Chapter Overview

Forensic specialists use impressions left by shoes, feet, tires, and teeth during crime-scene investigations. Forensic investigators have developed procedures for observing and capturing information from each kind of impression. In many criminal investigations, impressions and the casts made of impressions found at a crime scene are the only evidence that can help an investigator reconstruct a crime.

The Big Ideas

Evidence in the form of impressions is often found at the scene of a crime. There are three kinds of impressions: latent, patent, and plastic. Each kind of impression tells an important part of what happened at the scene of a crime. Foot, shoe, and tire impressions can be collected. From tire tracks, investigators can obtain width and wheelbase information that will help identify a vehicle. Teeth are as individual as fingerprints; therefore, dental impressions can be used as individual evidence. One of the most important aspects of working with impressions in forensic investigations is the need for investigators to observe and record observations carefully.

CHAPTER 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

CHAPTER 15

Casts and Impressions

THE MAN IN THE BRUNO MAGLI SHOES

One morning, the residents of Los Angeles's South Bundy Drive woke to sirens and fluttering police tape. Two bodies had been found, having suffered a horrific knife attack. Bloody footprints, made by size 12 Bruno Magli shoes, tracked the victim's blood along the path. The date was June 13, 1994, and the two bodies were those of Nicole Brown Simpson and Ronald Goldman.

The ensuing court case culminated in one of the most-watched television events in U.S. history. Many people were surprised by the "not guilty" verdict against Brown's ex-husband, Orenthal James (O.J.) Simpson. There was significant evidence linking Simpson to the crime scene, but all of it was class evidence, and nothing pointed to Simpson directly. Who was the man in the Bruno Magli shoes?

The shoe impression was created when the individual wearing the size 12 shoes stepped in a pool of congealed blood. Specialists determined that the impression was made about 20 minutes after the attack. Was the man in the Bruno Magli shoes the attacker or someone who came to the scene soon after the attack? Simpson denied owning a pair of Bruno Maglis, and the prosecutor could find no way to dispute this fact. The footprint evidence was of little value in the criminal case. However, after the criminal trial ended, a photograph was found showing Simpson wearing similar shoes. In the civil case that followed, jurors believed the attacker made the footprints, and Simpson was found responsible for the deaths of Brown and Goldman.

©AP Photo/LAPD

Bloody footprints at the Brown Simpson/Goldman murder scene.

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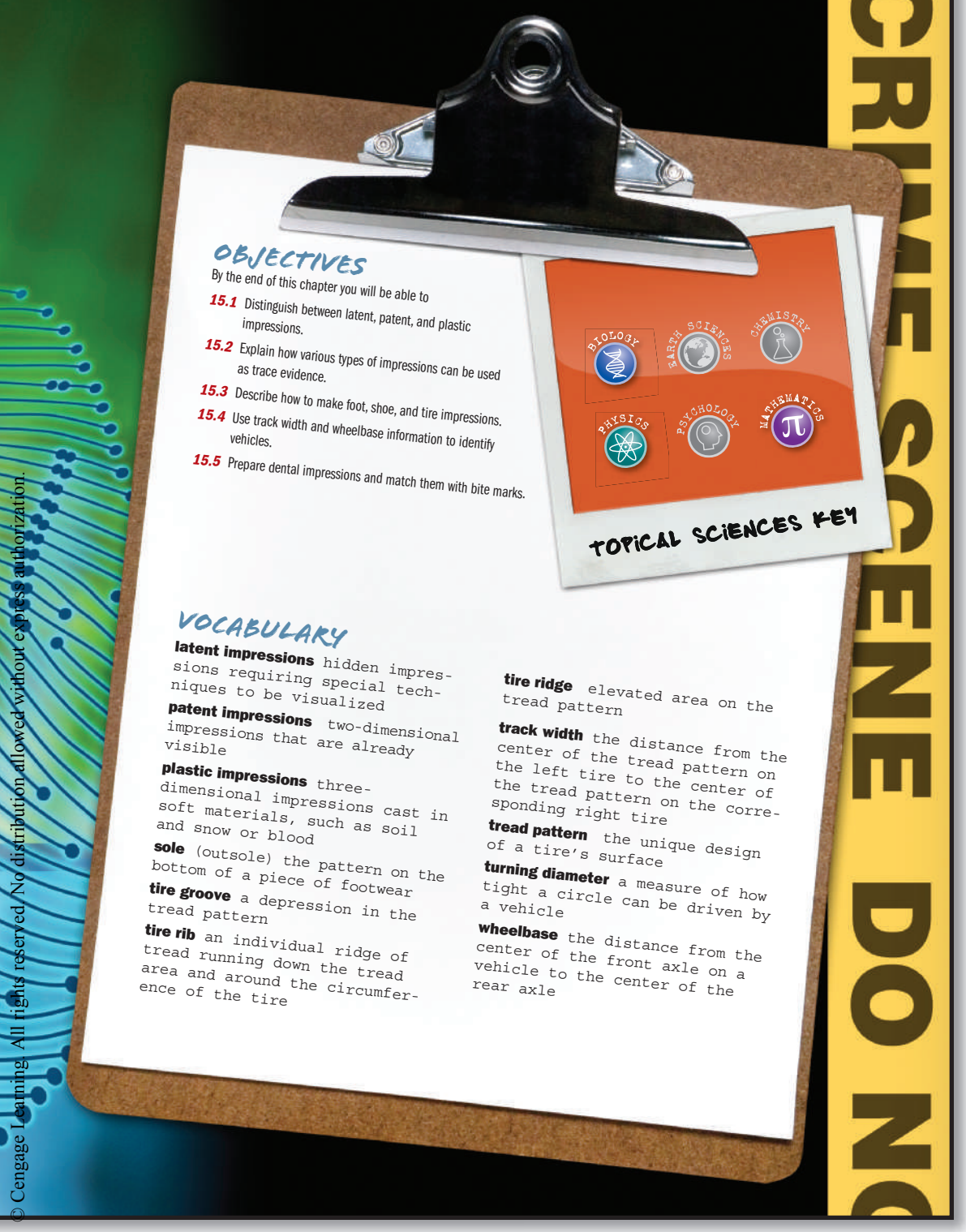
SCENARIO

After reading the scenario, lead the class in discussing these questions:
What role did footprints play in the O.J. Simpson murder trial?
Was this evidence important in the criminal case? The civil case?
What other information, in addition to the kind of shoes that made the print, do you think investigators can determine from footprints?
Do you think that evidence from footprints should be enough to convict a suspect? Explain your answer.



KEY SCIENCE CONCEPTS

Biology: structure of teeth

Physics: inertia, friction, kinetic energy, acceleration, velocity

Mathematics: tables and graphs; diameter, radius, circumference, and area of a circle; measurement

Teaching Resources

- Instructor's Resource CD-ROM includes:
  - PowerPoint Presentation
  - Lesson Plan and extended Objective Sheets
  - Teacher Notes and Activities
  - Activity Forms
  - Rubric
- ExamView CD-ROM
- E-book on CD-ROM

Web site: school.cengage.com/forensicscience

Engage

Discuss the following as a class:

- Bite mark and footprint evidence are found at the site of a crime. Which evidence is most likely to be used as individual evidence? Explain your answer.
- At the location of a hit-and-run accident, tire tracks are found in a muddy part of the road. What kinds of information might be contained in these tire tracks?
- What should investigators do if they find this kind of evidence?
- Why must special care be used when working with teeth, tire, and foot impressions?

Teaching Tip

Explain to students that latent impressions can be found when small quantities of oil, soil, or other substances are left on an otherwise clean floor. Oil, in particular, can be easily identified with special techniques that cause a thin film of powder to adhere to the sticky surface of the oil.

Explore

Use modeling Plaster of Paris or a similar material to create several footprint impressions. Be sure to use different kinds, sizes, and models of shoes. Ask students to interpret the footprints. What can they tell about the person who left these footprints? Challenge students to observe closely, and base their conclusions on their observations.

Teaching Tip

Paris, France, is built on one of the largest gypsum deposits in the world. Gypsum is calcium sulfate, which hardens when it gets wet. Plaster of Paris is really gypsum, and because of the large deposit in Paris, became known as Plaster of Paris.

INTRODUCTION

Crime-scene investigators do not always have the advantage of a crime being captured on camera. Often, the crime scene is devoid of all people. However, the environment has a way of recording what has happened. People, vehicles, and objects leave evidence of their presence at the crime scene in the form of a mark or an imprint. In an earlier chapter, you learned how fingerprints can identify an individual. In this chapter, you will explore impressions made by footwear, feet, teeth, and tires.

Obj. 15.1

TYPES OF IMPRESSIONS

Impressions fall into three basic categories: patent, latent, and plastic (Figure 15-1). **Patent impressions** are visible, two-dimensional impressions produced as an object moves through soil, dust, paint, blood, or other fine particles and leaves a trace. By contrast, **latent impressions** are hidden to the eye but can be visualized through the use of special dusting and electrostatic techniques or chemical developers. Oils, fine soil, and other minute debris can be carried onto clean floors and be transferred as a latent impression. Even clean shoes or feet can transfer materials onto newly waxed or polished floors.

Plastic impressions are three-dimensional imprints. These impressions can be left in soft materials, such as snow, mud, soil, or soap. One difficulty in dealing with plastic prints is that they are easily lost. A strong wind or a sudden change in the weather can mean the loss of important evidence. It is critical that photographs be taken immediately before trying to make any permanent cast.

Figure 15-1. *Examples of latent (left), patent (center), and plastic (right) impressions.*

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INDIVIDUAL OR CLASS EVIDENCE?

Depending on how it is made, impression evidence may be either class evidence or individual evidence. A particular **tread pattern** in shoes or in tires may identify the brand and size, but it does not identify a specific individual or tire. Distinguishing characteristics, such as a split on a shoe sole or unusual wear on a car tire, can be used as individual evidence. Dental impressions are typically considered individual evidence and have a long history of use to identify individuals, especially during wartime to identify remains.

Differentiated Learning

Teaching At-Risk Students

The many hands-on activities should help at-risk students more easily understand this chapter's content. Allow at-risk students to practice making casts of impressions by directing the class in making casts of small impressions left in sand.

Differentiated Learning

Teaching English-Language Learners

The words *latent*, *patent*, and *plastic* are very similar to one another. Assist English-language learners to distinguish the difference between these important vocabulary terms by asking these students to create visual examples for each kind of impression.

SHOE IMPRESSIONS

Obj. 15.2 and 15.3

The crime-scene investigator can obtain information about the person or persons involved or about the crime itself from a shoe or tire impression found at a crime scene. For example, the size of a shoeprint can tell police the size of the person's foot. The depth of a shoe or foot impression can tell police something of the person's weight. The type of shoe (e.g., work boots versus flat dress shoes) may tell something of the person's job or personality (Figure 15-2). The brand of shoe provides information about the buyer. A retired factory worker on a small pension probably would not wear expensive, imported dress shoes, nor would a wealthy, middle-aged woman last seen in an upscale restaurant wear worn tennis shoes.

Databases contain the names of specific manufacturers and tread patterns used to identify different types of shoes. The number of manufacturers that use the same generic **sole** patterns complicates shoe pattern identification. When a shoe impression is found at a crime scene, the crime-scene investigator will search the databases to find the manufacturer that produced the sole as well as to search for the company that purchased that sole for the shoes. Once the footwear has been identified, the impression can be used as class evidence to link a suspect to the crime scene by matching their footwear to an impression. Recall that merely matching the footwear may not provide sufficient evidence to prosecute a suspect.

SHOE WEAR PATTERNS

Although two different people may purchase the same type of shoes, the wear pattern on the shoes will appear quite different (Figure 15-3). We

Figure 15-2. *The type of footwear a person chooses to wear reveals information about him or her.*

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Figure 15-3. *The wear on a shoe's sole can tell you something about the owner.*

©J. Beam Photography

Evaluate

Ask students the following questions to determine their understanding of the material in this section:

- Under what circumstances can foot impressions be used as individual evidence?
- What kind of information is a person most likely to observe based on foot impressions?
- How are foot impressions used to reconstruct the events of a crime?

