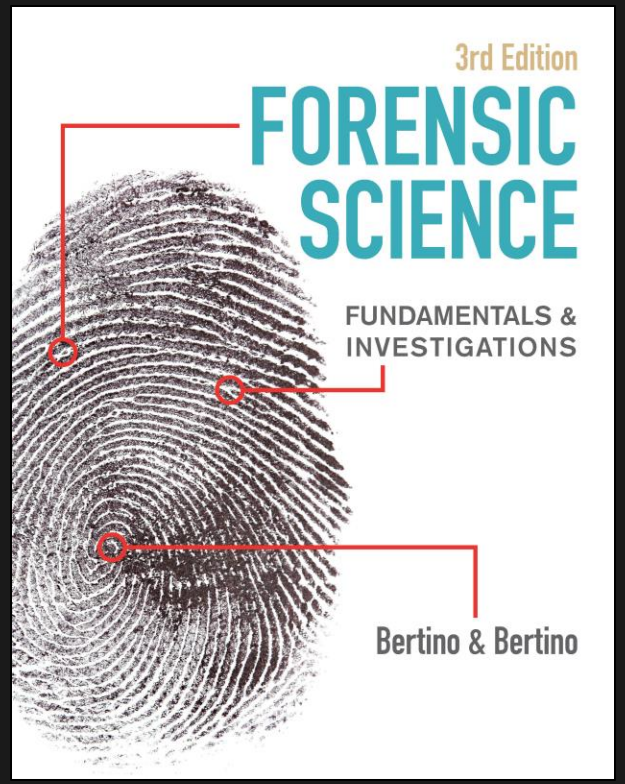
NATIONAL GEOGRAPHIC LEARNING | Cengage

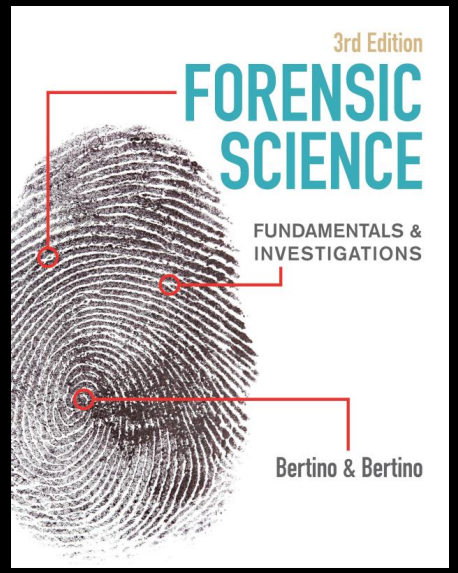


Forensic Science: Fundamentals & Investigations, 3rd Edition

Bertino/Bertino

Cengage MindTap

- **Real-world experiences** based on core science knowledge and skills
- **Accessible to ALL students**
- **Support for teachers,** new and experienced



NATIONAL GEOGRAPHIC LEARNING | Cengage

Real-World Experiences Based on Core Science

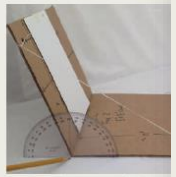
ACTIVITY 8–5

Blood-Droplet Impact Angle *Obj. 8.3, 8.9*

Objectives:
By the end of this activity, you will be able to:
1. Create blood-spatter patterns from different angles of impact.
2. Examine the relationship between angle of impact and blood-spatter
3. Calculate the angle of impact from bloodstains.

Time Required to Complete Activity:
Two 45-minute class periods
First period: Create blood-spatter patterns from different angles.
Second period: Measure bloodstains and calculate the angle of impact.

Materials:
(***per group of two students***)
Act 8-5 WKST *Data Tables*
1 dropper bottle of artificial or simulated blood (per two groups)
(2) 5 × 8-inch index cards
2 metric rulers and one 30-cm or 12-inch ruler
Newspapers
2 cardboard apparatuses (with string or twine)
1 protractor with 0-degree line along bottom edge
1 roll masking or drafting tape


Cardboard apparatus for dropp

SAFETY PRECAUTIONS:
Cover the floor in the work area with newspaper.
Artificial blood can stain clothing and furniture, so care should be taken t
spills.

Scenario:
Two police officers walk into a neighborhood convenience store. They dis
blood-spatter patterns on the walls and ceiling. "What happened here?" s
one officer as she walks around the store. The officers call in the situatio
forensics team is dispatched to the scene. Investigators will examine the
scene and seek answers to the following questions:
- Whose blood is this?
- Does it belong to just one or to several people?
- How many people were injured?

ACTIVITY 8–5 CONTINUED

- If more than one person was injured, is it possible to tell who was injured first?
- What type of injury caused the blood loss?
- What type of weapon caused the injury?
- If the weapon was a gun, from which direction was the bullet fired? Did the shooter point the gun upward, downward, or straight ahead?
- In what direction(s) did the injured person(s) move?

Background:
Blood-spatter analysis is a powerful forensic tool that helps investigators reconstruct what happened at a crime scene. In this activity, you will drop blood from different angles and observe how the size of the blood droplet is used to calculate the angle of impact.

Procedure:

PART A: PRACTICE DETERMINING ANGLE OF IMPACT FROM MEASUREMENTS

Using the measurements in Data Table 1 and a calculator, determine the angle of impact for the five bloodstain measurements given.

Data Table 1: Calculation of Impact Angle from Bloodstains

Stain	Width (*mm*)	Length (*mm*)	Width/Length (*sine*)	Decimal	Impact Angle (*inverse sine*)
1	8	10			
2	3	4			
3	5	9			
4	2	10			
5	8	9			

PART B: CALCULATING IMPACT ANGLE FROM DROPPED BLOOD

In this activity, each group drops artificial blood from two different angles of impact determined by your instructor. Measure each bloodstain and calculate the angle of impact based on the length and width of each blood drop. Blood will be dropped 30 centimeters above the target. Share and record the results from all groups, so data represent the impact angles from 10, 20, 30, 40, 50, 60, 70, and 80 degrees.

Group 1: 10 and 50 degrees
Group 2: 20 and 60 degrees
Group 3: 30 and 70 degrees
Group 4: 40 and 80 degrees

1. Labeling the Cards and Setting Up the Cardb

Note: Use two different cardboard setups; one for one other setup for your other angle of impact. There will b each cardboard setup.

a. Obtain two 5 × 8-inch index cards; turn the cards ov
b. Label each card with your initials and angle of impa with small letters and numbers.
c. Obtain two cardboard apparatuses. Note that one apparatus is shorter than the other side. Tape the the shorter side of one of the cardboard apparatus align the top of the card to the top of the cardboar
d. Place your cardboard setup with your 5 × 8-inch ca location where you can leave it undisturbed while t blood droplets dry for at least 30 minutes. (Refer to cardboard apparatus photo.) The longer end of the board should be on your desk or floor, and the sho piece of cardboard with the 5 × 8-inch card should elevated.
f. Repeat Steps 3 and 4 for your other angle of impact should have two cardboard setups with one card or

2. Using a Protractor to Establish the Desired Angle of Impact

a. Place the protractor so that the center zero mark is cardboard apparatus. The angle of impact is measu

Example 1: To obtain an angle of impact of 20 d

Desired impact angle is 20 degrees measured from the
Protractor reading is 90 minus the angle of impact, or 9

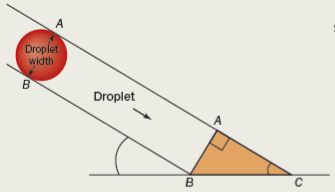
Example 2: To obtain an angle of impact of 30 degrees

Desired impact angle is 30 degrees measured from the vertical.
Protractor reading is 90 minus the angle of impact, or 90 − 30 = 60 degrees.

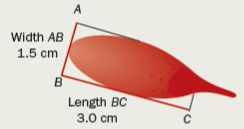
b. After setting the protractor for one of the desired impact angle:
(1) Use the string or twine to anchor the cardboard in position. Secure the string or twine to the bottom cardboard by inserting the dental floss in the notch in the bottom cardboard and passing the string or floss under into the opposite notch. This will lock the cardb Recheck the angle in case the card slipped, and

ACTIVITY 8–5 CONTINUED

impact by measuring the width of the blood droplet (*AB*) divided by the length of the blood droplet (*BC*).



$$\text{sine angle } C = \frac{\text{opposite } (AB)}{\text{hypotenuse } (BC)}$$



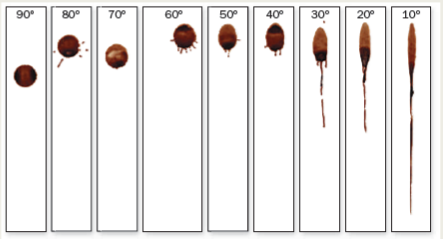
Note that the opposite side AB is the width of the bloodstain, and the hypotenuse BC is the length of the bloodstain.

$$\text{sine angle } C = \frac{\text{opposite } (AB)}{\text{hypotenuse } (BC)}$$

$$\text{sine angle } C = \frac{\text{opposite } (AB)}{\text{hypotenuse } (BC)} = \frac{\text{width (1.5 cm)}}{\text{length (3.0 cm)}}$$

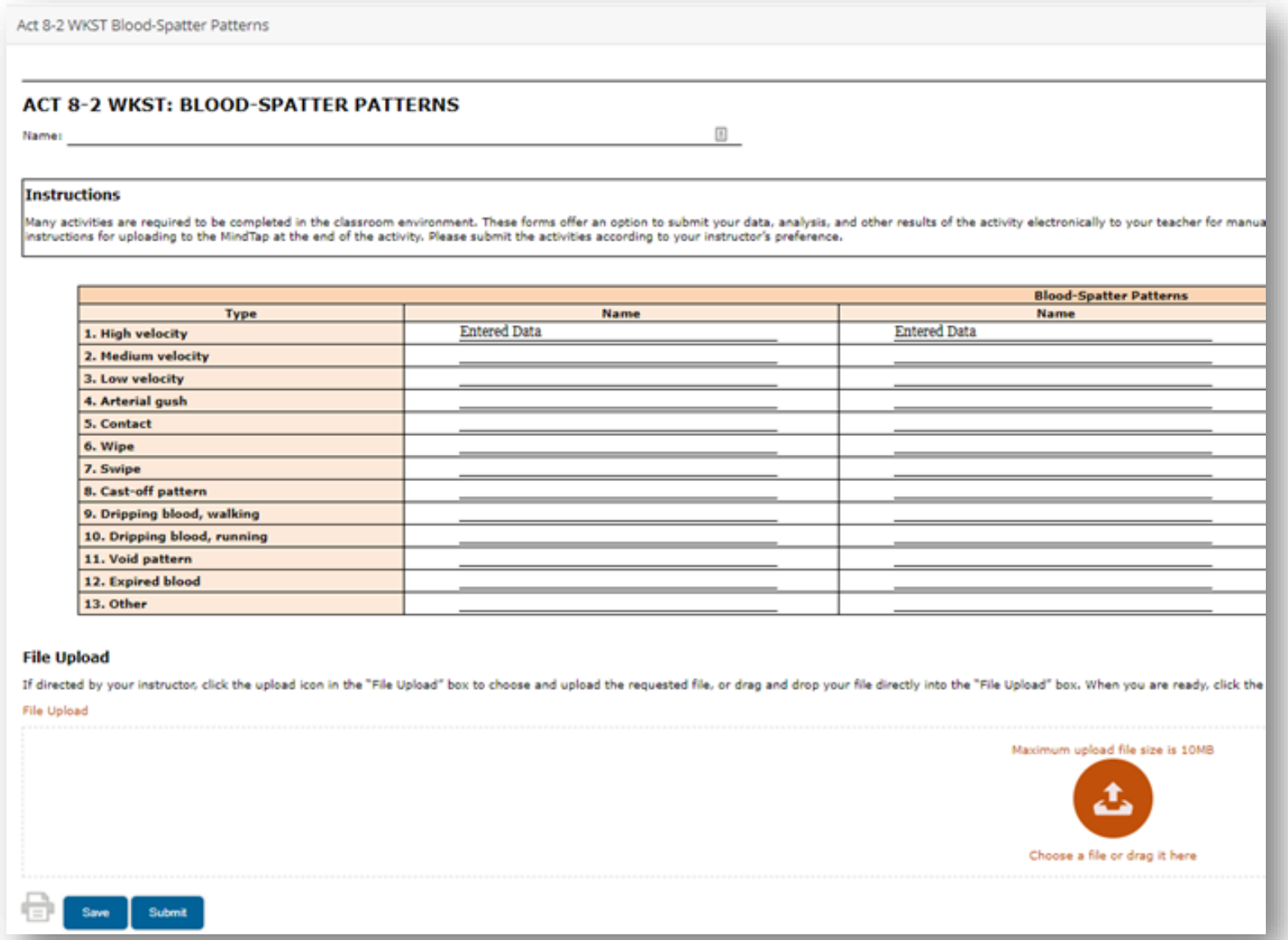
sine angle $C = 0.5000$
inverse sine $0.5000 = 30$ degrees

2. Refer to the photos of a student's bloodstains produced by dropping the blood at different angles using the "cardboard setup." The drops were produced by students using the cardboards setups used in this activity. Measure each of the bloodstains and calculate the *actual* angle of impact for each of the droplets using their width and length. Compare the calculated angle of impact with the labeled angle of impact. If they differ, suggest possible sources of error and how they could be avoided to ensure more reliable results.



