints, voiceprints, handwriting and human organic material (blood, skin, saliva, hair, etc.) can identify a specific person. Unique objects can be identified by small samples or by impressions (for example, tire tracks or the scratch marks left on bullets as they leave the bore of a specific gun). Class evidence, although less powerful than individual evidence, is still quite useful, especially when you find several independent examples that all lead to the same conclusion. Class evidence can be gleaned from soils, inks, fibres and any material that is mass- or batch-produced.

The collection and analysis of these various forms of physical evidence for use in courts of law is called *forensic science*. Let's look at a few techniques forensic scientists use to analyze clues collected in the field.

Fingerprint Identification

Every person has a unique set of fingerprints unless he or she is an identical twin. When our hands are dirty it is easy to see the prints left behind wherever we touch objects. It's not as obvious that invisible *latent* prints are deposited even when our hands are clean, due to the natural oils in our skin. Latent prints left on hard surfaces can be made visible by dusting with a fine power that sticks to the oils. Prints left on porous surfaces, such as paper, can be brought out by fuming techniques that use iodine, silver nitrate or ninhydrin solutions as developers.

Once a print has been collected its pattern is analyzed and a match with prints of identified individuals is attempted. The analysis is based on the overall shape of the pattern (*arch, loop, whorl* or a combination of these), the relative location of specific features within the pattern (bifurcations,

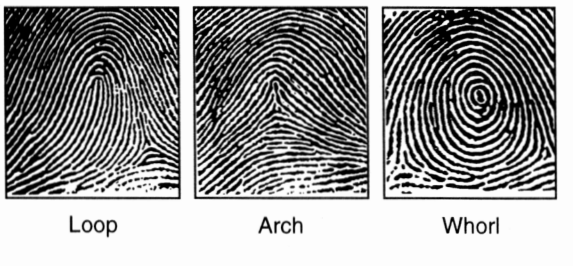

Figure 1.
Loop, arch and whorl fingerprint patterns.

ending ridges, dots) and the number of ridges between these features. The strength of a match is based on the number of characteristics two prints have in common.

Handwriting Analysis

Handwriting analysis is predicated on the fact that every person develops a unique form of handwriting by the time they reach maturity. Although an individual's writing might vary somewhat from one sample to another, enough basic features of the person's style remain unchanged to provide evidence of the author. These features can include the angle (or slant) of the writing, the open or closed nature of looped letters, the spacing between letters, the height of individual letters above and below the baseline of writing, flourish strokes at the end of words, and steadiness of hand, to name a few. This analytical technique should not be confused with the "handwriting analysis" that purports to determine an individual's personality based on their handwriting.

Materials Analysis

Comparison Microscopy

There are a host of tests that can be applied to determine the chemical composition or fine-scale structure of physical evidence such as paint, hair, fibre, paper and soil. A *comparison microscope*—two single microscopes used in tandem—enables you to examine the detailed structure of two samples simultaneously. Do paint chips found on the suspect's clothing exhibit multiple layers of paint that match the layers of paint on the wall at the crime scene? Are there tiny fibres on the suspect's shoes that match the crime scene carpet fibres? What about the fine-scale texture and colour of soil samples?

Paper Chromatography

In paper chromatography a substance (such as ink) is dissolved in a solvent and separated into its component substances. As the solution containing these component substances is drawn through a strip of filter paper by capillary action, each component travels a different distance based on how well it is held in the solution. The result is a pale stripe with distinct nodes of more intense colour where the preponderance of each component has separated out and remained behind. Since each ink type has a slightly different set of chemical ingredients, each ink type produces a distinct pattern by which it can be identified. This provides class evidence, not individual evidence: you can identify the batch of ink a sample came from, but not the specific pen.