Teaching Tip

Help students understand that making too many assumptions is not in the best interest of forensic investigators. For example, if the foot impressions left at a crime scene were made by worn tennis shoes, it is possible that a wealthy woman or executive could be wearing those shoes. Basing decisions on evidence, and not speculation, is an important trait of the successful forensic scientist.

Differentiated Learning

Teaching Gifted Students

Ask students to practice observing impressions by going to a public place such as a beach, library, or park. Instruct them to draw or take photographs of impressions they find. Ask students to submit four impressions with their written interpretations.

Teaching Tip

Reinforce the importance of collecting many different kinds of evidence in a criminal investigation. There are only a few cases in which one piece of evidence has been used to convict a person. Most of the time, the sum total of all the class and individual evidence is used to convict an individual.

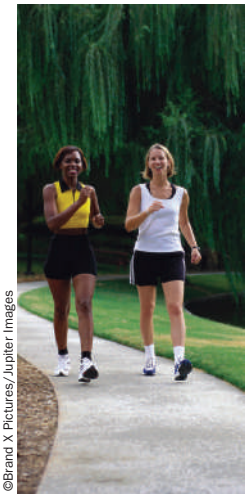
personalize shoes with our own characteristic way of walking and usage. A shoe tread showing strong individual character is classified as individual evidence. Some factors that personalize our footwear include:

- Whether a person walks on his or her toes or heels
- Body weight
- If the person walks straight ahead or tends to walk with toes pointed inward or outward
- The shape of the foot and the wearer's activities
- The surface on which the person usually walks
- Unique holes, cuts, or debris that may become embedded in the shoe

GAIT AND TRACKS

Numerous prints together tell an investigator about the person's *gait,* or walking habits (Figure 15-4). A limp or injury creates an asymmetrical gait; that is, when one foot is angled differently from the other or one foot makes a deeper impression than the other. This pattern is also created when someone is carrying a heavy weight. Tracks can indicate if a person was walking or running by the length of the stride and the pressure and shape of the impression. A trail of footprints can also point to the movements of their maker and possibly assist in recreating events.

Figure 15-4. *Stride pattern is also individual.*



Information that can be obtained from shoe impressions includes:

1. The number of people at the crime scene
2. Movements of the individuals at the crime scene
   - Did the event happen in just one room?
   - Did the event happen in several rooms?
3. The entrance and exit to the crime scene

COLLECTION OF SHOE IMPRESSION EVIDENCE

The steps necessary in collecting shoe impression evidence are (1) photographing impressions, (2) lifting latent impressions, and (3) casting plastic impressions.

Photographing Impressions

Use the following guidelines when photographing impressions:

- Take photographs before anyone touches or alters an impression!
- Fill the camera's viewfinder with the impression.
- Take photographs with the lens perpendicular to the impression to reduce distortion.
- Take multiple photographs of the impression from at least two different orientations (angles).
- If using a digital camera, check your photographs for clarity and retake them when necessary. (Forensic photographs are often taken with black-and-white film, although some departments have moved to digital color

photography. Film is used to guarantee the photograph was not altered. Color film is used to photograph blood spatter.)

- Place an identifying label and a ruler in position with the impression and re-photograph, making sure to focus on the impression, not the ruler.
- Use oblique lighting when possible. Sunlight can produce a glare.
- If an additional flash is needed, position the flash at least three to four feet away to avoid reflection in the photograph.
- If the impression is faint, spray it with a *light* coat of color-contrasting paint.

In a court case, the defense tries to discredit the prosecution's evidence. This is easily done if there is a lack of photographic proof that Exhibit A was found at the crime scene. Therefore, the forensic investigator's first task at the crime scene is to document the scene and the evidence with photographs (Figure 15-5). The only exception occurs when paramedics move a body when applying their lifesaving skills.

Figure 15-5. *Impression evidence is documented before any attempt is made at lifting impressions.*

Multiple lifts of the same print are possible using gel lifters. The second lift is fainter, but generally sharper in detail. Electrostatic lifting can also be done before gel lifting.

Lifting Latent Impressions

When a shoe or bare foot walks on a smooth surface, it leaves a print that is not usually visible to the unaided eye. A bare foot leaves a thin layer of body oil, while a shoe leaves a thin film of substances from either the plastic in the sole or dirt. It takes a trained crime-scene investigator to know where to look for latent prints. If the entry and exit areas have been identified, the task of latent print identification is made easier. There are several different methods to make latent prints visible, which include:

- Luminol to make bloody footprints visible and able to be photographed.
- Dusting of the latent print, similar to dusting for fingerprints, to reveal an impression and make it visible to be photographed and lifted.
- Electrostatic lifting and gel lifting techniques to capture invisible impressions.

Electrostatic Dusting and Lifting A dry shoe may deposit a small amount of dust with each step. Electrostatic dusting can reveal this fine dust and create an impression. It works by applying an electrostatic charge on a piece of lifting film, which is then placed over the latent print (Figure 15-6). The film picks up and holds the dust of the latent print. By viewing the film with a special light source, the impression can be made visible and photographed.

Electrostatic charges can lift impressions from paper; flooring, including carpeting, wood surfaces, and linoleum; and pavements, such as asphalt and concrete. This method can also help clean up surface debris and expose a more complete impression.

Gel Lifting Gel lifting is another method used to visualize and recover latent impressions. A gel lifter is a layer of thick gel sandwiched between paper backing and a plastic cover sheet. It is thick and flexible to conform to uneven surfaces. Best used on oily or moist impressions, the print is first dusted with powder, which sticks to the moist residues of the latent print. The protective plastic cover is peeled off the gel lifter, and the gel is pressed firmly over the print. Because the gel is not very sticky, it can be used on surfaces, such as paper, from which it would be impossible to lift an impression

Figure 15-6. *Electrostatic lifting uses a charge to hold the dust particles in place.*

Differentiated Learning

Teaching Gifted Students

Encourage students to research the process and equipment used in gel lifting. Have them present their findings to the class.

Digging Deeper

After reading the article mentioned in this feature, encourage students to discuss these questions:

- How is a shoeprint used to determine the kinds of activities the wearer of the shoe was involved in?
- When a shoe leaves a print, what else does the shoe leave behind?
- For more about shoeprint impressions, go to the Gale Forensic Science eCollection at school.cengage.com/forensicscience.

Figure 15-7. *Plaster cast of a shoe print.*

using normal fingerprint tape. The gel lifter is lifted off and the protective cover replaced. The gel lifter is then photographed to reveal the print. There are black, white, and clear gel lifters. The color used depends on the conditions and the color of the powder used (e.g., a white, black, gold, or silver powder).

Casting Plastic Impressions

A three-dimensional impression, such as a shoeprint in mud or snow, is called a *cast* and may be made to preserve physical evidence (Figure 15-7). The casting materials and techniques vary with the conditions at the crime scene. If the impression is in sand or dirt, a Plaster of Paris impression is made. Before pouring in the mixed Plaster of Paris, a light film of hair spray is applied to prevent the impression from collapsing under the weight of the plaster.

Snow presents a problem simply because it melts. Therefore, casting material needs to be used that will set at low temperatures and will not generate heat. An impression in snow can be cast by first using a spray wax applied in thin layers over the snow. Freezing instantly, the wax provides protection to the delicate print before the casting material is poured into the impression. The casting material used for snow is called *dental stone*, which hardens faster than Plaster of Paris.

Digging Deeper
with Forensic Science e-Collection

Go to the Gale Forensic Sciences eCollection on school.cengage.com/forensicscience and find the following article. Read the article and discuss, in not less than one page, how broadening the search for evidence beyond the obvious sources may be the future of crime detection.

Peter A. Bull, Adrian Parker, and, Ruth M. Morgan, "The forensic analysis of soils and sediment taken from the cast of a footprint," *Forensic Science International* 162.1–3 (Oct 16, 2006): pp. 6(7). From *Forensic Science Journals*.

FOOT LENGTH AND SHOE SIZE

The evidence of a shoe print is not the same as a fingerprint. A shoe print is not a direct record of the person, but it provides information about the person who left it. The size of a shoe varies by the shoe type. For example, a running shoe will give a much smaller impression than a steel-toed workboot of the same size. The shoe model must first be identified in order to gauge the correct shoe size to obtain an estimate of the foot size. A person's height is generally related to his or her foot size, but it is impossible to predict someone's exact height from foot size. Figure 15-8 compares mens' and womens' shoe sizing. Figure 15-9 shows a rough comparison of shoe size and height of an individual.

Figure 15-8. *Comparison of foot length and U.S. shoe sizing.*

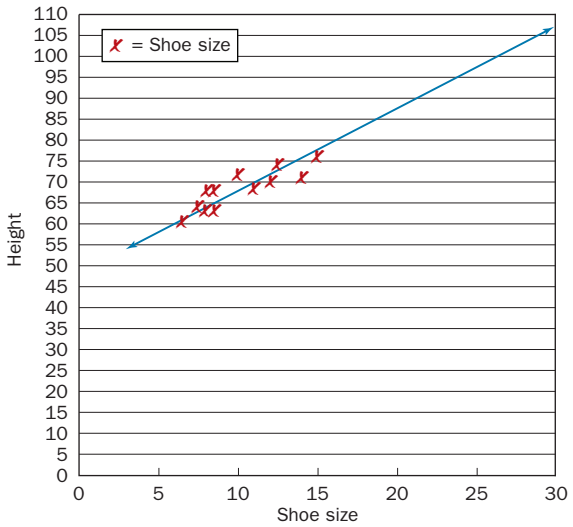
Foot Length (Inches)		9	9 1/8	9 1/4	9 3/8	9 1/2	9 5/8	9 3/4	9 7/8	10	10 1/8	10 1/4	10 1/2	10 3/4	11	11 1/4	11 1/2
Shoe Size	M	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7	7 1/2	8	8 1/2	9	10 1/2	11 1/2	12 1/2	14
	W	5	5 1/2	6	6 1/2	7	7 1/2	8	8 1/2	9	9 1/2	10	10 1/2	12	13	14	15 1/2

Differentiated Learning

Teaching At-Risk Students

Checking the measurements in Figure 15-8 can be easy and fun. Have students measure their or a classmate's feet, then check the chart for shoe size. Ask volunteers to share findings with the class. Discuss what might cause any major variances.

Figure 15-9. *Comparison of shoe size and height.*



TIRE TREADS AND IMPRESSIONS

Obj. 15.2 and 15.3

Tire evidence may be used to link a suspect or victim to a crime scene, and it can also reveal the events that took place. Tire marks may indicate the speed a car traveled when it left a road or the direction in which it traveled when fleeing a crime scene. Skid marks at the scene of a fatal accident are used to determine who may have been at fault. A forensic scientist examines tire tread and impression for two characteristics:

1. Tread pattern and measurements to identify the type of tire and perhaps the make and model of car
2. Nature of the impression to determine how the vehicle was driven

Motor vehicles can leave patent, latent, or plastic tire patterns. Patent impressions appear after the vehicle has tracked through a fluid material like oil, tar, or blood. Latent tracks may be left on asphalt or concrete roads by manufacturers' oils used to keep tires soft and pliable. Plastic or three-dimensional impressions may be left in off-road surfaces, such as mud, lawns, sand, or snow.

THE ANATOMY OF A TIRE

A tire's tread surface is divided into **ridges** (elevated regions) and **grooves** (indentations). The purpose of these ridges and grooves is to channel water away and provide traction as the surface area makes contact with the road or ground. Generally, every model of tire is unique as manufacturers continually try to improve handling qualities. The width and angle of the grooves in the tread are engineered to perform best on a specific surface. Touring tires have many smaller grooves to channel air and water at high speeds on smooth pavement, and knobby off-road tires have very wide grooves for

Science

Physics

Ask students which is harder to stop: a moving bowling ball or a moving table tennis ball? The bowling ball is harder to stop because it has more mass and therefore more inertia.