Student samples of bloodstains dropped from 90 to 100-degree angles of impact.

Real-World Experiences Based on Core Science



Act 8-2 WKST Blood-Spatter Patterns

ACT 8-2 WKST: BLOOD-SPATTER PATTERNS

Name: _____

Instructions

Many activities are required to be completed in the classroom environment. These forms offer an option to submit your data, analysis, and other results of the activity electronically to your teacher for manua
instructions for uploading to the MindTap at the end of the activity. Please submit the activities according to your instructor's preference.

	Blood-Spatter Patterns	
Type	Name	Name
1. High velocity	Entered Data	Entered Data
2. Medium velocity		
3. Low velocity		
4. Arterial gush		
5. Contact		
6. Wipe		
7. Swipe		
8. Cast-off pattern		
9. Dripping blood, walking		
10. Dripping blood, running		
11. Void pattern		
12. Expired blood		
13. Other		

File Upload

If directed by your instructor, click the upload icon in the "File Upload" box to choose and upload the requested file, or drag and drop your file directly into the "File Upload" box. When you are ready, click the

File Upload

Maximum upload file size is 10MB

Choose a file or drag it here

Save Submit

NATIONAL GEOGRAPHIC LEARNING | Cengage

Real-World Experiences Based on Core Science

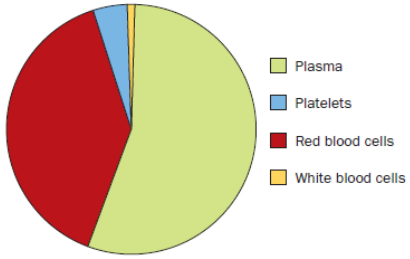
The Science of Blood *Obj. 8.2*

Prior to DNA p
vidual or link a
blood type, this
could not identi
exclude a perso
the blood type a
vides individual
at a crime scene
(or victim). As
personal identif
the biology of b

Blood Cells

Blood is a circu
cells, white blo
forms a differe
liquid known a

FIGURE 8-1 Cirde graph showing proportions of the components of blood.



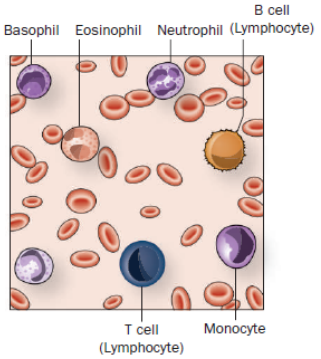
nutrients such a
minerals throu
ports wastes aw

Red blood
mainly oxygen
of the body. Th
is an iron-conta
gen in the lung
cells in all the t
in red blood ce
color in blood.
and foreign el
clotting and are
blood vessels.

White Blood Count and Immune Res

Our bodies have the ability to discriminate betwe
(self) and foreign elements called antigens (non
tions to protect our bodies by identifying cells or
as viruses, bacteria, fungi, parasites and proteins
ognizes the presence of foreign elements or anti
in the location of the invading material. Some wl
foreign elements. Other ty
proteins, known as antibod
response by identifying anc
that they can be destroyed.
for a particular type of ant
only blood components tha
sources of DNA for profiling
of white blood cells. Figure
blood components in a micr

FIGURE 8-2 Types of white blood cells.



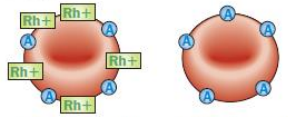
Discovery of Blood T

In 1900, Karl Landsteiner fo
did not always freely mix w
Instead, clumping of red
might occur, resulting in de
antigens, substances that t
red blood cells determines
Landsteiner described the A
antigens, such as the Rh fact

A and B Antigens

As Karl Landsteiner discovered, reactions to a blooc
blood proteins can have fatal consequences durin
antigens, foreign antigens (or proteins) on blood ce

FIGURE 8-5 Rh factor and ABO blood type examples.



a protein called *Rh factor* on their red blood cells. This factor is independent of the A and B antigens. Blood that has the Rh factor is designated Rh+ (positive), while blood that does not have this factor is designated Rh– (negative) (**Figure 8-5**).

Antigen–Antibody Response

To help white blood cells identify foreign elements, B-lymphocytes, specialized white blood cells, secrete antibodies. An antibody is a Y-shaped protein molecule that binds to the molecular shape of specific antigens, fitting like jigsaw puzzle pieces. The binding sites of the antibody are located on each tip of the Y-shaped molecule (**Figures 8-6** and **8-7**).

FIGURE 8-6 The general structure of an antibody.

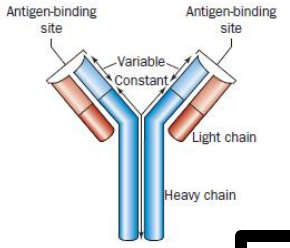
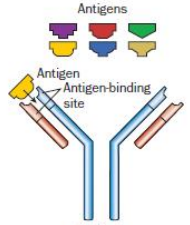


FIGURE 8-7 The shape of the antigen fits the binding site on the antibody.



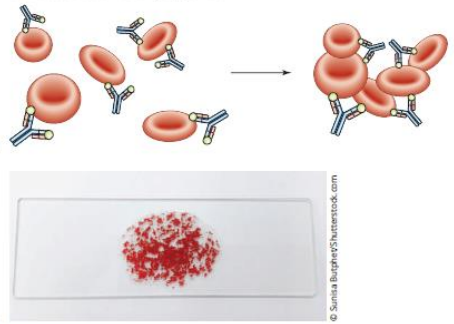
When a foreign element is re
system responds. This is called th
recognize the foreign antigen, an
be viruses, bacteria, fungi, or eve
different blood type.

Agglutination

There are many antigens on the s
one arm of a Y-shaped antibody a
the antibody can attach to another
clumping together of red blood ce

If agglutination occurs within
blood transfusion, blood could cea
by clumped red blood cells. Withe
not receive oxygen or eliminate ca

FIGURE 8-8 **a.** An antibody reaction to surface antigens on red blood cells causes agglutination, or clumping, of the cells. Agglutination of blood cells inside a body can be fatal. **b.** Note during agglutination how the red blood cells clump together.



Blood Typing Tests

When a patient needs a blood transfusion, their blood needs to be typed to ensure that the blood to be transfused does not contain any blood antigens that will cause agglutination. The person's blood is tested for the presence of three antigens: A, B, and Rh.

Three separate tests are performed. First, the patient's blood is mixed with antibodies that bind to the A antigen. If the patient's

Probability and Blood Types

Given the frequency of different alleles (variation of a gene) within a population, it is possible to determine the probability that a particular blood type will appear within a particular population. To determine the probability of two simultaneous events, multiply their individual probabilities. In **Table 8-2**, you can see the percentages of Americans who have the alleles for the A and B antigens and the Rh factor.

Support for teachers

Enrich

Consider replaying the antibody scenario, except this time when the antibodies have identified the red-capped antigen, have another white blood cell, known as a killer or cytotoxic killer T-cell, approach the antigen surrounded with antibodies. The role of the killer T-cell is to secrete digestive enzymes on the antigen. One of the jobs of white blood cells is to identify and destroy foreign antigens.

ACTIVITY

Consider introducing Activity 8-8 ACT: *Antigens and Antibodies* at this point in the lesson. This additional activity can be found on the Companion Site.

Teach

Discuss the medical history of bloodletting and the use of leeches. Ask students why they think blood has been studied much longer than DNA.

Teach

Help students understand how blood typing is used as evidence by discussing these questions:

- What kind of evidence is a blood type?
- How can a blood type be used to exclude a suspect in a case?
- Compare and contrast the use of blood typing to DNA profiling as a forensic tool to identify suspects and victims.

Academic Connections

BIOLOGY

Blood is an important tissue that is responsible for transporting nutrients, water, and oxygen to all of the cells in the body and for transporting carbon dioxide and wastes away from all of the cells in the body.

- The immune system depends upon circulating white blood cells to identify and destroy pathogens. This might also be a good time to discuss the overall importance of blood banks.
- In addition to transporting nutrients, water, and oxygen to the cells, blood carries hormones, vitamins, and minerals to nourish and regulate certain bodily functions.
- The movement of hormones through the blood enables one organ to control the function of another organ, even though the two organs might be located far apart. In this way, blood acts not just as a means of transportation but also as a communication system.
- Blood is responsible for delivering all of the body's wastes to the appropriate location for disposal. Waste gases, such as carbon dioxide, are delivered to the lungs, where they are exhaled. Other wastes are filtered from the blood in the kidneys, where they are dissolved in water and excreted as urine.

Assess

To assess students' understanding of the relationship between blood and DNA, ask them the following questions:

- What component of blood can be used for DNA analysis?
- How long has DNA analysis been possible?
- Why is DNA an important tool for forensic scientists?

Explore

For additional information on genes and blood type, refer to Learn.Genetics "Genes and Blood Type" (University of Utah).

Differentiated Learning

Additional Support for Learners

To help students visualize the quantity of blood in an average adult, show them 5.5 liters of water with red food coloring.

Academic Connections

MATHEMATICS

To illustrate how blood types are inherited, show (using a Punnett square) a cross between a mother who has blood type O and a father who has type AB. Genes are inherited through independent assortment. The mother can contribute only an O allele. The father can contribute either an A or a B allele. This couple could have children of either blood type A (O from the mother and A from the father) or B (O from the mother and B from the father). Point out that there is a 50% probability of these parents having a child with type A blood. Explain why these parents could not have a child with blood type O.

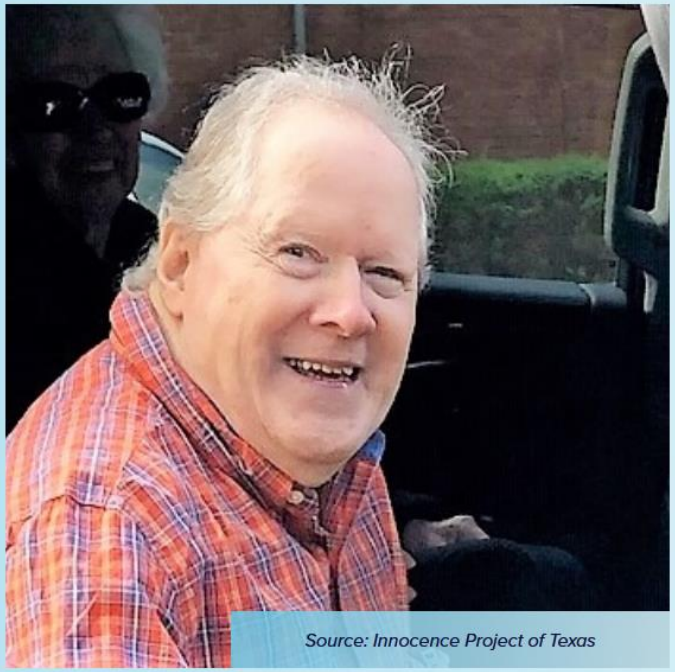
Real-World Experiences Based on Core Science

Joe Bryan
(1985, 2019)

Joe Bryan, a Texas high school principal convicted of murdering his wife Mickey, is serving over 30 years in jail. Bryan has always maintained his innocence of this crime. In 2018, the Texas Forensic Science Commission, an organization that investigates complaints about the misuse of forensic testimony and evidence in criminal cases, agreed to reopen his case based

Joe Bryan

Time Served: 32



Source: Innocence Project of Texas

CHARGE: Murder

CONVICTED: 1988

SENTENCE: 99 Years

RELEASED: 2020

COUNTY: Bosque

Think CRITICALLY

Discuss why the type O blood evidence found on the flashlight is considered a weak form of evidence tying Joe Bryan to the murdered victim.

Real-World Experiences Based on Core Science

ACTIVITY 13–3

Sorting of Sand by Size and Shape *Obj. 13.3, 13.4, 13.8*

Objectives:

By the end of this activity, you will be able to:

1. Compare and contrast sand samples using photographs of sand.
2. Estimate the size of sand grains.
3. Identify different shapes of sand grains.
4. Determine how well a sand sample is sorted.

Time Required to Complete Activity:

60 minutes

Materials:

Act 13-3 WKST *Sand Descriptions*
Act 13-3 WKST *Reference*
Stereomicroscope (or hand lens)

SAFETY PRECAUTIONS:

Wear safety eyewear. Carry the microscope using two hands.

Background:

The solid portion of the earth is made up of rocks and minerals. Sand is formed by the weathering of rock. As the fragments of rocks and minerals travel away from the source, they are subjected to wind, rain, freezing/thawing, and moving water and air. The greater the distance traveled, the more the rock fragments will be separated by size and the greater the degree of rounding of the edges of the rock fragments.

The following chart is a *simplified* reference describing four different sources of sand.

SOURCES OF SAND				
Characteristics	**Continental**	**Volcanic**	**Skeletal**	**Precipitate**
Color	Light with some darker minerals	Darker	Light	Light
Quartz (clear)	Mostly	Small amount	Some	Some
Distinguishing Traits	Light color	Dark color	Shells or skeletons	Round shape

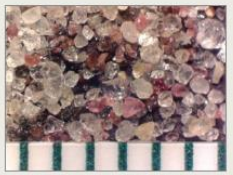
Refer to the reference charts and Act 13-3 WKST *Reference* to help with this activity. A PowerPoint presentation of the sand images used in this activity is available on the Companion Site.