Gas Chromatography

Gas chromatography is a useful technique that identifies the chemicals present in a mixture of gases or liquids. The sample, if not already in gaseous form, is vapourized and the resulting mixture of gases is passed through a narrow column. Each component gas travels at a different speed and reaches a detector situated at the end of the column at a different time, producing a characteristic peak on a graph called a *chromatogram*. When used in conjunction with a *mass spectrometer*—a device that further identifies each constituent chemical based on its unique pattern of fragmentation when bombarded with high-energy electrons—a more precise graphic representation of the sample's chemical make-up is produced. This can be used to identify the specific brand of product (paint, ink or gasoline, for example) you are dealing with.

One problem with gas chromatography and mass spectroscopy is the necessity to destroy the sample in the effort to analyze it. Other techniques that can determine the composition of a substance and leave it intact have been developed. *Spectrophotometers* measure the unique light-absorption characteristics of materials in the visible, infrared and ultraviolet parts of the spectrum. *Neutron activation analysis* determines the identity and quantity of each element in a substance by detecting the unique gamma ray energies emitted from each element when the sample is bombarded by neutrons in a small nuclear reactor. This technique is particularly good at identifying trace elements in hair samples.

DNA Analysis

DNA analysis is a relatively new technique that enables investigators to compare the genetic material—skin, blood, saliva, flesh and other organic materials—found at the scene of the crime with the genetic make-up of the suspect. DNA (deoxyribonucleic acid) contains the genetic code that determines all our physical characteristics. With the exception of identical twins, who have the same DNA, each person has a unique code that can be extracted from their cells—sort of a personal calling card that can inadvertently be left at the scene of a crime.

Voice Identification

The specific physical characteristics of the mouth cavity, larynx (voice box), tongue, teeth and lips, plus the habit of speech picked up within one's culture (accent), gives every person a distinct voice pattern that can be recognized by computer analysis. Two voice recordings, one of a mystery person and one of your suspect, can be compared for a match. As in handwriting analysis, the more words the two samples have in common, the more confident you can be of your analysis.

Now let's return to our smouldering campfire and the pursuit of the runaway jewel thief. In this case, we know "who done it." It's simply a matter of tracking the person down. What might we detect that will tell us if the thief was at the campsite and, if so, which way the thief went next? We don't have a crime lab in our pocket, so we'll have to look for obvious visual clues. The single, narrow, flattened area of grass a few feet back from the fire pit indicates only one person slept overnight at the site. Inspecting the fire pit itself, we see the flame is still alive under a thin layer of dirt. Someone recently tried to put out the fire and leave in a hurry. But is it our culprit? Yes! There, pinned under an unburned section of log, is a fragment of the towel a witness saw the thief wrap around the hand used to smash the glass counter, and tiny glass shards are still imbedded in the fabric. Which way did the thief go? The branches on the bushes have been broken over there. Yes—you can see a path of trodden, small shrubs leading off to the east. And there, where the path crosses a moist patch of bare ground, you can see shoe prints. They point eastward, they are the correct-size shoe, they sink into the ground a fair way (indicating the person weighs a good deal, as does our culprit) and the prints are spaced far apart—the thief's on the run and we're hot on the trail!

Elementary Science Program of Studies

General and Specific Learner Expectations

The following general and specific learner expectations have been taken directly from the 1996 Elementary Science Program of Studies. The specific learner expectations (SLEs) are referred to by number in the second column of the activities table.

General Learner Expectations

Students will be able to:

- Apply observation and inference skills to recognize and interpret patterns, and to distinguish a specific pattern from among a group of similar patterns.
- Apply a knowledge of the properties and interactions of materials to the investigation and identification of a material sample.

Specific Learner Expectations

Students will be able to:

1. In a natural outdoor setting, recognize evidence of recent human activity and recognize evidence of animal activity.
2. Observe a set of footprints and infer the direction and speed of travel.
3. Recognize that evidence found at the scene of an activity may have unique characteristics that allow an investigator to make inferences about the participants and nature of the activity, and give examples of how specific evidence may be used.
4. Investigate evidence and link it to a possible source by:
   - classifying fingerprints collected from a variety of surfaces;
   - classifying footprints, tire prints and soil samples from a variety of locations;
   - analyzing the ink from different pens, using paper chromatography;
   - analyzing handwriting samples to identify the handwriting of a specific person; and
   - comparing samples of fabric.