Science

Physics

Inertia is a property of matter that causes an object to resist a change in its motion. Inertia causes an object to maintain its motion or rest unless an external force acts on it. When a car is at rest, the engine must exert a force to begin the motion of the tires. If a large force is applied, the tires may spin on a surface, especially one lacking the right amount of friction, perhaps because of oil or ice. This process causes tire impressions to be left on the surface.

Evaluate

Organize the class into three groups. Ask each group to prepare a presentation, including visual examples, about one kind of tire impression. If the groups are too large for such an activity, add additional groups that will prepare presentations about other kinds of evidence vehicles might leave at the scene of a crime or accident, such as glass fragments, paint chips, oil, or radiator fluid.

Differentiated Learning

Teaching Gifted Students

Invite interested students to design and conduct an experiment showing the difference in inertia for objects with different masses.

Explore

Use Figure 15-10 for this activity. Ask students to draw what they think will be the impression made by the tire shown in the diagram. Remind them to label their drawings to reflect the names of the different parts of the tire that left the impression.

Teaching Tip

Ever wonder about the numbers on your car's tires? A tire might have P180/65R14 written on the sidewall. The P indicates use on a passenger vehicle, the 180 is the width in millimeters of the tire across the sidewall, the 65 is the aspect ratio of the tire's height to width, and the 14 is the rim diameter in inches. Ask students to check the rating on their (or their family's) car or truck tires.

Teaching Tip

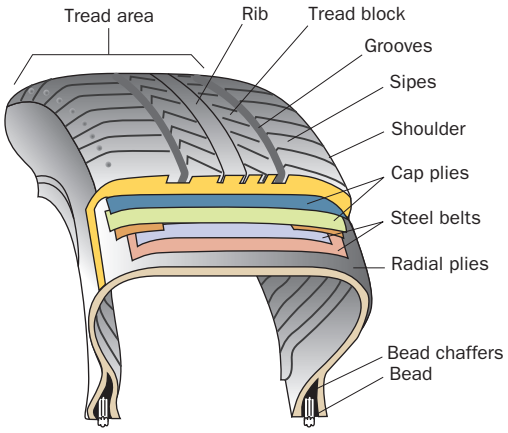
Tell students to be aware that the front and rear wheel base may be different on the same vehicle.

traction in slippery mud. A single tire tread usually indicates the general type of vehicle that left the mark.

RECORDING TREAD IMPRESSIONS

Tread patterns are symmetrical; the left and right sides of the tread are mirror images of one another. **Ribs,** the ridge of the tire, and grooves are counted across the entire tread width from shoulder to shoulder. If the tire has a central rib, then it will have an odd number of ribs. Any unique characteristics in the tread pattern are noted, including imperfections in the tread pattern of the tire, such as wear patterns or a pebble embedded in the grooves. Figure 15-10 shows different elements of a tire.

Figure 15-10. *The anatomy of a tire.*



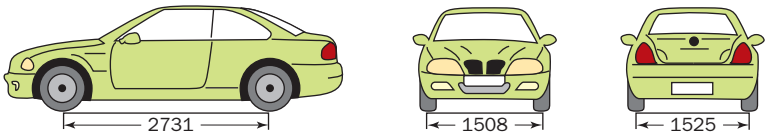
The impression from a crime scene may be matched to the vehicle of a suspect, known as a candidate vehicle. To do this, a record of the tire impression of the suspect's vehicle is taken. Similar to getting a fingerprint, ink is painted onto a tire, and the vehicle is driven over smooth pavement covered with paper or cardboard. A print at least three meters long is produced to ensure that the tire rotated through one revolution. All possible individual characteristics are noted. The individual characteristics link a specific vehicle with a tread impression from a crime scene.

Obj. 15.4

IDENTIFYING A VEHICLE

Tire impressions can identify the make and model of vehicle that was driven at a crime scene. Because the same type of tire may be used on many vehicles, identifying the tread pattern is often not enough. The track width and the wheelbase of the treads narrow down the search. **Track width** is measured from the center of each tire to the center of the opposite tire. Note that the front and rear track width measurements may differ. The **wheelbase** of a vehicle is the distance between the center of the front axle and the center of the rear axle (Figure 15-11). Measurements should be taken to the nearest millimeter.

Figure 15-11. *Every make and model of vehicle has its own track width and wheelbase measurements.*



Side view **Front view** **Rear view**

Turning Diameter

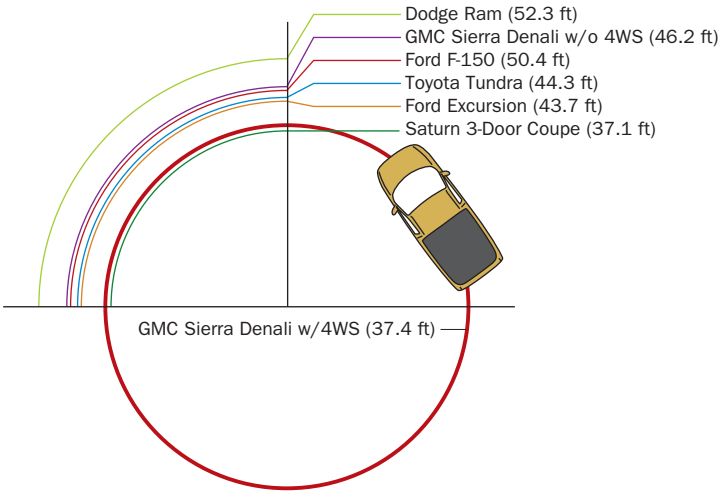
The **turning diameter** is a measure of how tight a circle can be driven by a vehicle or, put another way, the minimal space required for a car to make a

Differentiated Learning

Teaching At-Risk Students

To engage at-risk students, ask them to determine the turning radius and other tire-related characteristics of vehicles owned by their family members or friends. If none are available, make arrangements for them to measure a car you have secured. Be sure to stress the importance of safety when measuring or observing any car.

Figure 15-12. *Tread marks revealing turning diameter can help identify a vehicle. Some samples are shown here.*



U-turn (Figure 15-12). When a vehicle turns a sharp corner, even at moderate speeds, a track is created by the additional stress put on the front outer tire. When the driver makes a U-turn or similar sharp turn, the wheel is turned as far as possible. A longer wheelbase increases the turning diameter. This information helps the investigator determine the size of the vehicle. Sometimes turning diameter, also called turning radius, is not mathematically a diameter, but a radius, measured in millimeters, inches, or the nearest one-tenth foot.

A large database contains the track width, wheelbase, and turning diameter measurements for all makes and models of cars and can be easily checked to identify the vehicle that left the impressions (Figure 15-13).

Figure 15-13. *Examples from the database of automobile statistics by make and model.*

Make	Model	Wheelbase in mm	Turning Diameter in mm	Tire Size in mm	Tire Make
ALFA ROMEO	Alfa 146	2540	10300	175	Pirelli P4000
ALFA ROMEO	Alfa 156	2595	11600	185	Michelin Energy XH-1
AUDI	A3	2512	10900	205	Michelin Pilot HX MXM
AUDI	A4	2617	11100	195	Michelin Energy MXT
AUDI	A8	2882	12300	225	Michelin Pilot CX
BMW	3 series	2725	10500	225	Michelin Pilot HX
CADILLAC	DeVille	2890	12300	225	Goodyear Eagle RS
CADILLAC	Seville	2819	11700	225	Goodyear Eagle GA
CADILLAC	Seville	2850	12340	235	Goodyear Eagle Touring
CHEVROLET	Blazer	3122	12600	205	Uniroyal Tiger Paws
CHEVROLET	Corvette	2444	12200	285	GoodYear
CHEVROLET	Corvette	2655	11700	275	Goodyear F1 EMT
CHRYSLER	Grand Voyager	3030	12500	215	Goodyear NCT2 Touring
CHRYSLER	Neon	2642	10800	175	Goodyear Eagle NCT2
CHRYSLER	New Yorker	2870	11500	225	Michelin XGTV4
CHRYSLER	Stratus	2692	11000	215	Michelin MXV3A

Teaching Tip

If your school or district has an auto shop, ask the instructor to borrow tires for students to see and touch. You might also use any cars available to demonstrate differences in turning radii.

Explore

Several Web sites contain the complete chart of key automobile statistics. Encourage students to find the information about their car or one for a family member or friend. Have them exchange the information with a classmate and compare the data.

Differentiated Learning

Teaching Gifted Students

Ask students to demonstrate why the turning radius of one car may be different from the turning radius of another. Why do certain buses and trucks have such large turning radii?

Teaching Tip

Using Figure 15-14, ask students to reconstruct the events of this car accident from visible evidence. When multiple possibilities arise, stress the importance of using the evidence that is present in reaching conclusions.

Teaching Tip

Invite a police accident-reconstruction specialist to class for a presentation on how he or she determines the sequence of events related to an accident.

Make	Model	Wheelbase in mm	Turning Diameter in mm	Tire Size in mm	Tire Make
CHRYSLER	Stratus	2743	11000	185	Goodyear NCT2
CHRYSLER	Viper	2444	12300	335	Michelin Pilot SX MXX3
FERRARI	550	2500	11600	295	Pirelli P Zero
FORD	Escort	2525	10000	185	Michelin MXV2
FORD	Focus	2615	10900	185	Pirelli P6000
FORD	Galaxy	2835	11100	215	Continental Sport Contact
FORD	Galaxy	2835	11700	215	Conti Sport Contact
HONDA	Accord	2670	10740	195	Bridgestone Potenza
HONDA	Accord	2720	11000	185	Pirelli P4000
HONDA	Civic	2620	10000	175	Bridgestone SF-321
HONDA	Civic	2620	10200	175	Dunlop SP9
HONDA	Prelude	2585	9400	205	Yokohama A085
HYUNDAI	Excel	2400	9700	175	Hankook Radial 884
INFINITI	J 30 t	2761	11000	215	Dunlop SP Sport D31
JEEP	Grand Cherokee	2690	11400	225	Goodyear Wrangler HP
JEEP	Grand Cherokee	2690	11200	225	Goodyear Wrangler HP
JEEP	Grand Cherokee	2691	11100	245	Goodyear Wrangler HP
LEXUS	GS 300	2800	11000	225	Yokohama Advan A460
LEXUS	GS 300	2780	11800	275	Yokohama
MERCEDES	A	2423	10300	175	Goodyear GT

ESTABLISHING CAR MOVEMENTS FROM TIRE MARKS

A vehicle's direction of travel can be determined by studying:

- Vegetation disturbed as a vehicle entered or left a road
- Debris patterns cast off by a moving vehicle
- Splash patterns created as a vehicle moved through a puddle of water (or some other substance) or from a wet to dry pavement
- Substance transfer, such as oil leakage from vehicle to pavement or soil (The drips would be farther apart as the vehicle accelerates.)
- Tire marks left on the pavement or ground (Figure 15-14)

Figure 15-14. *In a multiple-car accident, skid marks are used to determine the path and speed of each vehicle.*

©David Frazier/PhotoEdit

ACCIDENT RECONSTRUCTION

Just as fingerprints at the scene of a robbery can incriminate a suspect, tire marks at an accident can incriminate a driver. Sometimes the drivers may not recall the exact series of events, or the story may not be consistent with the evidence. Photographs and measurements are recorded to reconstruct the events of an accident. The goal of accident reconstruction is to analyze the

Differentiated Learning

Teaching Gifted Students

Ask students to photograph tire impressions and check the Internet for tire tread patterns that might match. Have them share their findings with the class.

Differentiated Learning

Teaching English-Language Learners

Encourage English-language learners to participate in class discussions by first asking them to write down their thoughts in the language with which they are most comfortable. After the class discussion, talk briefly to each student about what he or she thought. Encourage students to keep participating in this way until they feel more comfortable sharing their thoughts vocally.

accident to help determine what happened, when it happened, where it happened, why it happened, how fast the vehicles were traveling, who was involved, and ultimately, who was at fault.