ACTIVITY 13–3 CONTINUED

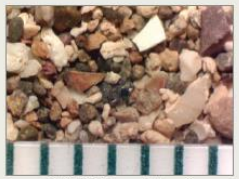
Procedure:

Refer to the photographs of sand samples. For each photograph, record the sand sample's size, degree of sorting, shape of sand grains, and source on Act 13-3 WKST *Sand Descriptions*. Refer to the reference chart *Size, Sorting, Shape, and Source* or Act 13-3 WKST *Reference*. The ruler in photographs 1-12 uses millimeters as the unit of measurement. The ruler in photographs 13-15 uses centimeters as the unit of measurement.

1. **Size:** Approximate size in mm OR variable
2. **Sorting**: Well sorted, moderately sorted, poorly sorted
3. **Shape**: Angular, subangular, subrounded, rounded
4. **Source:** Continental, volcanic, skeletal, precipitate



1. Beverley Beach, Oregon

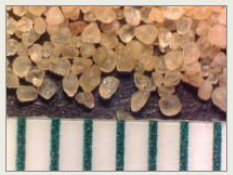


2. Kalihi Channel, Hawaii

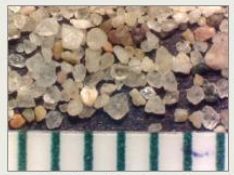
3. Keokea, Hawaii

1 _____
2 _____
3 _____
4 _____

4. Nile River, Egypt

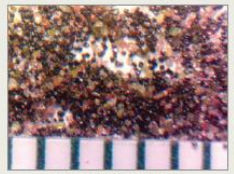


5. Nubian Desert, Egypt

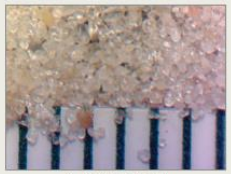


6. Old Apat Beach, Hawaii

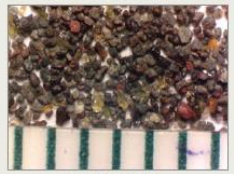
1 _____
2 _____
3 _____
4 _____



7. Unknown Sample 1

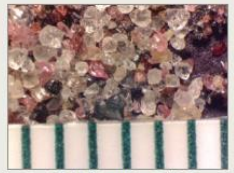


8. Red Sea, Israel

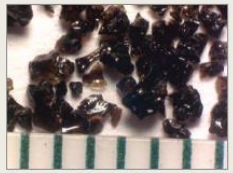


9. Waipio, Hawaii

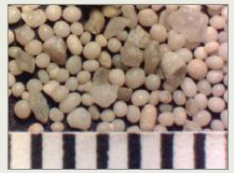
1 _____
2 _____
3 _____
4 _____



10. Unknown Sample 2



11. Volcano NP, Hawaii



12. Salt Lake, Utah

1 _____
2 _____
3 _____
4 _____

Real-World Experiences Based on Core Science

Case STUDIES

Japanese Fire Balloons—First Intercontinental Weapon (1944–1945)

In 1944, a young minister and his pregnant wife drove into the forests of Oregon for a church picnic. As the minister was parking the car, five teenagers and the minister's wife ran to a mysterious large white cloth entangled in the trees. Tragically, when one of the teens touched the cloth, a bomb exploded and killed them. Over the next year and a half, similar stories of people hearing bombs exploding or seeing fires starting were reported to the military. Fortunately, no other deaths occurred. Each incident was kept secret; nothing appeared in the news for fear that acknowledgment of these bombs would affect the war effort. Solving the mystery of the origin of the bombs and the cause of these explosions involved an incredible amount of detective work, consultations with geologists (who analyzed the sand's composition), military, and international collaboration.

During World War II, the Japanese created hot air balloons filled with hydrogen gas to transport fire and antipersonnel bombs to the United States. The Japanese were retaliating for the Tokyo bombing raids initiated by the United States in response to the Japanese bombing of Pearl Harbor in 1941.

Young Japanese high school girls constructed the balloons from mulberry bark made into paper (washi). The young girls worked long hours in dark, secret factories sewing and gluing the paper with a potato-like paste. Each balloon was 33 feet in diameter.

ASSOCIATED PRESS/AP Images

The Japanese understood that between 25,000 and 30,000 feet above sea level, the trade winds blew from Japan to the United States and could provide the force to transport the balloon and its bombs across the ocean. These were the first intercontinental bombs!

The Japanese had to solve the problem of the balloons rising during the warmer daylight hours and falling at night. During the warmer hours of the day, the temperature of the air increased. When the temperature increased, the volume of the air inside the balloons would increase, resulting in lower air pressure inside the balloons. As a result, the balloons would rise. As the air temperature decreased at night, the volume inside the balloons decreased (Charles's law). When the volume decreased, the air pressure inside the balloons would increase, causing them to sink.

Using a complicated series of controls, altimeters, and a series of 32 five- to seven-pound sandbags, the Japanese were able to get the balloons to stay at an altitude of around 25,000 feet, where the trade winds would continuously blow. At night, when the balloons would start to sink, a

Using a complicated series of controls, altimeters, and a series of 32 five- to seven-pound sandbags, the Japanese were able to get the balloons to stay at an altitude of around 25,000 feet, where the trade winds would continuously blow. At night, when the balloons would start to sink, a constant altitude was maintained by systematically dropping some of the sandbags. When all sandbags had been dropped, the fire balloons would land, setting off the fire balloons and the antipersonnel bomb.

The key to solving this mystery lie in the sandbags. Geologists analyzed the sandbags and determined that the sand came from several possible beaches in Japan. The unusual mixture of trace minerals along with the type of diatoms and forams indicated that the sand came from the northeastern shores of Japan.

Real-World Experiences Based on Core Science

The Science of Soil

Soil, one of nature's most basic and essenti
taken for granted. Consider the many wa
provides the following:

- Source of minerals essential for crop gr
- Source of fuel
- Home for many animals
- Substrate for maintaining a balanced ec
- Place to bury our dead
- Materials for the creation of pottery
- Materials used to construct buildings, l glass

In this section, you will examine how chemical, physical, and biological ways in soil are the basis for the forensic analysis of

Soil Formation

Soil is the top layer of the earth's crust that usually covers bedrock. **Soil** is a mixture of weathered rock, microorganisms, decaying organic matter, water, and air. The chemical composition of soil depends on the following:

- **Mineral** content (the naturally occurring crystalline structure found in soil)
- Type of rocks that formed the soil
- Local climate
- Type of the environment

Soil formation is a long and complicated process, developing over time as a result of the interaction of biological, physical, and chemical weathering. The formation of soil is affected by temperature, rainfall, ice, wind, and wave action. Animals also affect the soil: Plants, animals, fungi, and other living organisms add **organic material**, or carbon-based materials derived from living things, to the soil. Animals that dig or burrow in the soil help with the aeration (air circulation) and the mixing of soil. *Physical weathering* results in breaking larger rocks into smaller rocks as a result of abrasion (rocks colliding from falling, wave, or wind action), frost, and plants splitting rocks as their roots grow in cracks of rock. *Chemical weathering* changes the mineral content of the soil. For example, iron in rocks forms rust in the presence of water. Olivine, a greenish mineral found deep in the earth, weathers to form clay when brought to the surface. Note that some minerals, such as quartz, do not easily undergo chemical weathering and are therefore more commonly found on a beach with strong wave action.

Soil Texture

The size and shape of the particles found in the soil vary depending on the type of minerals originally found in the rocks and the type of weathering of the rocks. Soil texture (how the soil feels between your fingers) describes the size of the mineral particles that make up soil. There are three main soil textures based on the size of the granules: **sand**, **silt**, and **clay** (**Figure 13-1**). Sand is the coarsest texture, and clay is the finest texture. **Table 13-1** contains more information about soil textures. Most soil samples are mixtures that contain a combination of

FIGURE 13-1 A comparison of particle sizes in soil.

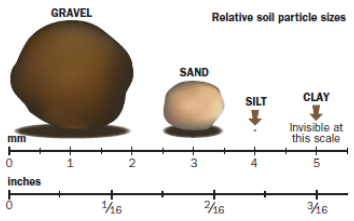


TABLE 13-1 Soil textures based on size

Soil Texture	Particle Size (*mm*)	Feels Like	Location	Characteristics
Sand	Coarse (2.0–0.05 *mm*)	Coarse granular	Deserts, beaches, riverbeds	Loses water, air circulates easily
Silt	Medium (0.05–0.002 *mm*)	Gritty	Sediment in riverbeds	Retains water
Clay	Fine (Less than	Sticky when wet, smooth	Varies	Retains water

DID YOU KNOW?

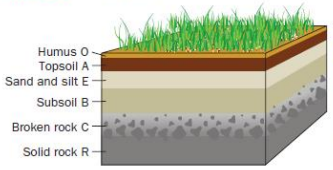
Stratigraphy is the study of how soil and rock layers have formed and are arranged. A soil profile can be described as a soil layer cake. The U.S. Department of Agriculture (USDA) has identified more than a thousand soil profiles in the United States. Visit the USDA's website usda.gov and follow the link to their Web Soil Survey to learn more about soil profiles in your area.

types of plants growing in the soil also affect the pH of the soil or its level of acidity or alkalinity (basicity). The pH scale ranges from 0 to 14. A pH higher than 7 is basic, and a pH lower than 7 is acidic. Evergreen needles will make the soil more acidic. Soils with a humus layer greater than 20 percent tend to be acidic as well. On the other hand, chalk—a white, porous carbonite rock derived from the skeletal remains of sea organisms—tends to make the soil more basic. The pH of soil plays a part in determining which organisms can survive in that soil and affects the type and rate of decomposition.

Soil Profiles

Sand, silt, or clay that is deposited by wind or water is called **sediment**. Sediment on dry land will settle into soil horizons, or layers, that are more or less parallel to the earth's surface. The soil in each horizon has characteristic properties, as described in **Figure 13-3**. The soil in a given geographic area will have a unique **soil profile**, or sequence of layers. Each soil horizon within the profile is labeled with an uppercase letter—commonly O, A, E, B, C, and R, from top to bottom. The three main soil profiles are A, B, and C. The top layer, O, is the organic layer. The E layer refers to soil formed by eluviation, or the movement of organic matter and minerals due to the downward movement of water. The R layer refers to rock.

FIGURE 13-3 Soil profile key.



Layer	Common Name	Description
O	*Humus*	Decaying organic matter
A	*Topsoil*	Dark; mixture of humus and minerals; plants sprout here
E	*Sand and silt*	Light; water leaches away most minerals
B	*Subsoil*	Clay and mineral deposits
C	*Broken rock*	No plant growth, little humus
R	*Solid rock*	Solid rock

Soil and Decomposition

The type of soil has an effect on the rate and manner of decomposition. In turn, a decomposing body has an effect on soil. Understanding this interaction is useful when trying to investigate crimes.

Effects of Decomposing Bodies on Soil

When a body is buried directly in the soil, it affects the soil chemistry in a complex series of ways. Toxic chemical products of decomposition, along with nutrient-rich decomposition fluids, seep out of the body and enter the soil. A cadaver decomposition island (CDI) (**Figure 13-4**) is formed by a unique concentration of decomposition products that initially kills vegetation. An isolated area barren of plant growth reveals that plant growth has been disturbed and has not resumed. It could mark a recent burial.

As decomposit
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Effect of Soil on

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effect on the soil.
the rate and ma
body. The burial
oxygen level all af

- *Burial depth an* courage someo more exposed body is buried, A burial of thre tions. Bodies fo a greater level o
- *Soil moisture a* increase the lik Chapter 12, is decomposition.
- *Soil texture.* Cla ture, and they c and contracting reducing the su Bodies in coarse buried in sandy preserved for hu mified corpse.
- *Soil pH.* Acidic can preserve bo reduce decomp isms are most a
- *Oxygen level.* In and putrescine stench can attra dogs, with their

DID YOU KNOW?

Many studies have been performed on the ancient "bog people"—human cadavers buried in acidic peat bogs in Northern Europe. The oldest skeletal remains of bog people have been dated to 8000 B.C. The oldest fleshed bog body was dated to 2000 B.C. The acidic peat bogs prevented decomposition and mummified their bodies.

Real-World Experiences Based on Core Science

The Science of Ballistics *Obj. 18.3*

As a basketball is thrown toward a hoop, it takes a downward curved path. The trajectory of any propelled object is described as a parabolic (curved) path (**Figure 18-2**).

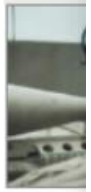
Bullets fired from a firearm differ in velocity and distance traveled before they ultimately fall to the ground or embed in a target. The path of the bullet, known as the bullet's **trajectory**, is not straight; rather it curves as the bullet travels through the air. Many forces act on that bullet as it leaves the barrel of the firearm, affecting the bullet's trajectory or path.

FIGURE 18-2 Note the parabolic or curved path of the projected basketball.