Cross-curricular Connections

Language Learning

- Read mystery and suspense stories to develop deductive reasoning skills.
- Write mystery stories using elements of games and activities completed.
- Study Sherlock Holmes mysteries.

Drama

- Enhance physical memory and the five senses.
- Synthesize stories through role-playing.

Health

- Understand genetics and DNA.
- Look at characteristics other than the muscular and skeletal systems (can be a nice extension).

Mathematics

- Measure evidence in various ways, charting and graphing results.
- Use spreadsheets on computers to graph class shoe sizes, heights, etc.

Children's Alternative Frameworks

Some children have difficulty with the concept of comparison to a mystery sample. They are keen to manipulate the microscopes and magnifiers to view fabric and hair samples up close, but they often do not consider comparing these samples to the mystery sample. Some children require a specific model regarding how to look for commonalities. It is also found that children are often quite literal in their interpretations and observations. For instance, the soil sampling activities appear too easy for them: they recognize an obvious similarity and it defeats further inquiry and testing. This particular concept needs further developing and, perhaps, a more thorough investigation using activities from a soil conservation and erosion unit.

Students don't always understand the difference between fact and inference. They are too young to have their handwriting analyzed, and they have not yet established a concept of signature.

Activities

Classroom teachers have identified the following activities that may be done to address the Specific Learner Expectations (SLEs) in the Program of Studies. The list is not prescriptive and teachers may select activities that are most appropriate for their students.

Activities have been listed under two headings: Key Activities and Extension Activities. Key activities are supported by authorized resources and identify "powerful and practical" means for achieving learner expectations. Extension activities represent alternative ways of achieving or supporting learner expectations.

Key Activities

Key Activity	SLE	Print Resources	Essential Materials	Comments
Brainstorming what students know or wonder about the topic. "How does science help solve crimes?"		*Explorations in Science, Level 6, Based on the Evidence, (Free Exploration)*, p. 7	chart paper, bins of possible evidence, books, microscopes, etc.	Both the free exploration and the individual brainstorming will help the teacher discover the students' prior knowledge and interests in this new topic.
Examining shoe prints and foot prints	1, 2, 4	*Explorations in Science, Level 6, Based on the Evidence, (A Shoe Print Tells the Story)*, p. 22 *Innovations in Science, Level 6, Science Detective (Making Tracks)*, p. 27	measuring tapes, rulers, magnifying lenses, rake, watering can, dental stone or plaster of Paris, paper and wax crayons for rubbings	Footprints can reveal the type of shoe a person is wearing, the weight and height of the person who made the prints, whether he or she was walking or running at the time the prints were made and the direction in which the person was travelling. Any work that you introduce about cast impressions is also related to the Wetland Ecosystems unit. By casting animal tracks around the pond's edge you can identify larger species that inhabit the area. If you wish to extend this with additional problems, you may want to acquire old bicycle tires.