In hit-and-run situations, the car is gone, but the tire marks leave clues leading to its identity. Tire marks at an accident scene can also provide clues to the speed and direction of the vehicle or vehicles involved in the accident. For example, a head-on collision between an innocent driver and a drunk driver would likely show only one set of skid marks on the correct side of the road leading to the impact site. A quick getaway is noted by a skid pattern left behind when the tires spin during acceleration and leave rubber markings on the pavement.

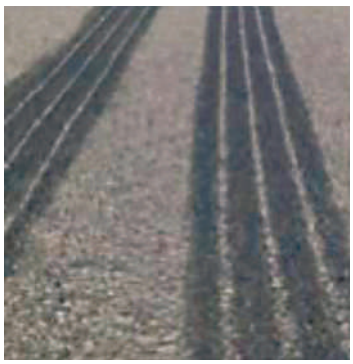
There are three basic types of tire marks:

1. Skid marks:

- Formed when someone brakes suddenly and lock the wheels.
- Provides evidence of the distance brakes were applied.
- Calculation of velocity can be made from skid marks.

Note the skid marks in Figure 15-15.

Figure 15-15. *Skid marks.*



2. Yaw marks:

- Produced when a vehicle travels in a curved path faster than the vehicle can handle and skids sideways.
- Tires and road surface melt from extreme temperatures.
- Audible squeal and often smoke occurs.

3. Tire scrubs:

- Produced by a damaged or overloaded tire or tires during or immediately after impact.
- Usually curved, irregular in width
- May have striations that look like stripes
- Determine area of impact

Through experience and experimentation, investigators can also estimate speeds of vehicles using the "skid-to-stop" formula. Measuring the weight of the car, the texture of the road surface, and the length of the skid marks, investigators can calculate the approximate speed of the vehicle when the brakes were pressed. This provides information, such as if the car that caused the accident was going over the speed limit. In such a case, more charges could be filed against the driver.

DENTAL IMPRESSIONS

Obj. 15.5

Locard's *principle of exchange* refers to an exchange of materials between a suspect and a victim or a suspect and a crime scene. Occasionally, a perpetrator will leave behind a bite mark. Like fingerprints, bite marks are considered to be individual evidence. Factors that contribute to the individuality of our teeth include the number, size, coloration, alignment, unique fillings, crowns, caps, the distance between teeth, and the overall condition of our teeth. In an older person, the teeth may have a unique pattern of

Science

Biology

Incisors are wedge-shaped teeth. They work in much the same way as other wedges. A wedge changes the direction of the applied force. Think about biting into a piece of fruit. There is a downward force as you push your incisors into the fruit. Your wedge-shaped incisors change the direction of the downward force into a sideways force that pushes the piece of fruit apart. Meat eaters' teeth are more wedge-shaped than those of plant eaters. Meat eaters use their teeth to cut and rip food. Plant eater's teeth are flatter because they use their teeth to grind up plants. Scientists can tell what an animal eats by examining the shape of its teeth.

Evaluate

Ask students to make a table with two columns labeled *foot impressions* and *tire impressions*. Instruct them to list the ways in which foot impressions and tire impressions are used as evidence. Then encourage them to discuss the advantages and disadvantages of each kind of evidence.

Teaching Tip

Point out to students that cars are complex machines full of a variety of chemicals. When a car is involved in an accident or crime, a great deal of physical evidence like paint, oil, and glass, will be left behind by the car. Matching these substances with those found on or in a suspect's car is an important part of any investigation.

Science

Biology

Human beings have just one set of adult teeth. This means that as teeth are worn down or damaged, artificial substances may be used to replace missing or damaged material. Most individuals have a unique dental pattern, particularly as they age.

Teaching Tip

Tell students that *skid marks* on pavement are in the direction of travel. *Yaw* marks from rear tires usually track outside the skid marks made by front tires. These yaw marks are curved and caused by steering changes while the brakes are applied. *Tire scrubs* are a type of yaw mark that show zebra-like striping.

Explore

Ask for volunteers to count the number of adult teeth they have. Do they have 32 teeth? Why or why not? Ask students to record a list of their own unique dental characteristics.

Evaluate

Ask students to explain how braces change dental characteristics. Have them discuss how this might impact dental evidence.

Teaching Tip

Ask a dental hygienist to come and talk to the class about dental disease and methods of preventing dental disease. Inquire about the availability of a forensic odontologist; many larger law enforcement agencies have one on staff.

Evaluate

Enamel is an extremely strong substance, but it can be damaged by substances that are too acidic. Help students list the kinds of substances they consume that might damage their teeth over long periods of exposure.

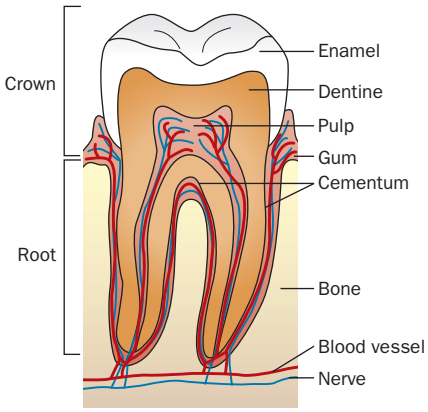
Tooth enamel can endure crushing pressure of approximately 100,000 pounds per square inch.

fillings, breakage, crowns, and caps. Certain antibiotics taken by children have been known to discolor their teeth.

STRUCTURE OF TEETH

The solid, white part of teeth is composed of two different kinds of tissue: a tough covering of *enamel* that protects the living *dentin* tissue underneath (Figure 15-16). Dentin is similar to bone and is composed largely of calcium and phosphorous. Enamel, also composed of calcium and phosphorus, is the hardest substance in the human body, which protects teeth at high temperatures.

Figure 15-16. *Cross-sectional view of a human tooth.*

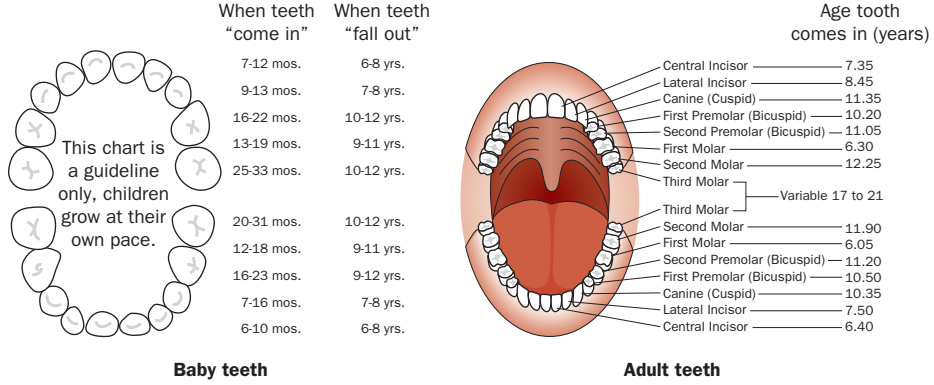


THE DEVELOPMENT OF TEETH

The appearance of 20 primary, baby teeth follows a predictable pattern beginning in the first 7 to 12 months of life. Gradually, the primary teeth are replaced by 32 permanent, adult teeth. The last teeth to develop are the wisdom teeth, which emerge between the ages of 17 and 21. The approximate age of a child can be estimated by viewing the child's teeth (Figure 15-17). An older child may have a mixture of baby and adult teeth. The presence of wisdom teeth usually indicates an age of over 17.

The complete, adult set of teeth encompasses 32 teeth, including wisdom teeth. There are eight incisors at the very front—four on the upper jaw and four on the lower jaw. These are straight teeth that work well in cutting food. The incisors are sandwiched between sharp, pointy canine teeth. There are four canines in total, one on each side of the incisors. Canines are also good for cutting and tearing. Next come eight premolars, two on each side. Premolars are flatter than canines, with ridges on them. There are 12 molars that are even flatter and wider and are involved in chewing and grinding. The shape of a set of teeth (the *dentition pattern*) varies from person to person. Differences in the size of teeth and jaws, position, and crowding make the inside of each person's mouth unique (Figure 15-18).

Figure 15-17. *Pathologists can determine the approximate age of a person from an impression of his or her teeth.*



Differentiated Learning

Teaching At-Risk Students

All humans have teeth at some point in their lives. Nevertheless, diet, which varies throughout the world, plays a major role in the health of a person's teeth. Ask students to predict what kind of diet would best promote dental health and what kind might be harmful to teeth.

DENTAL PATTERNS IN FORENSICS

Figure 15-18. *The difference in teeth placement is used to individualize an impression.*

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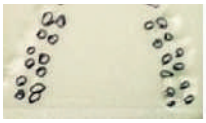
The individual pattern of teeth is used in forensic investigations in two ways. First, teeth can be used to identify remains, such as those of Adolf Hitler, Joseph Mengele, and the victims of the Waco Branch Davidian Church disaster (1993). Teeth can also be used in profiling and identifying a suspect from unique bite patterns or bite marks left at the scene of the crime.

The bite pattern of a suspect can be matched to the bite marks associated with a crime scene, just as fingerprints of suspects can be matched to fingerprints at a crime scene (Figure 15-19). Up to 76 points of comparison may be used when comparing bite marks, including dental chipping, surface indentations, distances between teeth, individual tooth dimensions, alignment of teeth, and the angle of the mouth arch. The presence or absence of certain teeth can be an indication of age, diet, economic status, and country of origin. Dental procedures and materials may also vary from country to country. All of these factors can provide clues leading to a crime suspect.

Dental remains have been studied since the time of Neru (66 A.D.)

If an assailant bites a victim, it is important that the bite marks be photographed while the impression is still visible. The photographs should include a ruler to establish a reference for size to better compare bite marks to a suspect's bite pattern. When an attacker bites a victim, saliva may be left on the victim's skin. If the bite mark is swabbed with a sterile cotton swab, DNA from the saliva may be collected and analyzed. The DNA profile can then be compared to the DNA of suspects.

Figure 15-19. *Overlaying a transparent tracing of the teeth points with the impression reveal when there is a match.*



Dental impressions on overlay—no match

Dental impressions on overlay—match

©Cengage Learning

SUMMARY

- There are three types of impressions: patent impressions, latent impressions, and plastic impressions.
- Generally, any impression evidence made by an object will be considered class evidence unless it has individualizing features, such as wear or damage.
- Tire impressions at a crime scene can lead to the identification of a vehicle and can provide evidence pertaining to events that occurred before an accident.
- Tire impressions are classified as skid, yaw, or tire scrub impressions.
- Impressions from teeth are considered individual evidence and, like fingerprints, reliability depends on the number of points of comparison and the clarity of the impression.
- Impression evidence must be carefully documented before it is moved. Photographs of the original impression always accompany the cast or record, such as a gel lift, used in court.

Dental technician James Kim has patented an identification method that is based on embedding information in crowns, bridgework, or other dental work. The dental record may help identify individuals killed in plane crashes, explosions, or other disasters when other identification methods fail.

Evaluate

Ask students to think about the circumstances in which teeth marks or teeth can be used as class or individual evidence. Ask them to describe a circumstance in which teeth impressions could yield material for DNA analysis.

Teaching Tip

Using Figure 15-19, engage students in a discussion of whether bite marks can be used to convict a person of a crime. Ask students to predict whether a particular dental pattern would be more or less common than DNA. Be sure students demonstrate mastery of the DNA content learned in previous chapters.

Differentiated Learning

Teaching Gifted Students

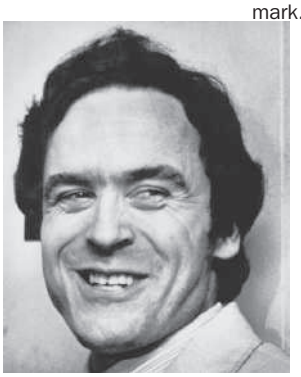
Some students may be interested in researching specific cases in which dental records were used to identify the remains of a person. Challenge interested students to create a presentation specific to one person who was identified in this way.

- Impressions may be used two ways: (1) to identify a person or object and (2) to determine actions that occurred in committing the crime. Identification is usually done by first matching the pattern and then the individual characteristics. A story is told by the series of footprints and/or tire marks that when carefully observed or recreated can illustrate what actions happened before the crime or accident.