The first force to act on the bullet is the pressure of expanding gases released when gunpowder is ignited. This explosion propels the bullet forward at a high vel
of the firearm. The greater the amount of gunpowder used, th
motion of the bullet. As the bullet exits the gun barrel, the bull
subject to the forces of air resistance and wind and the downw

In 1609, Galileo, an Italian astronomer, physicist, and er
to describe a parabolic trajectory or path of a projectile. Ga
with Sir Isaac Newton's explanation of the Three Laws of Mo
the basis for the physics and mathematics of ballistics. Newt
every action, there is an equal and opposite reaction," can be
the **recoil**, kickback or backward movement of a firearm w
The explosive force of the ignitions of the gun-
powder within the cartridge produces forward
propulsion (action) to the bullet, while a back-
ward force (the recoil) is absorbed in the firearm,
hands, and arms of the shooter (reaction).

FIGURE 1
movie An



Before discharging a firearm, the shooter makes adjustments for the height and distance of target, wind, and weather conditions (**Figure 18-3**). The longest distance recorded of a sniper hitting a target using a rifle is approximately 2 miles.

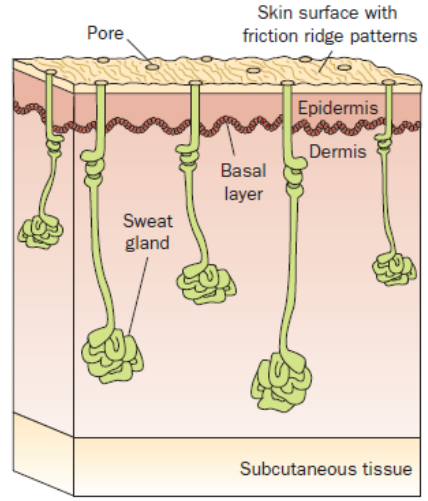
The Science of Fingerprints *Obj. 6.2*

Look at the surface of your fingers. Are they smooth and shiny? No. All fingers, toes, feet, and palms are covered in small ridges. These are raised portions of skin, arranged in connected units called *dermal, or friction, ridges*. They help us with our grip on objects that we touch. When these ridges press against things, they leave marks. A finger leaves an impression called a **fingerprint**.

The imprint of a fingerprint consists of natural secretions of the sweat glands that are present in the friction ridge of the skin (**Figure 6-4**). These secretions are a mixture mainly of water, oils, and salts. Dirt from everyday activities is also mixed into these secretions. Anytime you touch something, you may leave behind traces of these substances in the unique pattern of your dermal ridges. Due to the uniqueness of fingerprints to an individual, this type of

dual evidence.

FIGURE 6-4 Our fingertips are covered with hundreds of microscopic sweat pores that make our fingers moist and able to grip better.



ints has been known for
only recently discovered
ingerprints form in the
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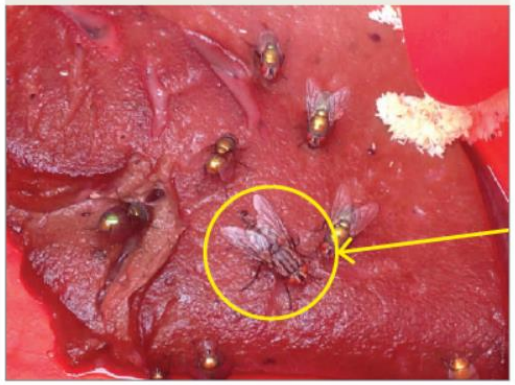
Note that although iden-
ey do not have the same
during gestation.) These
d in the areas such as the
lines on the surfaces of

terns happens in the basal layer of skin, where
e basal layer grows, unique ridge patterns form,
rrounding the fetus. The pattern can be altered
An injury of this type may create an alteration
ears on the original pattern.

The Science of Forensic Entomology: Insects and Decomposition *Obj. 11.3*

All organisms have specific requirements for survival. A habitat must be favorable, or the organisms will not survive. The most important factors for most organisms to survive are suitable temperatures, the correct amount of moisture, a suitable food source, and sufficient oxygen and a favorable environment to raise their young (**Figure 11-4**). Other factors affecting survival are the presence of other organisms competing for food and living space, predation, reproduction limitations, and toxic effects of wastes due to crowding.

FIGURE 11-4 Odors of decomposing liver attract blowflies (shiny) and the larger flesh fly (encircled). Clusters of white, blowfly eggs are visible on the right. Adult blowflies feed on decomposition fluid seepage.



When two different organisms have the same habitat requirements, they compete. For example, both fly larvae and beetle larvae compete for the decomposing flesh (Figure 11-3). The adult beetle reduces this competition by consuming fly larvae, which provides more food for the developing beetle larvae.

Decomposition

In this chapter, you will study the primary insects of decomposition with an emphasis on flies and beetles. After death, a decomposing body undergoes a

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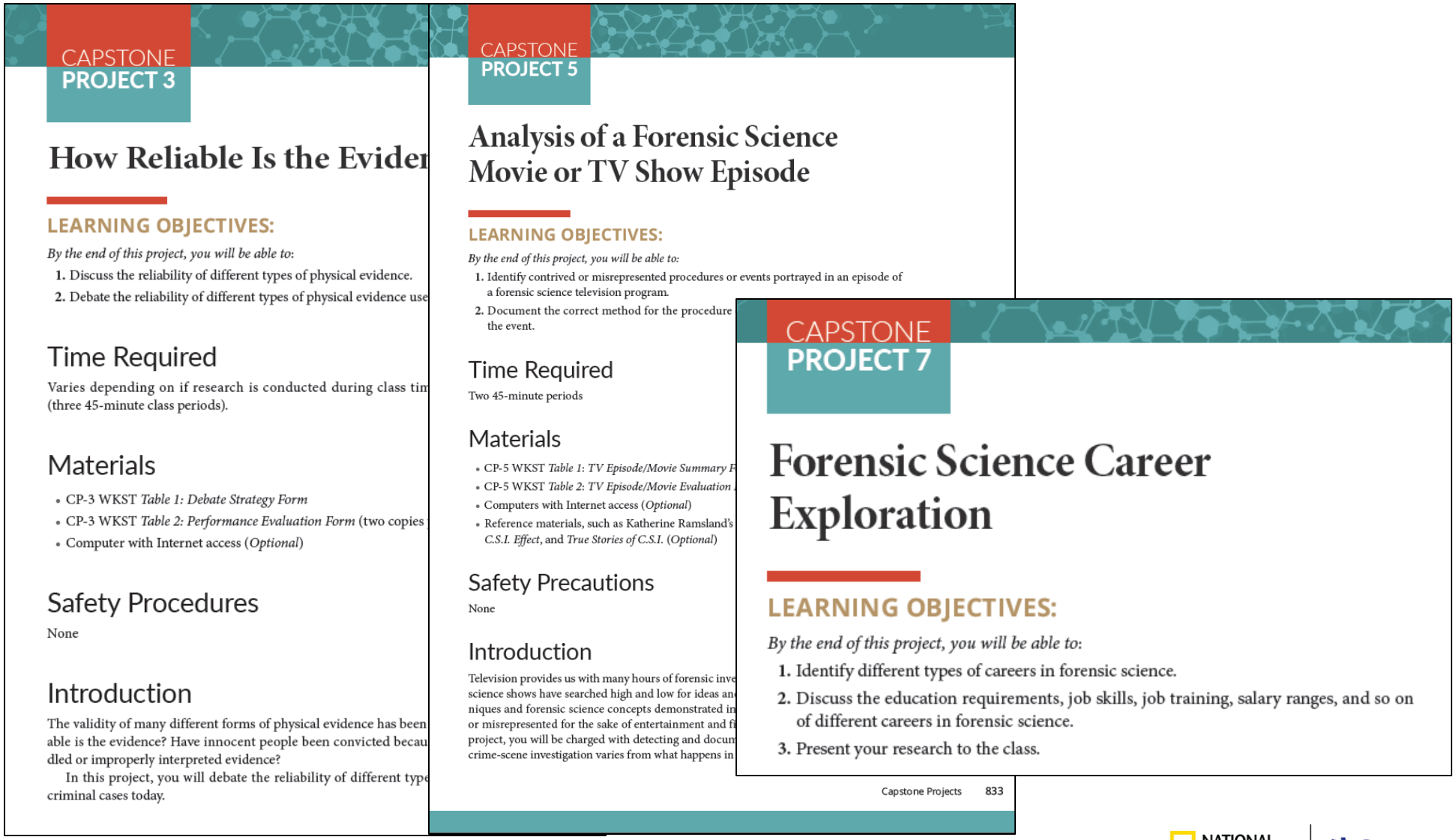
Ten **Capstone Projects** integrate the concepts learned throughout the course



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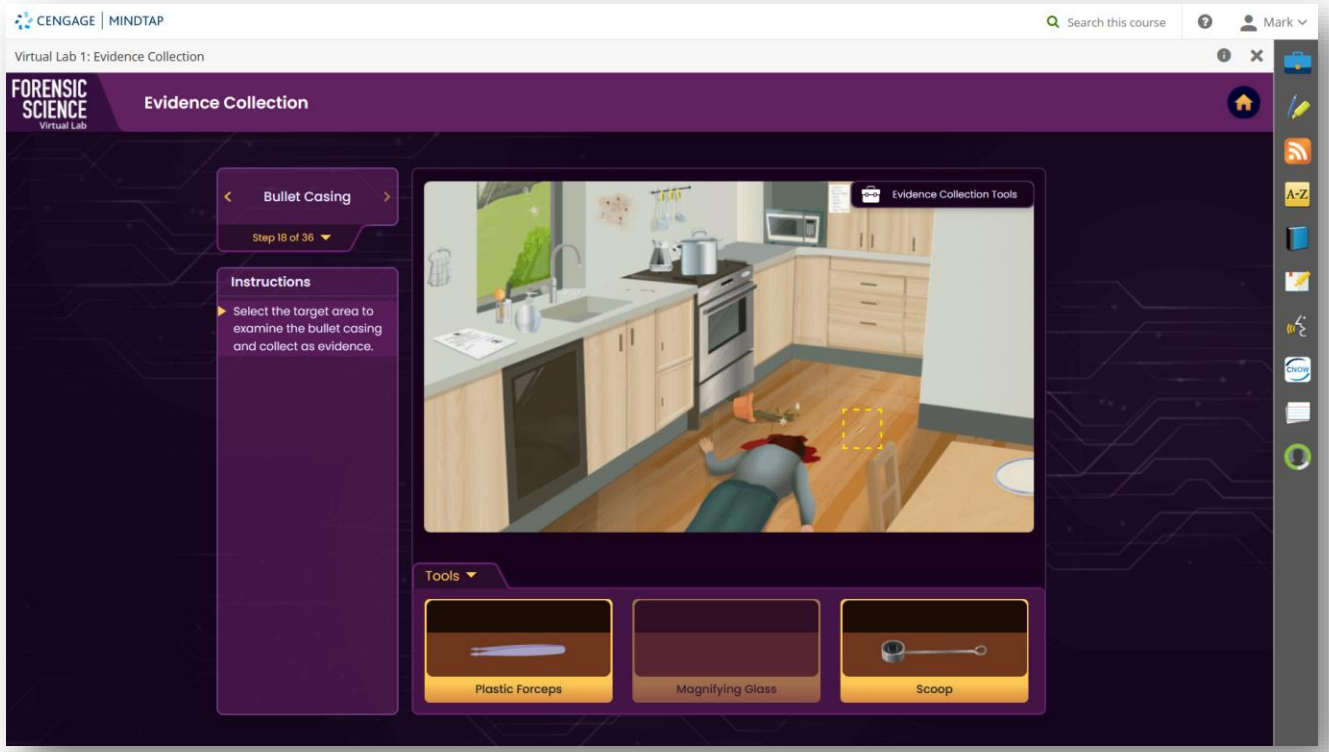

- **Virtual Lab** *The Death of Rose Cedar* (series of 10 labs using skills to solve a murder case)
- **Interactive Labs** for each chapter
- **Lab worksheets** are fillable PDF's
- Additional lab activities (23 more) not included in print book