Key Activity	SLE	Print Resources	Essential Materials	Comments
Observing a situation, reporting details and comparing these with the details seen by others	3	*Explorations in Science, Level 6, Based on the Evidence, (Take Another Look)*, p. 10	pencil, paper, 10 miscellaneous objects, chart paper	This activity helps students discover the strategies they use to remember certain situations and keep mental track of multiple details. Extension: Play the "Who is the Suspect?" game (*Explorations*, p. 11). Alternatively, have each child collect 3 or 4 items from home and place them in a lunch bag. These items should represent their personality and interests. In small groups, lay out the contents of each bag and let the groups draw their own conclusions to try to match the bag with its owner.
Making, comparing and classifying fingerprints	4	*Explorations in Science, Level 6, Based on the Evidence, (It's a Print)*, p. 12 *Innovations in Science, Level 6, Science Detective (Fingerprint Match)*, p. 12 *GEMS: Fingerprinting* (Ahouse), *Sessions 1 and 2 (Making Fingerprints and Classifying Fingerprints)*, p. 7	paper, pencils, ink pads, magnifying lens, clear tape	You can use any of these resources to develop your particular lesson plan. If you have identical twins in your school or class, you may wish to explore whether all people have a unique set of fingerprints.
Lifting fingerprints and other prints from different surfaces so that they can be compared to those of suspects	4	*Explorations in Science, Level 6, Based on the Evidence, (Take a Copy)*, p. 13 *Innovations in Science, Level 6, Science Detective (Dusting for Prints)*, p. 16	cornstarch or talcum powder, graphite powder, soft paint brushes, clear tape, white or black paper, a variety of powders, different surface materials (glass, mirrors, tin foil, etc.), magnifying lens, facial tissues	This activity teaches the students a technique for lifting prints and discovering which surfaces retain the best examples of prints. Extension: Have the students try different white powders (e.g., icing sugar) to see which give a better print when lifted.

Key Activity	SLE	Print Resources	Essential Materials	Comments
Using knowledge of fingerprints or lip prints to solve a classroom mystery	3, 4	*Explorations in Science, Level 6, Based on the Evidence, (Find the Suspect)*, p. 15 *Innovations in Science, Level 6, Science Detective (The Scene of the Crime)*, p. 8 *GEMS: Fingerprinting* (Ahouse) *(Solving the Crime)*, p. 23	object with prints (for example, tape recorder, glass mug), ink pads, magnifying lens, paper, pencil lead powder, tape, brush, white and black paper	Setting a real mystery will spark the students' interest, but this lesson will need careful preparation and setup. You may buy a kit or a game; "Clue" is a good example.
Exploring chromatography to compare different inks	4	*Explorations in Science, Level 6, Based on the Evidence, (It's in the Colour)*, p. 17 *Innovations in Science, Level 6, Science Detective (Investigating Ink)*, p. 19 *GEMS: Crime Lab Chemistry* (Barber), *Session 1 (Investigating the Evidence)*, p. 6	coffee filter strips, water soluble felt-tip markers of different makes and colours, Petri dishes, pans or trays of water (wallpaper trays would be ideal), ruler, tape	You may wish to develop an operational definition of chromatography and discuss with the students how this technique might aid in crime detection.
Using knowledge of chromatography to find out who left a note at a crime scene	3	*Explorations in Science, Level 6, Based on the Evidence, (The Pens Have It)*, p. 18	a note written with a black water-soluble felt-tip marker; 4 or 5 different black water-soluble felt-tip markers (labelled Suspect A, Suspect B and so on), pan, filter paper, ruler, tape, aluminum foil, jar	Share strategies used to record student observations and solve the mystery.
Observing and comparing different handwriting samples (to extend the analysis of notes)	4	*Explorations in Science, Level 6, Based on the Evidence, (Forger's Delight)*, p. 19	pens, paper, magnifying lens, note samples, 3 or 4 suspect samples (labelled)	Have the students list the way they detected the forgeries.