CASE STUDIES

Gordon Hay (1967)

In Scotland, the dead body of 15-year-old Linda Peacock was found with a distinct bite mark on her body. Bite mark impressions were taken from the residents of a nearby boy's detention facility, and a match was found. Gordon Hay became the first person convicted of murder based on a bite mark.



©J.R. Eyerman/Time Life Pictures/Getty Images

Theodore Bundy (1978)

A man wearing a stocking cap entered a Florida State University sorority house and attacked some of the women inside. Two women were killed and two more seriously injured. One of the women had a bite mark that was photographed as evidence. Subsequent attacks followed in other states. Ted Bundy was charged with the Florida State University attacks after his dental impressions were compared to those left on a victim. The FBI's Behavioral Science Unit had profiled Bundy as a very neat, organized, serial killer. Bundy was so meticulous that he never left fingerprints even in his own apartment. Bundy escaped from police twice, only to be recaptured. Bundy was found guilty of murder and was executed in 1989. Before his execution, he implied having committed approximately 50 murders.

Lemuel Smith (1983)

Lemuel Smith had a history of violence, which started while he was a teenager. After spending 17 years in prison for multiple violent crimes, Smith was released. Six weeks later, the bodies of two people were found murdered in the neighborhood where Smith was living. Another rape and murder occurred later the same year. Seven months later, the mutilated body of another female victim was found.

Smith was finally arrested during the kidnapping of another female. A bite mark on the nose of one of his victims matched an imprint of his teeth. In March 1978, Smith confessed to five murders. His defense included that he might be suffering from a multiple personality disorder. Based partly on the bite mark evidence, Smith was ultimately found guilty of multiple murders, kidnappings, and rapes and sentenced to more than 100 years of prison time.

In 1981, in the Green Haven Correctional Facility, a female corrections officer named Donna Payant disappeared. Her mutilated body was found in a Dumpster. This was the first time in the United States that a female corrections officer was killed on duty. On examination, Payant's body showed a bite mark. Dr. Lowell Levine, a forensic odontologist who worked on one of Smith's earlier convictions, recognized the bite mark pattern. Smith was charged, convicted, and sentenced to die.) On a legal technicality, his sen-

tence was changed to life imprisonment. Levine still works at the crime lab in Albany, New York.

Tire Evidence Solves a Murder

©J.R. Eyerman/Time Life Pictures/Getty Images

In Largo, Florida, tire tracks were found next to a dead woman's body. Police sent photographs of the tracks to Pete McDonald, former Firestone Tire & Rubber Co. tire design engineer. McDonald helps police all over the United States solve crimes by analyzing photographs of tire impressions. McDonald can determine the type, size, and brand of the tire that made the impression, as well as the vehicle that was likely to be fitted with the tire.

In the Florida case, McDonald was able to identify the brand and size of the tire and the likely vehicle. Police checked purchase records for local tire dealerships and found a match. A woman who purchased the tire lived with a man who had recently served time in prison for violent crime. Using the tire impression information, police found a suspect.

The police asked the tire dealer who sold the tire for help in gathering evidence against the suspected murderer. The dealer agreed and called the suspect and told him his tires had been recalled. The dealer offered new tires to replace the old ones. The suspect came to the shop and traded for the new set of tires. The old tires were sent to McDonald for further analysis. The tire impression, combined with other evidence, convinced a jury to convict the man and send him back to prison for murder.

Think Critically **Although they might seem easy to cover up, why might footprints, tire tracks, and bite marks be hard to conceal?**

Close

Organize students into three groups—one each responsible for shoe, tire, and bite impressions. Ask each group to summarize how the impression is made and photographed, and whether the impression is class or individual evidence.

CAREERS

There are many famous forensic scientists in the United States. Among them is Dr. Henry Lee, currently the Chief Emeritus of the Connecticut State police. Dr. Lee played a pivotal role in the defense's case during the O.J. Simpson criminal trial for the murder of Nicole Brown Simpson. Dr. Lowell Levine, a forensic odontologist from New York, has helped match Lemuel Smith to his victims using bite marks. Check out http://www.crimelibrary.com/notorious_murders/not_guilty/lemuel_smith/7.html. For more information about Dr. Levine and the Lemuel Smith case, go to the Gale Forensic Science eCollection at school.cengage.com/forensicscience.

CAREERS IN FORENSICS

Before *CSI*, there was *Quincy*; before *Quincy*, there was Thomas Noguchi

In 1961, Thomas Noguchi emigrated from Japan and was hired as a medical examiner with Los Angeles County. Just a year into the job, he performed the autopsy on Marilyn Monroe. Fame and fortune have followed him ever since. He did the autopsies on Senator Robert F. Kennedy, Sharon Tate, Natalie Wood, and John Belushi. If a case seemed particularly important or perplexing, Dr. Noguchi was called. Before the age of big forensic labs, Dr. Noguchi was a forensic investigator, going over every crime scene with a fine-toothed comb. With a career as a coroner spanning decades, Dr. Noguchi has numerous stories to tell about how his forensic investigations have helped the dead tell their tales.

AP Photo/Damian Dovarganes

Thomas Noguchi.

In an interview with *Omni* magazine, Dr. Noguchi told of "one homicide I investigated, the homeowner returned early, surprising the burglar, so the burglary ended in murder. But the burglar was hungry, so he had a bite to eat before leaving. We found distinct teeth marks in the cheese!" In another case, Dr. Noguchi examined the body right at the crime scene, to determine if a truck had dumped her, as it appeared. The corpse told Dr. Noguchi otherwise. She had been brought to the site alive, and later shot. Because the murderer had to get out of the van to shoot the victim, the area was searched for footprints. When the footprints were found, an arrest was made.

One of Dr. Noguchi's claims to fame was that he invented a unique technique to cast a stab wound. Through trial and error, Dr. Noguchi found just what he needed: a substance that was liquid at the boiling temperature of water, but quickly hardened into a solid. He used mercury, which is injected into the stab wound, and five minutes later can pull out a detailed three-dimensional replica of the weapon. You can read more about Dr. Noguchi's cases in his book, *Coroner*, published in 1983, in which he demonstrates one of his favorite sayings, "let the dead speak for himself."

The career of Thomas Noguchi has its own tales to tell. He was fired from his job as coroner for L.A. County twice because of his willingness to openly talk to the media about a case. In each instance, he was reinstated. In fact, Dr. Noguchi has been very outspoken about the consequences of drug use and speaks of drug designers as mass murderers. Dr. Noguchi is now in his eighties, but he continues to write and to educate. He feels death—and its study—is very important. He has said: "There are lessons to be learned from death. And because these death events are repeated over and over again, we must strive to understand them."

Learn More About It
To learn more about careers casting impressions at crime scenes, go to school.cengage.com/forensicscience.

CHAPTER 15 REVIEW

True or False

1. There are two basic types of impressions—patent and latent. *Obj. 15.1*
2. Impressions are always considered class evidence only. *Obj. 15.2*
3. Before anyone touches or alters an impression, it should be photographed. *Obj. 15.2*
4. Electrostatic dusting is used on impressions that are dry and lack depth. *Obj. 15.3*
5. Footprints can be recovered from snow. *Obj. 15.3*
6. Tire patterns are generic and difficult to trace. *Obj. 15.3 and 15.4*
7. The turning diameter of a Volkswagen Beetle is greater than that of a Cadillac sedan. *Obj. 15.4*
8. The front and rear track width of a vehicle is always the same. *Obj. 15.3 and 15.4*
9. Dental work and dental impressions can be matched to a particular suspect. *Obj. 15.5*
10. The presence of wisdom teeth is a partial indication of age. *Obj. 15.5*

Short Answer

11. Distinguish between the following measurements on a car: *Obj. 15.4*
    a. Track width

    _____

    b. Wheelbase

    _____

    c. Turning diameter

    _____

12. List characteristics of teeth that would enable them to be used as individual evidence as opposed to class evidence. *Obj. 15.5*

    _____

    _____

13. What characteristics of shoes are noted when trying to match a shoeprint found at a crime scene with a shoeprint of a suspect's shoe? *Obj. 15.2 and 15.3*

    _____

    _____

Chapter 15 Review

True or False

1. False
2. False
3. True
4. True
5. True
6. False
7. False
8. False
9. True
10. True

Short Answer

11. Track width is the distance between the center of the tread pattern on the left tire to the center of the tread pattern on the corresponding right tire. Wheelbase is the distance between the center of the front axle and the center of the rear axle. Turning diameter is the distance needed for a car to complete a U-turn.
12. Sample answer: Teeth placement and number, as well as wear patterns and evidence of dental work, would allow teeth to be used as individual evidence as opposed to class evidence.
13. Characteristics noted are size of shoe, tread pattern, visible logos, and wear patterns.

14. First a photograph of the impression including a ruler is taken. Next, a thin layer of hair spray is applied to the impression. Finally, the impression is filled with Plaster of Paris.
15. Sample answer: tread patterns, wear patterns, track width, wheelbase, turning diameter.
16. Student reports will vary but should summarize findings.
17. Measure the distance between the placement of the outer wheel at the beginning of the turn and the outer wheel when the car is halfway through the turn.
18. Skid marks are formed when someone brakes suddenly. Yaw marks are produced when a vehicle travels in a curved path and skids sideways. A damaged or overloaded tire produces tire scrub. The differences are the part of the tire that makes the mark and the mark's appearance.

14. Describe how a Plaster of Paris impression is produced. Include in your answer the role of each of the following: *Obj. 15.1*
    a. Plaster of Paris

    b. Hair spray

    c. Ruler

15. List five different characteristics to note when comparing a tire from a suspected tire to the tire mark found at the crime scene. *Obj. 15.2 and 15.3*

16. Do further research on imprint or impression evidence in the O.J. Simpson or Ted Bundy cases, or research case studies not mentioned in the text that had their cases resolved as a result of impression or imprint evidence. Submit a written report on your findings. *Obj. 15.2 and 15.3*

17. Describe how to calculate the turning diameter of a car. *Obj. 15.4*

18. Tire marks are categorized into one of three categories: *Obj. 15.4*
    a. Skid

    b. Yaw

    c. Tire scrub

What are the differences among these tire marks?

19. Tire impressions of a tire must be made using the complete rotation of a tire. Explain why this is important if the tire impression is to be compared with a photograph of a tire impression found at a crime scene. *Obj. 15.3*

20. Describe how you could distinguish the teeth of an adult from the teeth of a teenager or child. *Obj. 15.5*

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www.crimelibrary.com/criminal_minds/forensics/bitemarks/4.htm

www.crimelibrary.com/notorious_murders/famous/simpson/brentwood_2.html

19. Complete rotation of the tire is necessary so that all surfaces have been examined for a match with the photo.

20. Sample answer: Wisdom teeth should be present in an adult. Children and teenagers will not have grown these teeth yet. The wisdom teeth may be visible beneath the surface of the gum line in children and teenagers.

Background

In this activity, students make a plaster cast of a shoeprint and a tire impression both inside and outside the classroom.

Safety Precautions

1. Students must wear safety goggles when mixing plaster and when using hairspray.
2. Remind students to dispose of unused plaster correctly and not to dump it down a drain.
3. If doing the lab inside, then use pump-style hairspray and not aerosol. Using aerosol sprays may pose a problem for students with asthma.

ACTIVITY 15-1 *Ch. Obj. 15.3*

CASTING PLASTER OF PARIS IMPRESSIONS

Objective:

By the end of this activity, you will be able to:
Construct a Plaster of Paris impression of shoe or tire prints.

Background:

Shoeprints and other impressions made by suspects can often provide the clues that lead to solving a crime. As well as photographing the shoe or tire print, a permanent impression is produced. These impressions are used as evidence during court proceedings. In this activity, you will make Plaster of Paris impressions using two different methods.