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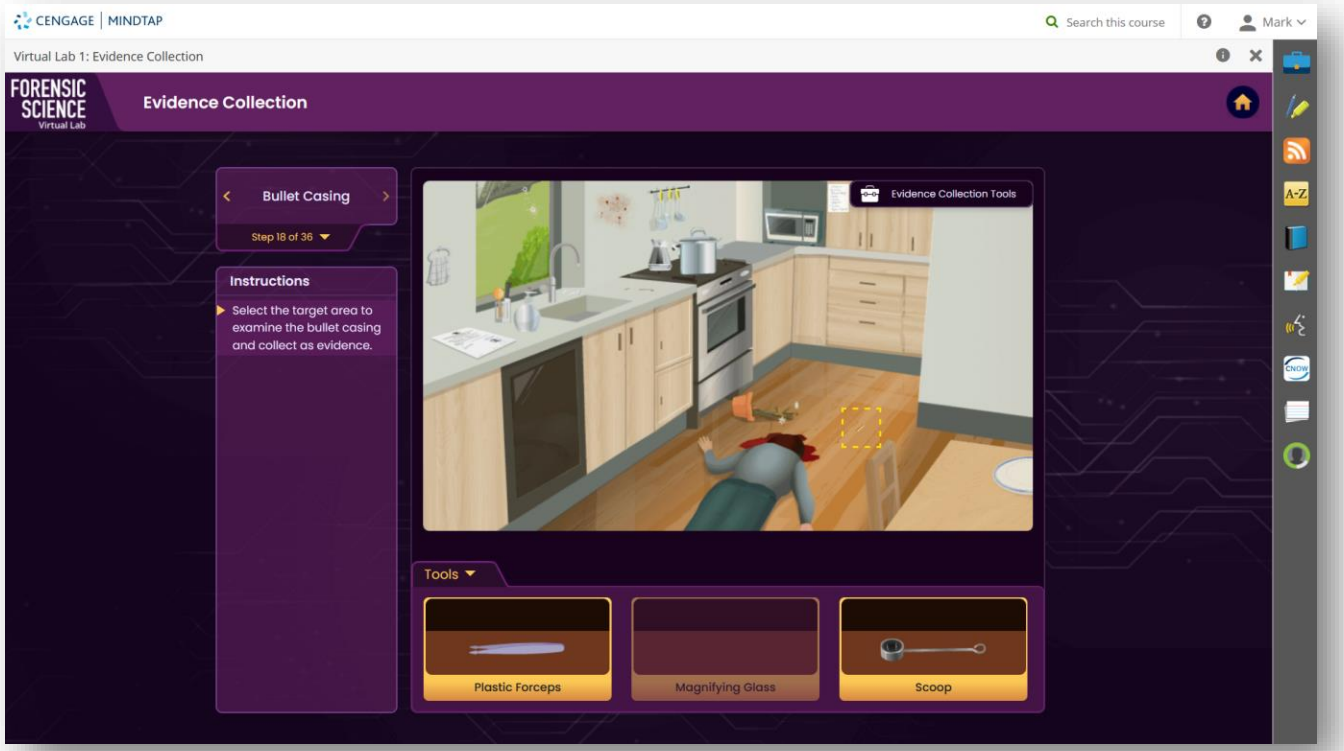
Virtual Lab - The Death of Rose Cedar

- Virtual Lab 1: Evidence Collection
- Virtual Lab 2: Suspect Identification
- Virtual Lab 3: Fingerprinting
- Virtual Lab 4: Hair Analysis
- Virtual Lab 5: Fiber Analysis
- Virtual Lab 6: Handwriting Analysis
- Virtual Lab 7: Glass Density
- Virtual Lab 8: Soil Analysis
- Virtual Lab 9: Blood Spatter
- Virtual Lab 10: Ballistics
- Virtual Lab: Final



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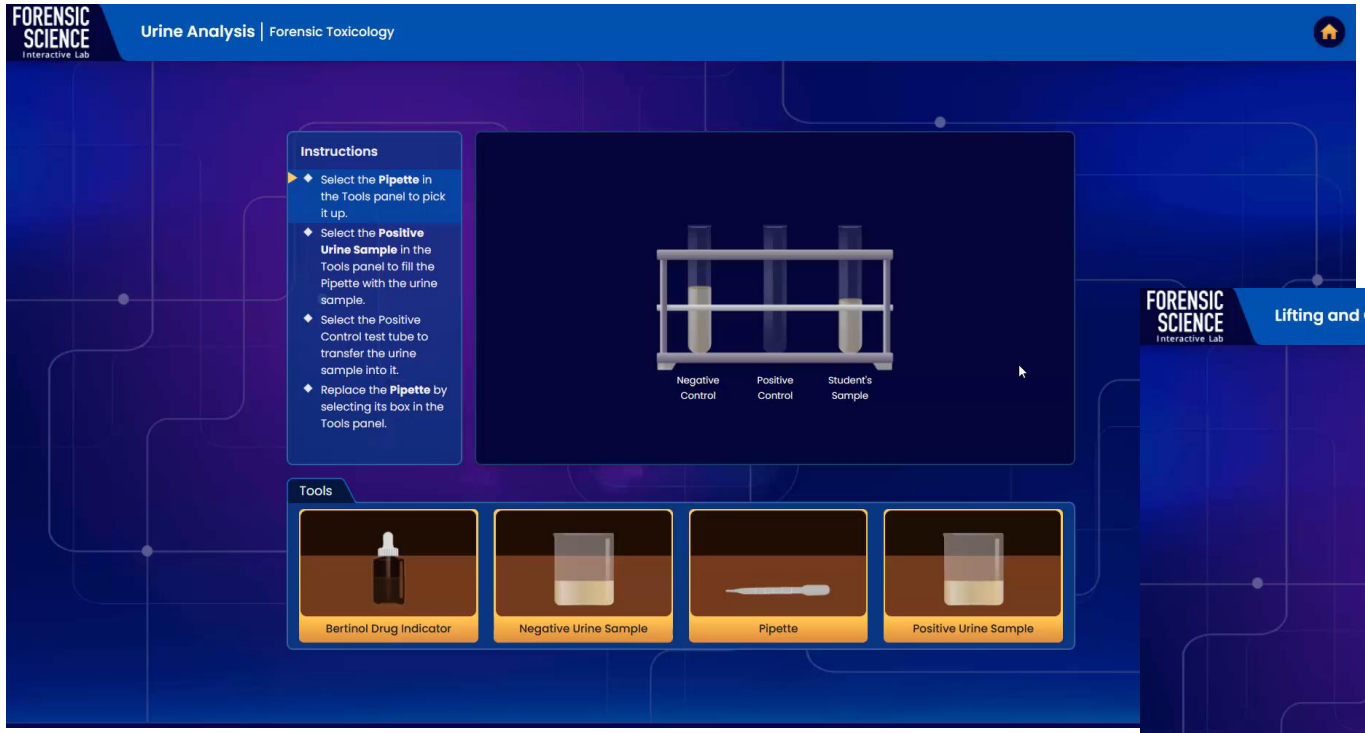

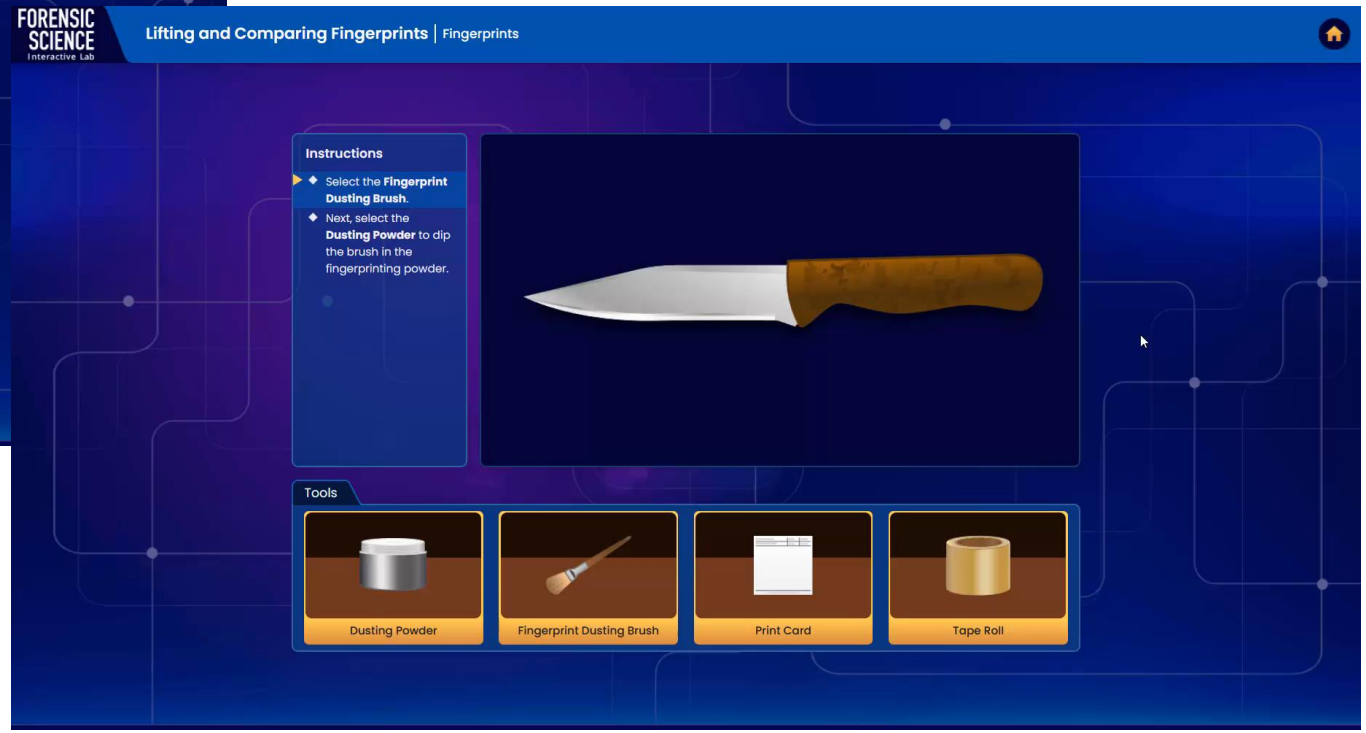

Interactive Labs for each chapter

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Chapter Opening Scenarios highlight intriguing news shaping forensic science today

Who Are You? Cold Cases Solved Using Forensic Genealogy

In April 1981, the body of a young girl with red, braided hair wearing a buckskin jacket (known as the "Buckskin Girl") was found murdered by the side of an Ohio road. Detailed fingerprint analysis; dental record comparisons; hair, pollen, and isotope analysis; and facial reconstructions completed by the National Center for Missing and Exploited Children (NCMEC) network failed to identify the young woman until 2018. At that time, a volunteer group known as John and Jane Doe Project used the stored 37-year-old blood sample with its degraded DNA to compare the unidentified person's DNA with the DNA found in public genealogical databases (GEDmatch provides tools for DNA and genealogical analyses). Based on that search, relatives were identified from the public genealogical database, family trees were viewed, interviews were conducted by detectives, and ultimately, the "Buckskin Girl" was identified as 21-year-old Marcia L. King from Arkansas.

This was one of the many cold cases solved by using public genealogical databases and SNPs (single nucleotide polymorphisms) to analyze DNA. You may have heard of genealogy searches through Ancestry.com and 23andMe. As of 2019, over 26 million people have submitted their DNA to undergo this genetic screening. To collect an individual's DNA, the mouth is swabbed, and then the sample is mailed to the company for analysis. They analyze the DNA to trace ancestry and help locate relatives. This same amazing technology is being used to solve many cold case crimes because SNP analyses use shorter DNA fragments. Degraded or damaged DNA evidence, once thought to be useless, can now be reevaluated and used to identify perpetrators of crime who have eluded capture. It can also be used to identify the remains of unknown deceased individuals such as the "Buckskin Girl."

National Center for Missing and Exploited Children

Artist sketch of the unidentified murder victim known as the "Buckskin Girl."

Courtesy of Marcia King's Mother

Marcia Lenore King's remains were identified 37 years after her murder using public genealogy databases.

Aaron Hernandez: Murderer or Victim of Chronic Traumatic Encephalopathy?

din Lloyd's body was found in an industrial park with gunshot wounds to his back and chest in 2013. Lloyd was a miprofessional football player visit- area during the off-season. Car tread the murder scene were photographed rch for a unique tread pattern.

y was found about a mile away from leboro, Massachusetts, residence of ndez, a football player for the New ots. On June 18, 2013, as part of the investigation, the police searched the n Hernandez, who had a history of roblems working with his teammates. din Lloyd's body was found, investi- ined that Hernandez destroyed his system and cell phone and employed eaners to thoroughly clean his residence. By June 26, Hernandez was arrested for the minutes after his arrest, the Patriots released Hernandez as a player.

e evidence in the case was circumstantial. Prosecutors stated that Hernandez's DNA he crime scene. Four stones wedged in a tire of Hernandez's rental car created a pression. When investigators compared the crime-scene photographs of tire impres- the crime scene with Hernandez's rental car tire impressions, they were consistent o line up perfectly. On April 15, 2015, Hernandez was found guilty of murder in the charge that in Massachusetts automatically carries a sentence of life in prison with- y of parole. No motive for the murder was ever substantiated.

9, 2017, correction officers found Hernandez in his cell, an apparent victim of sui- g. After his death, Boston University researchers studied his brain and diagnosed nic traumatic encephalopathy (CTE). Researchers stated that Hernandez's CTE may sed by repeated head trauma during football practice and games. They suggested which results in poor judgment, aggression, paranoia, anger, emotional instability, explain some of Hernandez's criminal acts and other behavior.

Debby Wong/Shutterstock

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- Advances in forensic science procedures and techniques
- Students learn the newest technologies

Advances in Forensic Toxicology *Obj. 9.7*

New rapid, noninvasive, and portable drug-testing devices may soon replace breathalyzer, blood, and urine tests. One of these devices is a postage-stamp-sized, paper-based device that analyzes oral fluids (saliva). The saliva moves through six different channels of the device. Each channel is specific for identification of a dif-
ferent drug. A color change results if the sample contains any of the c

Another device uses a person's fingerprint to identify the use of dil
As drugs, such as cocaine, heroin, and morphine, are metabolized (b
by your body, some of their metabolites are excreted through the
drug metabolites resist washing and are detected on the touch test (I
A paper spray mass spectrometry analyzes the metabolites found on
to identify specific drugs. Tests are quick, and there is no chance for
substitute the sample. Although traces of metabolites can be transf
drug user to a nondrug user during a secondary transfer, the quan
found in the drug user's fingerprint is 100× more than the trace an
drug found as a result of a secondary transfer.