Key Activity	SLE	Print Resources	Essential Materials	Comments
Examining different soil samples found on a suspect's shoe and comparing them with the soil at the scene of the crime	4	*Explorations in Science, Level 6, Based on the Evidence, (The Soil Caper)*, p. 20	5 soil samples, each in a labelled jar (Suspect A through Suspect E), jar containing soil evidence, magnifying lens, filter, paper, distilled water, litmus paper or red cabbage indicator	Have the students share how they recorded their observations and what strategies they used to determine the solution to the mystery.
Examining fibres and hairs	4	*Explorations in Science, Level 6, Based on the Evidence, (Fibre Follies)*, p. 24 *Innovations in Science, Level 6, Science Detective (Cloth Capers)*, p. 34	fabric swatches, tweezers, magnifying lenses or microscopes, scissors, line master 2	If you have not prepared the students for microscope work, you may wish to include several lessons on microscope use prior to *Fibre Follies*.
		Explorations in Science, Level 3, Design, Test, Build! (Fabric Fascinations), p. 15		Have the students share how they determined the similarities and differences between the various samples of fabric.
Examining facial features, hands and hair	3	*Explorations in Science, Level 2, Getting to Know Me (Facial Features)*, p. 11	mirrors, construction paper, art materials	The activities from *Explorations, Level 2, Getting to Know Me* can be modified to extend their understanding of unique characteristics and common features. Students can cut out features from print materials and make collages.
		Explorations in Science, Level 2, Getting to Know Me (Hair's to You), p. 12	magnifying lenses	
		Explorations in Science, Level 2, Getting to Know Me (The Eyes Have It!), p. 16	coloured pencils, mirrors	
		Explorations in Science, Level 2, Getting to Know Me (Taking a Closer Look), p. 18	graphs for posting, line master 2, mirrors	
		Explorations in Science, Level 2, Getting to Know Me (Focusing on Our Feet), p. 19	string, squared paper, sponges, paint	
		Explorations in Science, Level 2, Getting to Know Me (Give Us a Hand), p. 20	sponges, paint, string, squared paper, lima beans magnifying lenses, ink pads	
		Explorations in Science, Level 2, Getting to Know Me (Figuring Out Fingerprints), p. 14		

Extension Activities

Extension Activity	SLE	Print Resources	Essential Materials	Comments
Creating crime scenes for others in the class to solve	1, 2, 3, 4	*Explorations in Science, Level 6, Based on the Evidence (The Clues Are Present)*, p. 27	as determined by students; you may wish to provide them with a planning sheet to help them set up their "crime scene" evidence	Each group can present its scenario and the evidence on different days. You will likely need to provide several class periods and homework days to allow students to create their scenarios and present to class. You will need to organize a schedule over several days for sharing, or let one group try to solve another group's mystery. A discussion of DNA fingerprinting may be of interest to the students.
Performing a series of forensic tests to solve a classroom mystery and sharing inferences and conclusions before an audience	2, 3, 4	*Innovations in Science, Level 6, Science Detective (Getting Your Papers)*, p. 37 *GEMS: Mystery Festival* (Beals) *(The Felix Mystery)*	many of the same materials used in earlier activities, props, pH paper, candles, matches	This activity provides an excellent way to test the children in their problem solving approach. They need to apply all previous techniques and build from their observations and inferences to form a case for a mystery solution.
Exploring invisible messages		*Explorations in Science, Level 6, Based on the Evidence (The Pens Have It, Extending the Activity)*, p. 18	crayons, white paper, paint, pencil, lemon juice, light source	
Creating codes and secret messages			real lemon juice, white vinegar or whole milk, small containers, toothpicks or cotton swabs, paper, heat source (light bulbs)	

Extension Activity	SLE	Print Resources	Essential Materials	Comments
Investigating soil acidity		*Explorations in Science, Level 6, Based on the Evidence (The Soil Caper, Extending the Experience)*, p. 20		
Examining different types of hair under a microscope	4	*Explorations in Science, Level 6, Based on the Evidence (Hair-Raising Experience)*, p. 26 *Explorations in Science, Level 2, Getting to Know Me (Hair's to You!)*, p. 12	magnifying lenses, microscopes, slides, tweezers, line master 3, prepared slides from different animals and humans	The students can note differences and devise a way to keep a record of the hair of each person in the class.

Assessment

For a broader discussion of science classroom assessment techniques see *Assessing Student Learning* in the introduction of this publication on p. 15. Good places to begin looking for the unit-related ideas are *Explorations in Science* assessment handbooks, *Innovations in Science* teaching notes, Unit tests and Portfolio ideas, Alberta Education sample tests at **www.education.gov.ab.ca** and Alberta Assessment Consortium at **www.aac.ab.ca**

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