Materials:

(per group of two to four students)

Part A:
1 cardboard box
1 large plastic garbage bag (at least kitchen-sized)
1 empty plastic, 39 oz. coffee can filled with sandbox sand
1 quart-sized resealable bag filled with Plaster of Paris (premeasured)
1 sneaker or boot that shows a tread pattern on the sole
1 empty, small coffee can (any 13 oz. metal or plastic coffee can)
1 can inexpensive aerosol hair spray (to share with other groups)
1 paintbrush
1 pencil or awl or sharpened skewer
1 stiff toothbrush (old ones are fine!)
1 wooden paint stir stick or paddle
12-inch ruler
newspapers
(optional) several tree twigs or wooden cooking skewers
(optional) digital camera

Part B:
all of the materials listed in Part A plus
1 set of Plexiglas strips
4 pieces of duct tape (or clamps)

Time Required to Complete Activity:

Two 45-minute periods: one to make the cast and one to allow casts to dry and to clean the cast impression

Safety Precautions:

1. Handle all materials as directed by your instructor.
2. Wear safety goggles when mixing Plaster of Paris and when using the hairspray. The spray can also irritate some people's throat and nasal passages.

3. Dispose of unused Plaster of Paris in a garbage container; do not dump it down the sink drain!
4. Thoroughly wash all equipment as soon as possible after use. After dumping out any excess Plaster of Paris, allow the remaining plaster to dry. The old plaster can be removed after it dries by pounding on the sides of the plastic coffee can.
5. Work outside if conditions permit. If you are working inside, use newspaper to line any desktops. The sand can scratch the surface of some countertops.

Procedure:

Part A: Preparing a Shoeprint Impression

This procedure allows you to prepare the impression inside the classroom, or you can also take an impression of a footprint left in the sand outside of the classroom.

1. Gather all materials.
2. Line the cardboard box with the plastic garbage bag and place the box on top of the newspapers.
3. Empty the sand from the large coffee container into the bottom of the cardboard box.
4. Using your hand or the paint stir stick, smooth out the surface of the sand in the cardboard box.
5. Step firmly into the sand. Do not rock your foot back and forth. Gently remove your foot from the sand by lifting your foot straight up. View your impression. If it does not seem to be a good impression, smooth out the sand and repeat the process.
6. Hold the hairspray can 12 inches above the impression and spray. If you hold the can too close, the spray will destroy your impression. Spray the entire area of the impression, along with one inch of the sand surrounding the impression. The sand will look wet.
7. Place a ruler next to the print. Use a digital picture to photograph the print and the ruler. Take your photo from directly above the print and perpendicular to it.
8. Fill the small coffee container halfway with tap water and then pour the water into the large coffee can.
9. Slowly add the Plaster of Paris in the plastic bag to the water. Do not dump the plaster into the water all at once. Stir continually as the plaster is being added to the water.
10. Stir until you have a smooth consistency (similar to pancake batter) and until the plaster is dissolved. Do not overstir, because this will cause your plaster to become very thick.
11. Hold the paint stirrer about an inch or two above the footprint. Pour the Plaster of Paris over the paint stirrer and onto the print. (This helps to keep the plaster from splashing into the print and collapsing the print.)
12. If the impression of the shoeprint is small, you will not need to use all of the Plaster of Paris. Add enough Plaster of Paris to cover the impression, but do not overload the impression.
13. Discard the unused Plaster of Paris in the garbage. *Do not dump Plaster of Paris down the sink drain.*
14. Gently smooth out the top of the Plaster of Paris with the paint stir stick, distributing the plaster evenly over the footprint. Twigs can be

Procedures

1. Make sure students read all directions *before* beginning the activity.
2. Casting Plaster of Paris impressions can be done easily both inside or outside the classroom.
3. This lab activity requires very little cost and just a few materials that can be assembled from your home.
4. The students can supply many of these items, such as the empty coffee cans, old paintbrushes, and toothbrushes. Hardware stores are usually willing to provide you with free paint stirrers.
5. A key to making this a quick and easy process is setting up the lab kits for each individual team in advance. This reduces the time needed to actually cast the impression, and provides an easy method to reassemble materials after the labs are completed.
6. If you choose to set up complete lab buckets of materials for each team in advance, the impressions can be made in one class period. Cardboard boxes can be used as the lab bucket. The cardboard box can later be used to contain the sand when preparing the impression.
7. The impressions need to dry before the students move them. If doing this activity inside, be sure to have the students set them up in an area where the impression will be able to harden for at least 30 minutes after pouring the Plaster of Paris.
8. Substitute as you see fit any materials for the frame you have on hand. (Shoeboxes work well.) To save money, use duct tape instead of the clamps if you construct the plexiglass casting frame.

Teaching Tips

1. Do not use white playground sand. It does not provide enough contrast when cleaning and visualizing the print.
2. Store premeasured sand in large 39-oz. plastic coffee containers. Completely fill the container with sand. Do not try to substitute regular soil because the impression will not be as distinct as an impression made from sand.
3. The ratio of plaster to water is approximately two parts plaster to one part water.
4. Premeasure the plaster (one full small canister for coffee, 13 oz.) and dump the plaster for one impression into a quart-sized, resealable bag. Have the students save the resealable bag and the kitchen garbage bag so that you can reuse them for the next class.
5. Students pour the water directly into the bags—less mess as they just squeeze to mix and then pour directly from the bags. If using the bags as mixing containers, be sure to use the gallon-sized sealable plastic bags.
6. Using warm (or hot) water makes plaster harden quicker, so it is best to use cool or room-temperature water.
7. Be sure that students do not try to overstir the plaster. If students continue to stir, the plaster will begin to harden too quickly. Plaster should have the consistency of pancake batter.
8. Adding twigs (or skewers) to the casting as it hardens is supposed to give the casting additional strength. You may find this too cumbersome. It is easier to add a little extra thickness to the plaster.
9. Sand can be reused. Before storing, allow the sand to dry and remove any pieces of leftover plaster.

added to the plaster at this point to provide additional strength while hardening.

15. Allow the shoeprint to harden for at least five minutes. Use an awl, stick, or pencil to label the shoeprint with your initials, date, and case number.
16. At this point, you can leave the plaster cast until the next day or next class. Do not attempt to lift the print until the plaster has dried. Wait at least 30 minutes. Lifting the cast impressions too early results in the plaster cracking.
17. Gently pry up the plaster cast with your fingers along its edge. Turn it over. It will probably still be damp on the side closest to the sand.
18. Gently brush away the sand with the paintbrush.
19. Use the toothbrush or awl to remove any additional loose sand.

Cleanup:

20. Wipe clean and dry the pencil, awl, stir stick, and small coffee can.
21. Save the resealable plastic bag so that it can be refilled for later use.
22. After dumping out any excess Plaster of Paris from the large coffee can, wipe it with a paper towel. Allow the remaining Plaster of Paris to air-dry. Once the plaster is dry, it is possible to knock out the remaining Plaster of Paris by pounding on the sides of the plastic can. Dry out the large coffee can thoroughly because it will be used to store the sand.
23. Mix sand by hand to break up the hair spray coating.
24. Remove and discard the residual plaster from the sand.
25. Pick up the opposite sides of the big plastic bag (filled with sand) and funnel the sand back into the now-clean, dry 39 oz. coffee can.
26. Dispose of the plastic bag and cardboard box.
27. Shake out the paintbrush and toothbrush to remove any residual sand.
28. Return all lab materials to your instructor.
29. Sweep and clean the area surrounding your setup to remove all sand.

Storage of Castings:

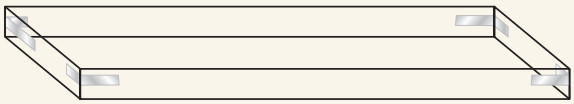
30. Allow the castings to air-dry.
31. Wrap in newspapers or paper towels, and store in shoeboxes.

Part B: Casting Outdoor Shoe Prints, Footprints, or Tire Prints

This procedure works especially well if you plan to cast shoe, foot, or tire impressions outside in their natural environment.

1. Obtain a set of precut Plexiglas strips long enough to cover the area you wish to cast. Tape the outside corners of the Plexiglas using five-inch pieces of tape. If you need to cast a longer section of the tire print to obtain a full rotation of the tire, you can use longer sections of Plexiglas.

The Plexiglas tray.



10. When photographing the prints before casting the impression, you may want to have one student assume the role of forensic photographer and photograph all of the impressions. Be sure students include a ruler in the photograph. Photograph using natural sunlight or indirect lighting if possible.
11. Dental stone may be preferable to Plaster of Paris because it is two to three times stronger, but it is about 10 times more expensive.
12. Premeasuring and prepackaging the Plaster of Paris in resealable bags can save time. It also prevents excess Plaster of Paris dust from being spread around.
13. Do not dump Plaster of Paris down the sink drain. Have large trash containers available.

2. This type of frame prevents the tire or shoe print from being disturbed by wind, people, or animals. A second advantage is that this setup can be easily disassembled and conveniently stored. When using the Plexiglas frame, you do not need a cardboard box.
3. Place the plastic bag on level ground or a board to protect it and provide for quick cleanup.
4. Place the rectangular Plexiglas frame on top of the plastic bag and around the impression.
5. Empty the 39 oz. coffee can of sand into the frame. Level off the sand with the paint-stirring stick.
6. Follow the procedure in Part A from Step 5 onward.

Part C: Casting an Impression from a Tire Track

In this part of the activity, you will prepare a cast of a preexisting impression found in the dirt or soil outside of the building. Follow the same directions as in Part B, except:

1. Prepare your frame to fit the size of the tire track. You need a frame long enough to make an impression that represents a full rotation of the tire.
2. Place the rectangular Plexiglas frame around the tire impressions.
3. Gently spray the tire impression with hair spray holding the can at least 12 inches away from the impression.
4. Continue with the rest of the lab described in Part A, Step 6 onward. If the tire impression is long, you will need to mix more than one can of Plaster of Paris.

Questions:

1. Why do crime-scene investigators build a frame around the shoe print before casting?
2. What was the purpose of spraying with the hair spray?
3. Why is it important to brush the excess sand from the plaster casting?
4. Shoe prints can be obtained in the winter from snow, but Plaster of Paris cannot be used. What would happen if you tried to produce a cast of an imprint in snow using Plaster of Paris?
5. Why are footprints easier to cast than tire tracks?
6. Suppose two people both wear size 10, Michael Jordan sneakers. Describe characteristics that could be found in the impressions of these two sneakers that could be used to distinguish which of the two people left his or her shoe print.
7. Describe the print patterns that would distinguish between the following:
   a. an obese person and a thin person
   b. a person shuffling and a person walking normally
   c. a person who is running and a person who is walking
   d. a person walking with an injured right foot and a person walking with both feet uninjured
   e. a person walking who is in a hurry and a person walking at normal speed
8. Suppose a lawyer exhibited a small section of a tire imprint during a trial. Why would the opposing lawyer want to see the tire impression of the entire tire and not just the one section?

Answers

Check students' castings and cleanup techniques.

Questions

1. To restrict the flow of the plaster.
2. The hair spray forms a barrier between the plaster and the print and helps protect the shape of the print.
3. Removing excess sand speeds up drying and allows you to see more detail.
4. Plaster of Paris generates heat, which would melt the snow print.
5. Sample answer: Footprints produce a smaller impression than tire tracks.
6. Sample answer: degree of wear on the soles, depth of impression because of weight, where the wear patterns are most pronounced would depend on the person's foot (e.g., Some people wear down the heel before the ball of the foot, whereas some people wear the inside of the sole before the outside).
7. a. A heavier person makes a deeper impression.
   b. In between footprints, a scuff mark would be visible.
   c. The stride is longer if someone is running.
   d. The injured foot may not have as deep an impression as the healthy foot. The footprint may only show the toe or heel of the shoe.
   e. A person in a hurry will make longer strides with uneven footprints.
8. Sample answer: If there were any imperfections in the tire, the lawyer would want to see the entire tire. By showing only part of the rotation, it might be possible to hide the area in question.

ACTIVITY 15-2

Background

In this activity, students explore the relationship between foot length, shoe size, shoe length, and height.