A new technique called *TD-DART-MS* is a rapid screening pres
using real-time mass spectrometry that requires minimal to no pr
samples. Samples can be analyzed from alcohol swipes of the outside
This can be performed in the lab, or it can be performed by law en
the field if they have the device. Unfortunately, most law-enforcer
ments cannot afford this technology.

FIGURE 9-14 Drug analysis from fingerprint touch test.

Source: Intelligent Fingerp

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Advances in Tool Mark Analysis *Obj. 17.7*

Forensic experts have traditionally used visual pattern recognition to compare marks found at crime scenes with those made with suspect tools. This method was challenged in a famous 2000 Florida court case, which established that knife blade tool mark evidence was inconclusive because of inadequate scientific testing. In response, the U.S. Department of Energy's Ames Laboratory at Iowa State University began developing new technology to scientifically determine the uniqueness of tool marks.

Researchers at the Ames Laboratory built a large tool image database that includes examples of screwdrivers, pliers, wire cutters, bolt cutters, tin snips, wood chisels, crowbars, and other tools. A forensic comparison microscope is used to compare crime-scene tool marks with the images of the different tools found in the database. This comparison identifies the type of tool used to produce the tool mark. An algorithm developed by researchers statistically analyzes the tool images and the crime-scene tool mark evidence. Using artificial intelligence, the computer takes objective mathematical relationships and develops degrees of consistency between the tool image and the crime-scene tool mark evidence.

Another research project at the Ames Laboratory involves the use of 3-D characterization methods and statistical methods to distinguish tool marks. The researchers use a *profilometer*. This rapid, nondestructive technique requires no contact with the tool and magnifies, scans, and measures the surface contours (irregularities) of a sample in either two or three dimensions. The profilometer uses the information to create a contour map of the marks from the scan to precisely identify a tool mark. This technology reduces the subjective nature of tool mark comparisons and replaces it with a more objective and statistical comparison. This technology also allows forensic specialists to objectively compare marks on a tool to the marks made by a tool at the crime scene.

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Careers in Forensics focus on trending careers:

- Meet real forensic scientists
- Job requirements
- Preparation
- Education required
- Challenges/rewards

Careers IN FORENSICS

Dr. Rob Fitzpatrick

FORENSIC GEOLOGIST

Forensic geologists use earth science and geologic materials, such as soil and rocks, to solve criminal and civil cases. To become a forensic geologist, you need to take college-level courses in geology, mathematics, chemistry, law, and forensic science. Some laboratories that employ forensic geologists include the Forensic Laboratory in the United States, La Polizia Scientifica in Italy, the Centre of Forensic Sciences in Toronto, and the National Research Institute of Police Science in Japan.

Dr. Rob Fitzpatrick, an Australian soil chemist, is one of the leading forensic soil science experts. Dr. Fitzpatrick has been the director of the CAFSS for more than 10 years and recently developed a manual to assist other forensic soil examiners. The double murder case involving Matthew Holding in the UK studies was solved with the help of Dr. Fitzpatrick's soil analyses, which linked the soil on the shovel in the suspect's car to a quarry in Australia.

Forensic geologists like Dr. Fitzpatrick often work primarily in areas outside of law enforcement. They may help authenticate paintings by identifying the amount of mineral or organic material used to make the paints. This information is used to determine when the painting was painted and possibly by whom.

Forensic geologists may be hired to test soil and rocks in an area being sold as a mine. the rock formation. His expertise helped narrow the search area for Osama bin Laden.

Catherine Ursillo/Science Source

Careers IN FORENSICS

T. Paulette Sutton

BLOODSTAIN PATTERN ANALYST

T. Paulette Sutton, one of the world's leading experts on bloodstains, is the former Assistant Director of Forensic Services and Director of Investigations at the University of Tennessee, Memphis. She has been involved in nationally known murder cases and has worked hard during a long career to make a positive contribution to the legal system. "It's best for my fellow man that we get killers off the street," she says. Since her official retirement in 2006, she has continued to teach, consult, and testify about her area of expertise.

Sutton began her career by training as a medical equipment technician at the University

Sutton's analysis sometimes finds truth rather

ASSOCIATED PRESS/AP IMAGES

"There's nothing I love more than feeding questions to investigators."—T. Paulette Sutton

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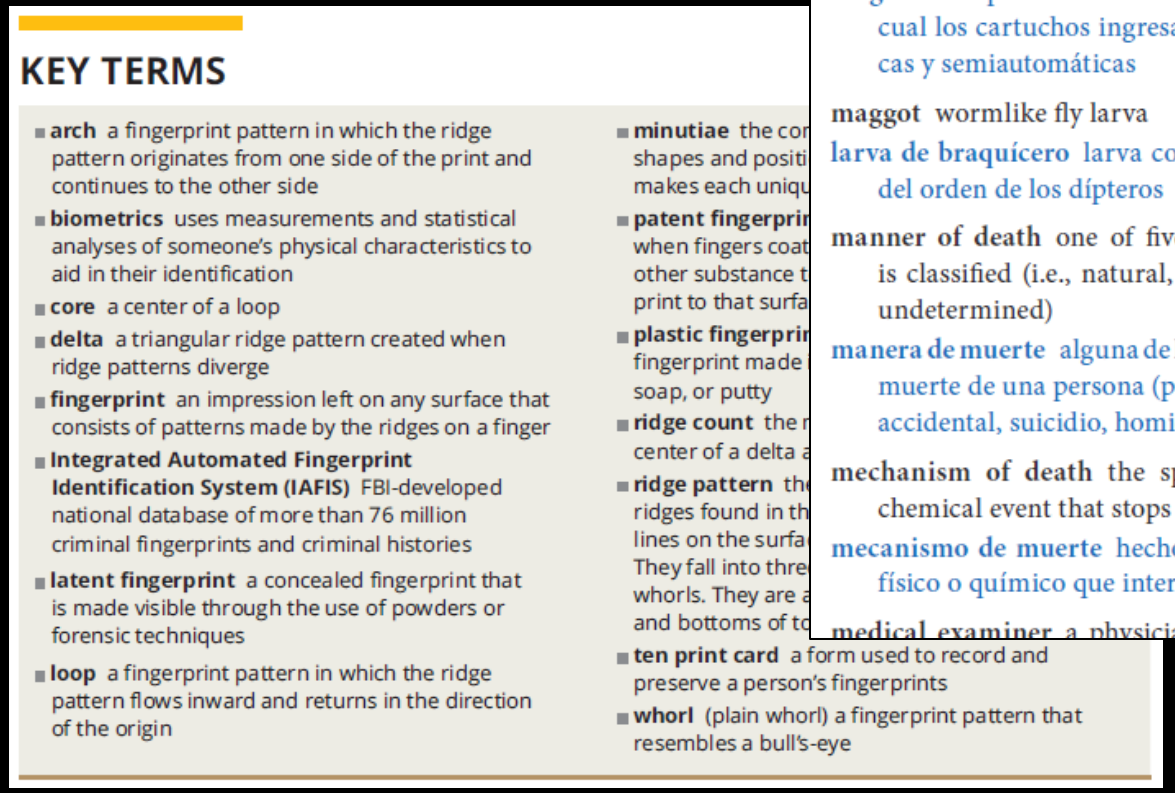
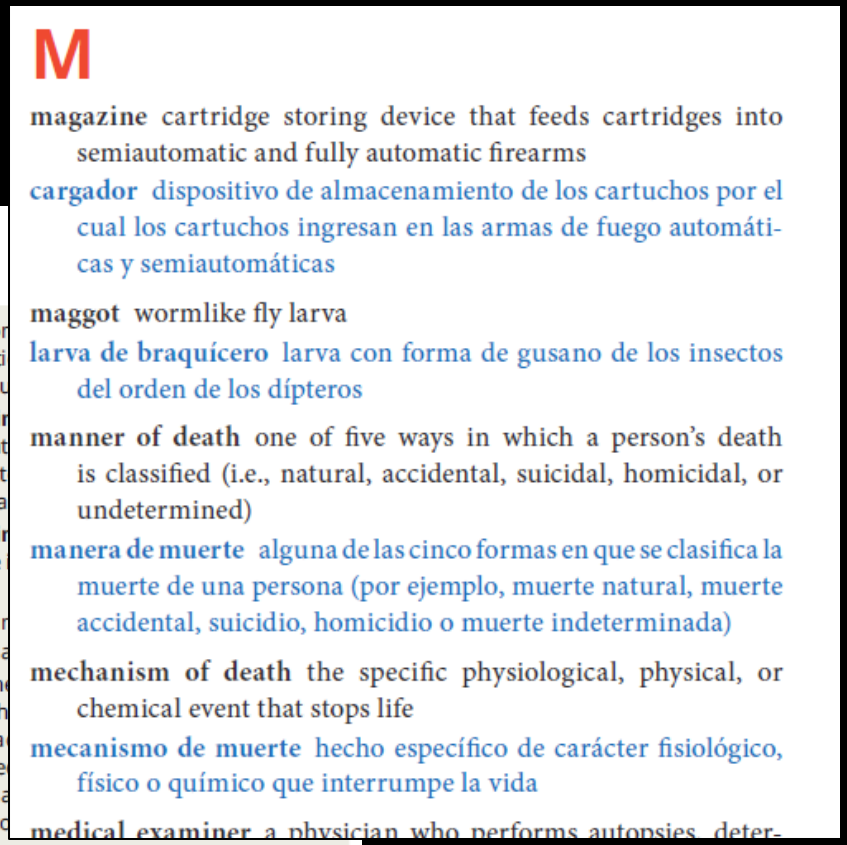
- Scientific **terms and vocabulary defined** in text
- New English/Spanish Glossary



KEY TERMS

- **arch** a fingerprint pattern in which the ridge pattern originates from one side of the print and continues to the other side
- **biometrics** uses measurements and statistical analyses of someone's physical characteristics to aid in their identification
- **core** a center of a loop
- **delta** a triangular ridge pattern created when ridge patterns diverge
- **fingerprint** an impression left on any surface that consists of patterns made by the ridges on a finger
- **Integrated Automated Fingerprint Identification System (IAFIS)** FBI-developed national database of more than 76 million criminal fingerprints and criminal histories
- **latent fingerprint** a concealed fingerprint that is made visible through the use of powders or forensic techniques
- **loop** a fingerprint pattern in which the ridge pattern flows inward and returns in the direction of the origin
- **minutiae** the cor shapes and positi makes each uniqu
- **patent fingerprir** when fingers coat other substance t print to that surfa
- **plastic fingerprir** fingerprint made soap, or putty
- **ridge count** the r center of a delta a
- **ridge pattern** th ridges found in th lines on the surfa They fall into thre whorls. They are a and bottoms of to
- **ten print card** a form used to record and preserve a person's fingerprints
- **whorl** (plain whorl) a fingerprint pattern that resembles a bull's-eye



M

magazine cartridge storing device that feeds cartridges into semiautomatic and fully automatic firearms

cargador dispositivo de almacenamiento de los cartuchos por el cual los cartuchos ingresan en las armas de fuego automáticas y semiautomáticas

maggot wormlike fly larva

larva de braquícero larva con forma de gusano de los insectos del orden de los dípteros

manner of death one of five ways in which a person's death is classified (i.e., natural, accidental, suicidal, homicidal, or undetermined)

manera de muerte alguna de las cinco formas en que se clasifica la muerte de una persona (por ejemplo, muerte natural, muerte accidental, suicidio, homicidio o muerte indeterminada)