Safety Precautions

There are no safety precautions for this lab.

Procedures

1. Print, copy, and distribute Activity Sheet 15-2 from the IRCD.
2. Make sure students read all directions *before* beginning the activity.
3. Before measuring their shoes and feet, be sure that all students measure using the same technique. Make sure they:
   - Use the right foot.
   - Stand up when taking their measurements.
   - Measure their foot length with their sock on their foot.
   - Be sure that the top of their head is level when measuring height.
4. Be careful when using plastic rulers. Some students may stand on the ruler to measure their foot and can easily break the ruler. Ask a local shoe store to donate a shoe sizer; this will eliminate any differences resulting from brand and type of shoes. If this is used, wipe the surface with an alcohol prep pad between students.
5. If personal measurements are listed on the board, suggest that students use a code name. Some students may be particularly sensitive about the size of their feet.

ACTIVITY 15-2 *Ch. Obj. 15.3*

SHOE SIZE (FOOT SIZE) AND HEIGHT

Objective:

By the end of this activity, you will be able to:
Explore the relationship between foot length, shoe size, shoe length, and height.

Background:

Shoeprints left at a crime scene have been photographed, and casts have been made of the impressions. What information about the suspect can be obtained from this evidence?

Materials:

1 pen or pencil
1 calculator
1 yardstick
12-inch ruler

Time Required to Complete Activity:

40 minutes (student work in pairs)

Safety Precautions:

none

Procedure:

Part A: Shoe and Foot Size Comparison

1. Measure the length of your right shoe (or footprint cast) at its greatest length to the nearest one-eighth of an inch. To measure your shoe size, stand next to a 12-inch ruler. Place the end of the ruler next to the end of your heel and measure to the end of your big toe.
2. Record the length of your shoe in Data Table 1. This should be approximately 1 to 1 ¼ inches longer than your foot.
3. Remove your shoe. Measure the length of your right foot at its longest point. (Note that some people's second toe is longer than their big toe.) To measure your foot, stand alongside the ruler.
4. Record the length of your foot to the nearest one-eighth of an inch in Data Table 1.
5. Find your foot length in your textbook, Figure 15-8. What shoe size is given *in the table* for your foot length? Record your answer in Data Table 1.
6. When you purchase shoes, what shoe size do you buy? Record your answer in Data Table 1.
7. Is your actual shoe size and the estimated shoe size found in Figure 15-8 the same? Record your answer.
8. Record your gender in Data Table 1. Record the difference (if any) between your actual shoe size and your estimated shoe size and record your gender. Use + or – signs for shoe size difference. (Actual – Estimated = Difference)

Science

Mathematics

Tables and graphs are useful in math and science to organize data and make data more useful. Figure 15-10 shows a scatter plot with a line of best fit drawn through the data points.

Science

Mathematics

A scatter plot is a graph that shows the relationship between two sets of data. In this case, the scatter plot in Figure 15-10 shows a person's shoe size and height. Scatter plots can be used to show trends. Three different types of trends can be illustrated in a scatter plot: positive correlation, negative correlation, and no correlation.

9. Choose a partner of the opposite gender. Repeat Steps 1 to 8 for your partner. Record all answers in Data Table 1.

Part B: Estimating Height Based on Shoe Size

10. Measure your actual height. To do this, remove your shoes. Stand against a wall with your head looking straight ahead. Have your partner measure your height to the nearest half-inch. Record your answer in Data Table 2.
11. Using your actual shoe size and the information found in Figure 15-9, your height is estimated to be how many inches? Record your answer in Data Table 2.
12. Are your actual height and the height according to Figure 15-9 the same? Record your answer in Data Table 2 as "yes" or "no."
13. What is the difference between your actual height and your height according to the table? Record your answer in Data Table 2 as described in Step 8.
14. Repeat Steps 10 to 12 for your lab partner. Record the information in Data Table 2. Record your gender in Table 2.

Data Table 1: Foot Length and Shoe Size

Questions	Your Measurements (inches)	Lab Partner's Measurements (inches)
Length of shoe		
Length of foot		
Shoe size according to Figure 15-8		
Actual shoe size		
Is your actual shoe size the same as size in Figure 15-8 in your textbook? (yes or no)		
Difference between actual size and estimated size (+ or –)		
Gender (male or female?)		

Data Table 2: Shoe Size and Height Comparison

Questions	Your Data (inches)	Your Partner's Data (inches)
Actual height		
Height according to Figure 15-9 in your textbook		
Are your actual height and the graph height the same (yes or no)?		
What is the difference between your actual height and the height according to the graph?		
Gender (male or female?)		

Answers

Check students' data tables.

Questions

1. Answers will vary.
2. Many other factors can influence foot size and shoe size, such as genetics, weight, and type of shoe, making an absolute correlation impossible.
3. Sample answers: Separate data should be recorded if the person was wearing sneakers. Body weight should be taken into account when comparing results. Time of the day should also be factored into this data. Later in the day, the foot may appear slightly larger than earlier in the day. To improve accuracy, the same person should take the measurements to ensure the same method was employed. A smaller unit of measure could be used to improve accuracy in measurement. To take more accurate measurement, use a caliper instead of a ruler. Separate data should be compared when reviewing data for males and females. The data table did not take into account someone's age. Foot size increases faster in a teenager than overall body size. This data table would best be used when comparing adult shoe size and height.
4. Sample answers: Measure the foot and shoe twice and take the average. Compare results with a larger sample size. Try to design the activity to eliminate other variables. Data Table 1 did not distinguish between male and female foot length when comparing foot size to shoe size. If more data were presented showing males and females separately, it might present a closer approximation to the correct
5. Sample answer: This graph seems to present a more accurate measurement for shoe size and height than the first Data Table comparing foot size and shoe size. (We have found that more students found that their estimated height was within 2 inches of the data listed on the graph.)
6. Because students are still growing, and possibly at a different rate from their feet, the relationship will be quite variable.

Questions:

Part A: Comparison of Shoe Size to Foot Size

1. Compare your results in Data Table 1 to the results of other members of the class. To make it a more valid comparison, compare all of the male results separately from all of the female results.
2. If you allow a plus or minus one- to two-inch difference, did you find that a majority of the students got their actual shoe size from Figure 15-8 or was the shoe size indicated in Figure 15-8 different from their actual shoe size?
3. List some of the experimental errors that may have been made in doing this study.
4. List ways to improve the reliability of your data.
5. Based on class results, how accurate is Figure 15-8 in estimating someone's shoe size based on his or her foot size? Support your answer with data from your experiment.
6. Why would data collected from teenagers give more variable results than data collected from adults?

Part B: Comparison of Height and Shoe Size

1. Compare all of the results for the males in the class. How accurate was Figure 15-9?
2. Compare all of the results for the females in the class. How accurate was Figure 15-9?
3. List the possible experimental errors in this study.
4. List ways to improve the reliability of your results.
5. Based on class results, how accurate is Figure 15-9, the graph that estimates someone's height based on shoe size? Support your answer using data.
6. Consider another formula to estimate someone's height based on shoe size:
   Foot length (in inches) × 6.54 = height (in inches)
   Use this formula to calculate your own height:
   Your height based on this formula = _____ inches
   Your actual height = _____ inches
   Is this a more accurate correlation between foot size and height? Why or why not?
7. Based on your observations, can someone's height be estimated by measuring the size of his or her shoes? Explain your answer.

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Part B

1. Sample answer: The graph did not indicate whether the height measurement used was with or without shoes. The type of shoes was not stated.
2. Sample answers: Use a data table that distinguishes between males and females. Use a data table that includes the type of shoes worn. Use a data table that takes age into account. This data table would not be useful if trying to determine the height of a teenager. Foot length increases before overall body height. It is not uncommon for teenagers to have very large feet compared to their height.
3. Incorrect measurements taken, and you are still growing.
4. More careful measurements.
5. Answers will vary.
6. Answers will vary.
7. Answers will vary.

ACTIVITY 15-3 *Ch. Obj. 15.3 and 15.4*

TIRE IMPRESSIONS AND ANALYSIS

Objectives:

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

1. Produce tire tread patterns from a tire.
2. Describe how to create tire tread patterns using three different methods.
3. Analyze and measure tire treads.
4. Compare a partial tire tread pattern with two complete tire tread patterns.

Background:

Mailboxes were being knocked down and vandalized on Oak Hill Drive. Bicycle tire tracks were identified near all the damaged mailboxes. Two neighborhood teenagers were among the list of possible suspects. Tread mark impressions were made from their bike tires and compared with impressions found at the sites of vandalism. Did any of the tread patterns match?

Time Required to Complete Activity: 40 minutes

Materials:

(teams of two to four students)
petroleum jelly and fingerprint powder *or*
ink pad and small paint roller *or*
inkless pad and paper
newsprint paper or a cardboard box
marker
gloves
scissors
chalk
rulers
at least two bicycle tires on rims or two small tractor tires or lawn mower tires
unknown tire tread sample approximately 0.6 meter in length

Safety Precautions:

Make sure the surface of the tire to be examined is free from hazardous materials (e.g., glass, nails). Wear gloves when working. This activity can be very messy and is best done outside. If working inside, be sure to cover the floor with newspaper or cardboard.

Procedure:

1. Place either a piece of newsprint about 2.5 meters long or cardboard pieces at least 2.5 meters long on the floor. (Cardboard boxes cut into 1-meter lengths and a width of at least 20 cm.)

ACTIVITY 15-3

Background

In this activity, students create two tire impressions, examine them, and record their findings. They also examine a partial tire tread pattern and attempt to match this pattern to one of the other two.

Safety Precautions

1. Remind students to avoid taking tire impressions in an area with moving vehicles.
2. Students need to wear gloves when working with tires.
3. It is best to complete this activity outside. It can be very messy.

Procedures

1. Print, copy, and distribute Activity Sheet 15-3 from the IRCD.
2. Make sure students read all directions *before* beginning the activity.
3. Use the same materials for activities 1 and 2.

2. Put on gloves.
3. Select one of the following three methods to produce your tire impression:
   a. Using your gloved hand, smear petroleum jelly over the surface of the tread and brush the tread with fingerprint powder.
   b. Roll the small paint roller over the fingerprint ink pad. Roll the inked roller over the tire to ink the tread of the entire rotation of the tire.
   c. If your tire is small, use an inkless ink pad and roll the tire over the inkless ink pad.
4. Mark the tire with chalk and mark the paper (or cardboard) with a marker as a starting point. Be sure the tire completes at least one entire revolution as it marks the paper or cardboard. Mark the end point of the revolution on the paper.
5. Lay paper or cardboard aside to dry.
6. Label the tire impression paper or cardboard (where you plan to roll the tire) with the following information:
   a. Date
   b. Names of investigating team members
   c. Case number
   d. Tire size
   e. Tire manufacturer
   f. Serial number from tire
   g. Tire placement on vehicle (i.e., front or rear, driver or passenger side)
7. Examine the tire impression. Label all unique identifiers you find on the tire print with a pen. Measure the position of any unique identifiers on the tire print starting from the starting point. Record the distance to the nearest millimeter.
8. Record your information on Data Table 1 (Suspect 1).
9. Repeat Steps 1 to 8 using the second tire. Record your information in Data Table 2 (Suspect 2).
10. Obtain a copy of a partial crime scene tire tread pattern from your instructor; examine it as you did tire samples 1 and 2.
11. Record your answers in Data Table 3 (Crime Scene).
12. Attempt to match the unknown sample to Tire 1 or Tire 2. Six to eight unique identifiers between a tire and tread pattern are considered to be a good match.

Data Table 1: Tire 1 Data (Suspect 1)

Identifier	Location from Starting Mark (cm)	Description

Data Table 2: Tire 2 Data (Suspect 2)

Identifier	Location from Starting Mark (cm)	Description

Data Table 3: Crime Scene Data

Identifier	Location from Starting Mark (cm)	Description

Questions:

1. Did the crime scene sample match Tire 1 or Tire 2? Justify your answer.
2. Why was it necessary to produce a complete rotation of the tire?
3. When viewing tread pattern analysis, what type of information can be obtained from the tread pattern that would help identify a specific car? Explain.
4. Do an Internet search and find tire identification database that could be used to help identify a tire.