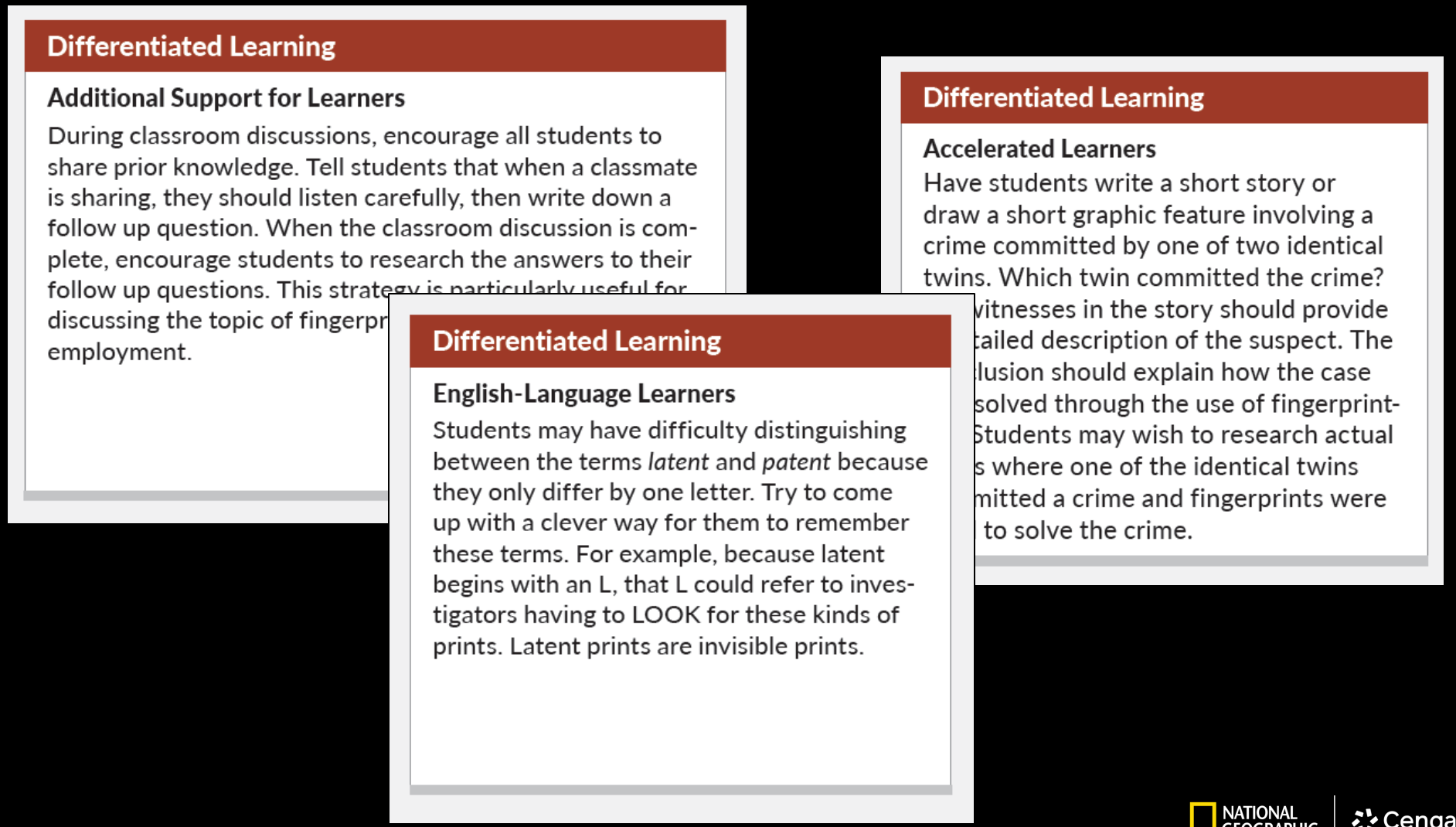
mechanism of death the specific physiological, physical, or chemical event that stops life

mecanismo de muerte hecho específico de carácter fisiológico, físico o químico que interrumpe la vida

medical examiner a physician who performs autopsies, deter-

Accessible to ALL Students

Teacher's Edition support for different levels of students and ELL



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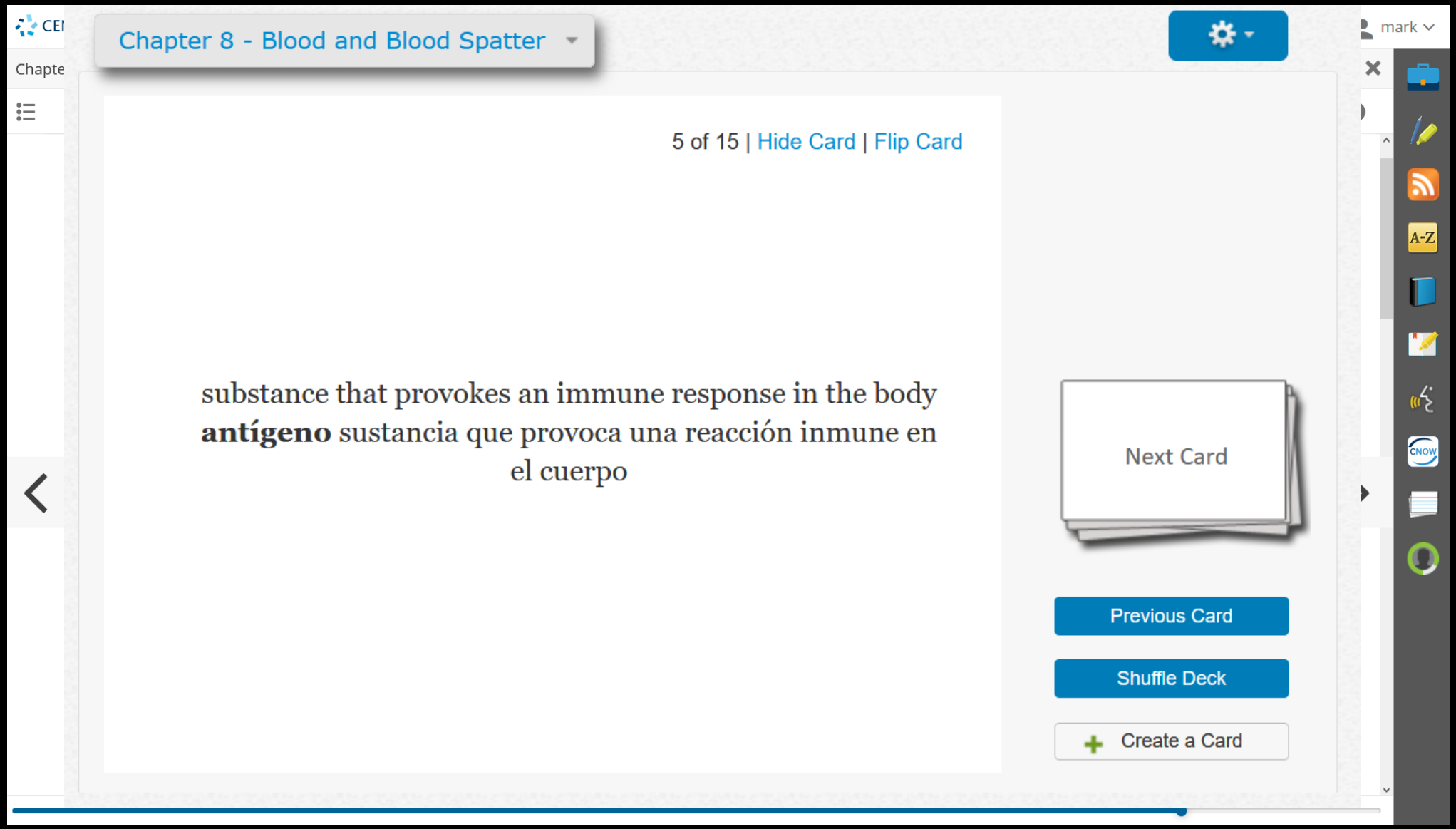

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Support For Teachers

Teacher's Edition:

- Guidance to **Engage**, **Explore**, and **Enrich** every lesson
- **Teaching notes** and strategies
- Reference to **chapter Activities** built in to each lesson

Engage

Ask students to brainstorm what they know about fingerprints and fingerprint evidence. Discuss their responses and correct misconceptions.

Teach

Ask students if they are aware of what jobs require fingerprinting as a requirement for employment. (The list varies by state but always includes jobs that involve care of the elc children, and the disabled. Tell students that today all members of the military, s bus drivers, and teachers a required to be fingerprinte Ask students if they think individuals for any job sho fingerprinted as a requiren for employment.

Explore

Have students research the following programs and report on how they are used to help identify immigrants and why some people believe they violate their First Amendment Rights:

- Automated Biometric Identification System (IDENT) database, headed by US Immigration and Customs Enforcement, prevents illegal entry into the U.S. by storing over 200 million identities.
- Homeland Advanced Recognition Technology (HART) to replace IDENT in the future with the ability to store biometrics s at a faster speed.

Enrich

Ask a fingerprint technician to visit your class and demonstrate the correct procedure in preparing a ten card.

ACTIVITY

Consider introducing Activity 6-4 *How to Print a Ten Card* at this point in the lesson.

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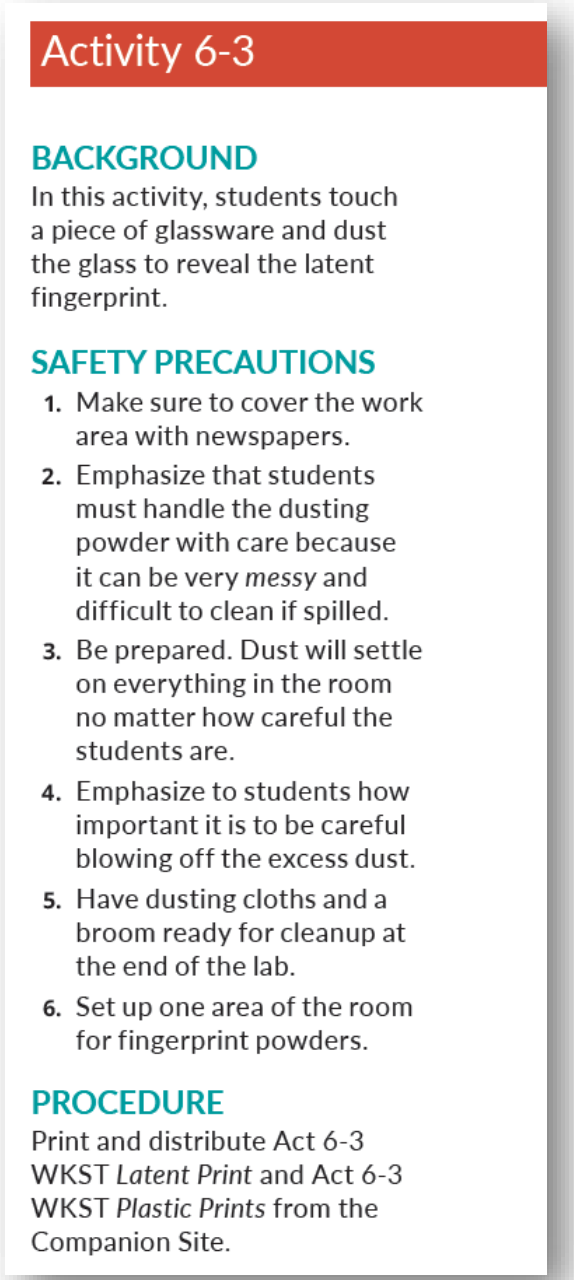


Activity 6-3

BACKGROUND

In this activity, students touch a piece of glassware and dust the glass to reveal the latent fingerprint.

SAFETY PRECAUTIONS

1. Make sure to cover the work area with newspapers.
2. Emphasize that students must handle the dusting powder with care because it can be very *messy* and difficult to clean if spilled.
3. Be prepared. Dust will settle on everything in the room no matter how careful the students are.
4. Emphasize to students how important it is to be careful blowing off the excess dust.
5. Have dusting cloths and a broom ready for cleanup at the end of the lab.
6. Set up one area of the room for fingerprint powders.

PROCEDURE

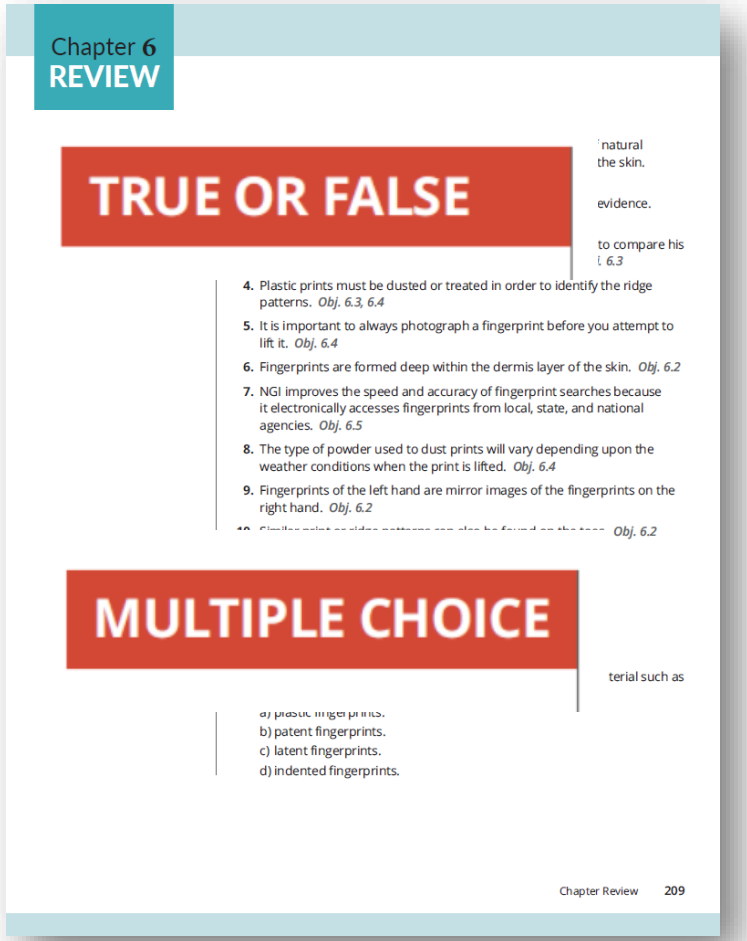
Print and distribute Act 6-3 WKST *Latent Print* and Act 6-3 WKST *Plastic Prints* from the Companion Site.

- **Hands-on Activity** support
- **Reteach** strategies for remediation

Reteach

Remind students that latent fingerprints left at a crime scene are usually only partial prints. In 2013, NGI started a new program called Latents and National Palm Print System (NPPS). More than 18,000 local, state, tribal, and federal law enforcement agencies can search through the latent print files to help solve both current crimes and cold case crimes.

Assessment



Chapter 6
REVIEW

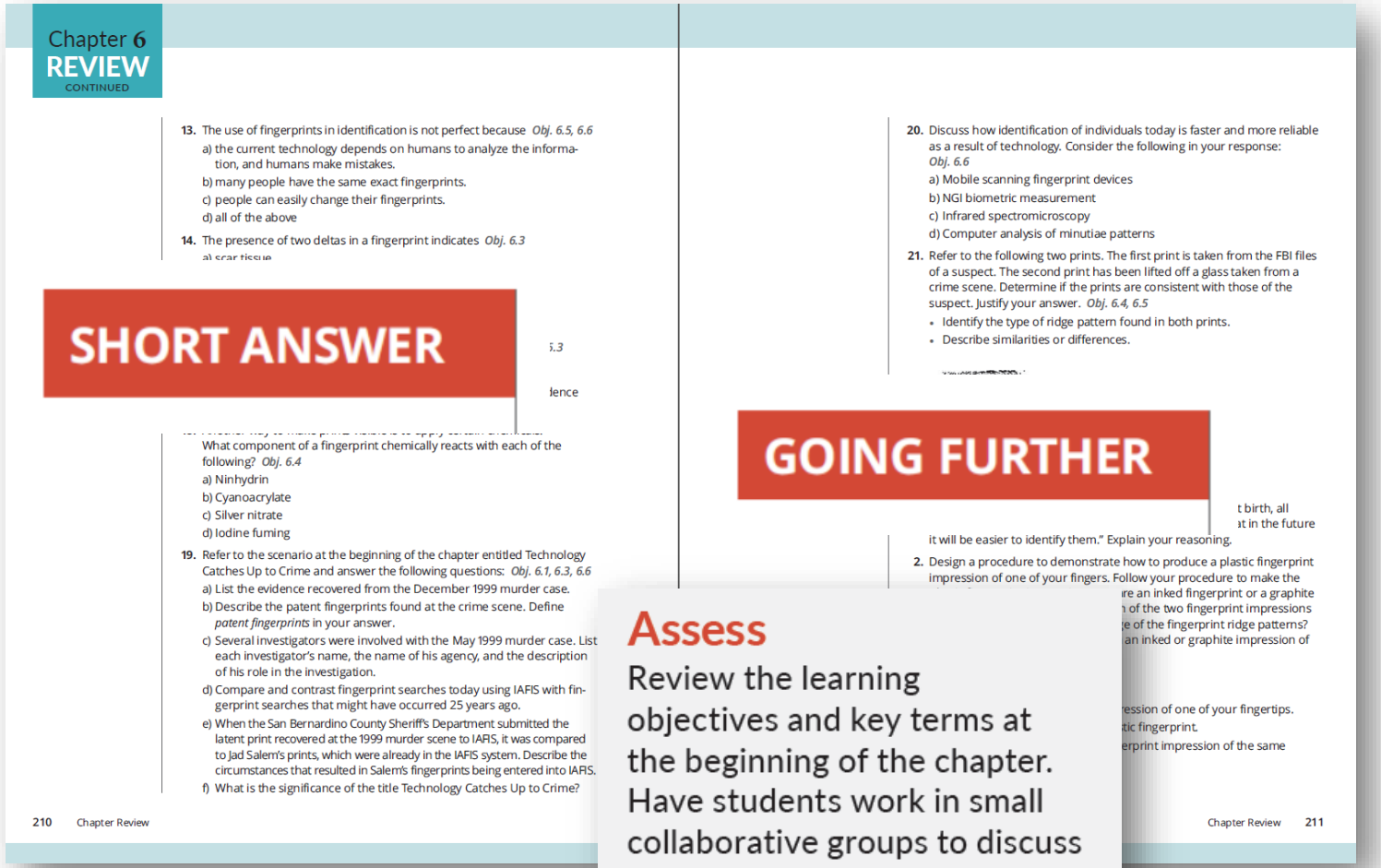
TRUE OR FALSE

4. Plastic prints must be dusted or treated in order to identify the ridge patterns. *Obj. 6.3, 6.4*
5. It is important to always photograph a fingerprint before you attempt to lift it. *Obj. 6.4*
6. Fingerprints are formed deep within the dermis layer of the skin. *Obj. 6.2*
7. NGI improves the speed and accuracy of fingerprint searches because it electronically accesses fingerprints from local, state, and national agencies. *Obj. 6.5*
8. The type of powder used to dust prints will vary depending upon the weather conditions when the print is lifted. *Obj. 6.4*
9. Fingerprints of the left hand are mirror images of the fingerprints on the right hand. *Obj. 6.2*

MULTIPLE CHOICE

b) patent fingerprints.
c) latent fingerprints.
d) indented fingerprints.

Chapter Review 209



Chapter 6
REVIEW
CONTINUED

13. The use of fingerprints in identification is not perfect because *Obj. 6.5, 6.6*
    a) the current technology depends on humans to analyze the information, and humans make mistakes.
    b) many people have the same exact fingerprints.
    c) people can easily change their fingerprints.
    d) all of the above
14. The presence of two deltas in a fingerprint indicates *Obj. 6.3*

SHORT ANSWER

What component of a fingerprint chemically reacts with each of the following? *Obj. 6.4*
a) Ninhydrin
b) Cyanoacrylate
c) Silver nitrate
d) Iodine fuming

19. Refer to the scenario at the beginning of the chapter entitled Technology Catches Up to Crime and answer the following questions: *Obj. 6.1, 6.3, 6.6*
    a) List the evidence recovered from the December 1999 murder case.
    b) Describe the patent fingerprints found at the crime scene. Define *patent fingerprints* in your answer.
    c) Several investigators were involved with the May 1999 murder case. List each investigator's name, the name of his agency, and the description of his role in the investigation.
    d) Compare and contrast fingerprint searches today using IAFIS with fingerprint searches that might have occurred 25 years ago.
    e) When the San Bernardino County Sheriff's Department submitted the latent print recovered at the 1999 murder scene to IAFIS, it was compared to Jad Salem's prints, which were already in the IAFIS system. Describe the circumstances that resulted in Salem's fingerprints being entered into IAFIS.
    f) What is the significance of the title Technology Catches Up to Crime?

20. Discuss how identification of individuals today is faster and more reliable as a result of technology. Consider the following in your response: *Obj. 6.6*
    a) Mobile scanning fingerprint devices
    b) NGI biometric measurement
    c) Infrared spectromicroscopy
    d) Computer analysis of minutiae patterns
21. Refer to the following two prints. The first print is taken from the FBI files of a suspect. The second print has been lifted off a glass taken from a crime scene. Determine if the prints are consistent with those of the suspect. Justify your answer. *Obj. 6.4, 6.5*
    - Identify the type of ridge pattern found in both prints.
    - Describe similarities or differences.

GOING FURTHER

it will be easier to identify them." Explain your reasoning.

2. Design a procedure to demonstrate how to produce a plastic fingerprint impression of one of your fingers. Follow your procedure to make the

Chapter Review 211

Assess

Review the learning objectives and key terms at the beginning of the chapter. Have students work in small collaborative groups to discuss and respond orally or in writing to each objective stated as a question.

Think CRITICALLY

What is your opinion? Does familial searching data need to be protected?

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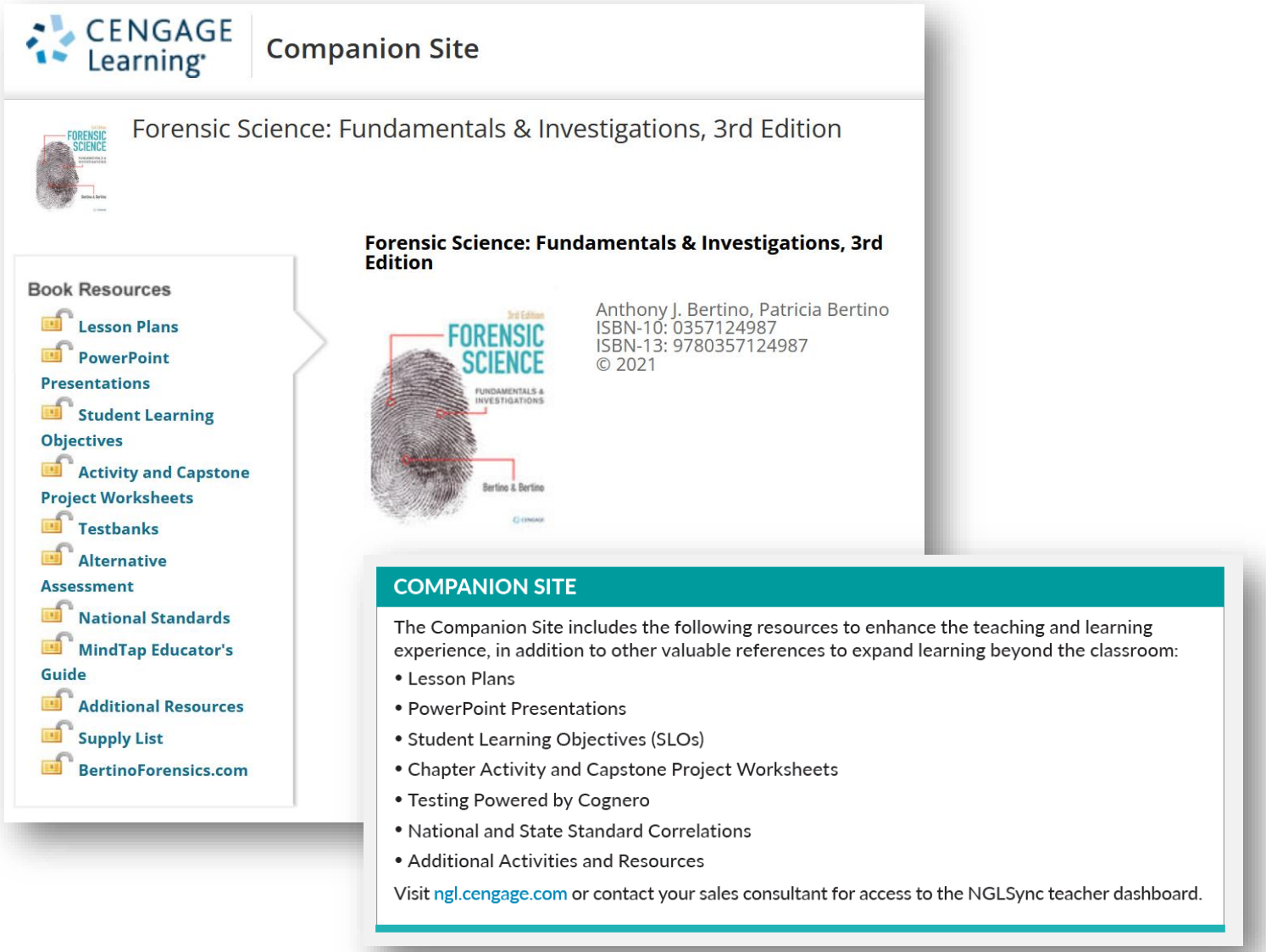

- Lesson Plan and Teacher Notes
- Activity Worksheets
- PowerPoint lecture slides and activity slides
- Test Banks and Alternative Assessments

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Support For Teachers

Anthony “Bud” Bertino

Patricia Nolan Bertino

- Available to help teachers along the way:
  - Author website - bertinoforensics.com
  - Frequent conference presenters
- Taught high school science for over 30 years each
- Understand teacher and classroom needs

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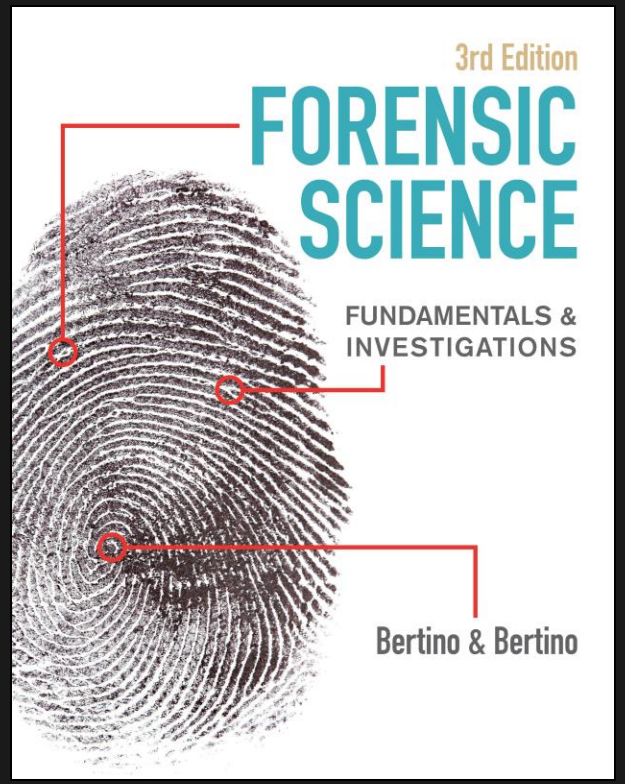

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