Further Study:

Obtain old tires from a garage or landfill. Prepare tire prints that would demonstrate the following:

1. Car that did not have its tires balanced properly.
2. Car that did not have its tires aligned.
3. Car that was driven with underinflated tires.
4. Car that has a damaged tire.
5. Car that was driven without sufficient tread.
6. Car that was driven with snow tires.

Answers

Check students' data tables.

Questions

1. Answers will vary.
2. To ensure the entire circumference of the tire's tread pattern is examined.
3. Sample answer: tread pattern, track width, wheelbase, model of cars that used that particular tread pattern, year in which that particular tread pattern was used, wheel alignment of the car, determination if the tires needed balancing or air based on wear patterns.
4. Answers will vary.

Further Research and Extensions

Obtain old tires from a garage or landfill. Prepare tire prints that would demonstrate the following:

- Car that did not have its tires balanced.
- Car that did not have its tires aligned.
- Car that was driven with underinflated tires.
- Car that has a damaged tire.
- Car that was driven without sufficient tread.
- Car that was driven with snow tires.

Background

In this activity, students measure the track size, track width, and wheelbase of three different cars and record their findings. They then compare crime-scene data to their measurements and try to link one of the three cars to the crime scene.

Safety Precautions

1. Students should be aware at all times of any vehicles or people in the area when they are taking measurements of the cars. Do not take tire impressions in an area with moving vehicles.
2. All traffic should be blocked before students begin their measurements.
3. If time is a factor, ask students to measure the family car at home and bring their results to school.

ACTIVITY 15-4 *Ch. Obj. 15.4*
VEHICLE IDENTIFICATION

Objectives:

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

1. Using an actual car, measure the tire width, track width, and wheelbase.
2. Use information in databases to identify cars based on their tire width, track width, wheelbase, and turning ratio.
3. Given information obtained from an accident report, either eliminate or link a suspect's car to the crime scene.

Time Required to Complete Activity:

40 minutes for each part of activity

Materials:

per team (three teams of students; one for each car)
3 tape measures or 3 meter sticks (or yardsticks)
3 laser measuring tools and one square meter of cardboard or wood
3 different vehicles to measure
data sheet

Safety Precautions:

Be aware of traffic patterns in the area where vehicles are being measured. Traffic should be blocked off before students begin their measurements.

Scenario:

An eyewitness said that a young, male driver in a black car ran a stop sign, striking the oncoming car in the middle of the intersection. It appeared that the young man who ran the stop sign was talking on his cell phone at the time of the incident. Brakes were applied but applied too late and the vehicles crashed. In a panic, the young driver of the black car quickly backed up, made a U-turn, and abruptly left the scene of the accident. When the police arrived, the black car was gone. The other car was struck on the driver's side just in front of the driver. All that was left at the crime scene were tire marks. The crime-scene investigators took photographs and began diagramming the crime scene. All tire marks were carefully measured and documented.

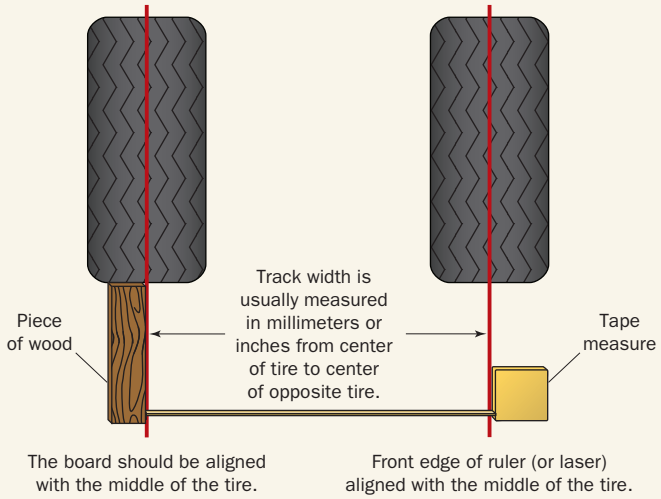
With the tire marks and measurements, the crime-scene investigator will be able to help reconstruct the accident. Information about the hit-and-run car can be obtained from the tire mark measurements. Just like fingerprints at the scene of a robbery can incriminate a suspect, tire marks at an accident can also incriminate a driver. Sometimes the drivers may not recall what happened, or the story they tell the police may be somewhat altered to try to protect themselves from getting a ticket or a jail sentence. When accident scenes are reconstructed using tire marks and measurements are made at the scene of the accident, the tire marks do indeed tell a story.

Procedure:

Part A: Measuring a Car's Track Size, Track Width, and Wheelbase

1. Review definitions for tire width, track width, and wheelbase in the chapter.
2. Three different teams will be assigned to three different cars. Each team is responsible for obtaining all of the measurements from their assigned car and sharing their information with other team members.
3. On Data Table 1, record the manufacturer, model, and year of the car that you will be measuring.
4. To measure the front track width, place a board or piece of cardboard in front of the tire. The right edge of the board or cardboard should be aligned directly in front of the tire.
5. Using the cardboard (or board) and the laser pointer or tape, measure the track width of the front tires of the assigned vehicle to the nearest millimeter (see the figure).
6. This measurement can be taken from center to center.
7. Record your information in Data Table 1.
8. Repeat the process for the rear tires, and record the rear track width in Data Table 1.
9. Measure the tire width of a front tire and a back tire on the driver's side. Record your answer in millimeters in Data Table 1.

Measuring track width.



10. Measure the wheelbase of the vehicle. Recall that your measurements are taken from the middle of the front tire to the middle of the rear tire. Record your answer in millimeters in Data Table 1.
11. Record information about the number and patterns of the tire ridge in Data Table 1.

Procedures

1. Print, copy, and distribute Activity Sheet 15-4 from the IRCD.
2. Make sure students read all directions *before* beginning the activity.
3. Determine which cars in your school parking lot can be used for students to record their data on car measurements. If possible, have the chosen cars be in an area of the parking lot that will be easily accessible and away from the mainstream of traffic. In choosing cars, try to find three different types of cars to accentuate the differences in data.
4. Select one of the cars as the car used at a crime scene. You will supply data on the crime-scene evidence that should match one of these cars. Do not give students the crime-scene data until after they have recorded their own information.
5. Depending on time constraints, allow students to work in teams. Each individual team can either measure one car and then share their data with the other groups, or teams may rotate and take measurements of all three cars and then compare their data.
6. Students can share one or two laser measuring devices. These devices are more accurate than stretching a tape measure.
7. Use the metric system when taking measurements. This will avoid the confusion of converting inches measured to the nearest 1/16 of an inch to decimal form before converting to the metric system.

12. Repeat the process for each of the other two vehicles, and record your information in Data Table 1 or obtain the information for the other two cars from the other lab teams.
13. Your instructor has information pertaining to an accident scene that was determined based on the tire marks left at the accident. Record that information in Data Table 1.
14. Compare the data from the accident to the data obtained from the measurements taken of the three suspected cars. Is it possible to eliminate any of the cars based on their measurements? Is it possible to link a particular car to that crime scene?

Data Table 1: Car Measurements

Vehicle Number	Manufacturer	Model	Year	Front Track Width (mm)	Rear Track Width (mm)	Tire Width Front (mm)	Tire Width Rear (mm)	Wheelbase (mm)	Number of ridges (ribs)	Ridge Pattern (angular, straight, direction)	Other Visual Observations
Car 1											
Car 2											
Car 3											
Evidence Data from Crime Scene											

Do any of the three suspect vehicles match the crime scene?
Explain your answer.

Part B: Linking a Car to a Crime Scene

Try to identify the car using information provided on the pavement at an accident site with the database in Figure 15-13.

1. Wheelbase = ~2689 mm
   Turning diameter = ~11,100 mm
   Tire size = 245
   Vehicle was probably a _____
   Justify your answer.
2. Wheelbase = ~2620 mm
   Turning diameter = 11,102 mm
   Tire size = 195
   Vehicle was probably a _____
   Justify your answer.
3. Wheelbase = 2689 mm
   Turning diameter = 10,739 mm
   Tire size = 195
   Vehicle was probably a _____
   Justify your answer.
4. Wheelbase = ~2835 mm
   Turning diameter = ~11,700 mm
   Tire size = 215
   Vehicle was a _____
   Justify your answer.
5. Wheelbase = ~2408 mm
   Turning diameter = ~10,800 mm
   Tire size = 215
   Vehicle was probably a _____
   Justify your answer.

Questions:

1. When evaluating evidence, which of the following is most significant, and which is the least significant, and why?
   a. Wheelbase
   b. Turning diameter
   c. Tire size
2. Is it possible to eliminate any of the cars based solely on this most significant measurement? Explain.
3. In Part A, did any of the skid marks found at the crime scene match any of the suspects' cars? Explain.
4. If any of the cars' data matched the crime scene, would this be sufficient evidence to convict? Explain.
5. What additional testing might be performed on the suspected car?

Further Study:

Accident reconstruction is an important area in forensics. This area of forensics requires knowledge of physics and math. Explain the role of each of the following:

Friction
Kinetic energy
Acceleration
Velocity

Answers

Check students' data tables and vehicle identifications.

1. Jeep Cherokee
2. Audi A4
3. Mercedes C
4. Ford Galaxy
5. Toyota RAV 4

Questions

1. Tire size can be measured in several locations on the tire and would be the most accurate. Wheelbase and turning diameter require a lot more tread pattern to calculate.
2. No, all variables are needed.
3. Answers will vary.
4. No. This would still be considered to be class evidence and would need to be supported by other evidence.
5. Sample answer: Individual characteristics, such as specific wear patterns, may be investigated.

Science

Mathematics

Diameter and radius are segments of a circle.

Science

Mathematics

The radius of a circle is a segment that has one endpoint at the center of the circle and another endpoint on the circle. The diameter of a circle is a segment that passes through the center of a circle and has both endpoints on the circle. The diameter of a circle is twice the radius. You can use the diameter (d) or the radius (r) of a circle to find the circumference (C) of a circle by using the formula $C = \pi d$.

Further Research and Extensions

Have students discuss how skid mark evidence

1. demonstrates that someone ran a stop sign.
2. indicates exactly where a collision occurred.
3. can indicate a 'quick get-away.'
4. indicates the direction of movement of the vehicle.

Background

In this activity, students create dental impressions and transparencies of their teeth. They will also compare five different dental molds and try to match bite marks to the molds that made them.

Safety Precautions

1. Large amounts of saliva tend to be produced during this activity. Provide paper towels or tissues. Make sure all paper is discarded properly to avoid the spread of bacteria from saliva.
2. Make sure students wash their hands with soap and water after wiping the saliva from their dental impressions.

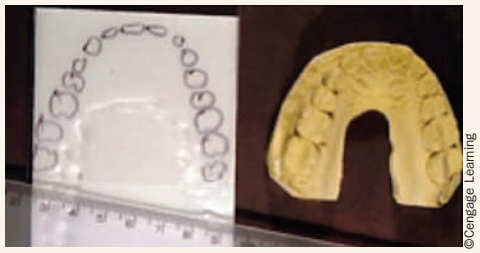
ACTIVITY 15-5 *Ch. Obj. 15.5*
DENTAL IMPRESSIONS

Objectives:

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

1. Create a Styrofoam impression of your own bite marks or bite marks created from professional dental castings.
2. Produce a transparency of your bite marks from your own dental impression or from the bite marks produced from the professional dental castings.
3. Match bite marks found on a victim with bite marks from a suspect.

Plaster casts are often made of a suspect's teeth to be used in the courtroom to better see the match between impressions and teeth.



Materials:

(students work in teams of two)
4 Styrofoam bite plates, approximately 6 cm by 7.5 cm
2 hand lenses
tissues
4 transparency sheets (8 × 8 cm)
2 permanent markers
scissors
2 transparencies of bite marks from victim
1 resealable plastic bag (for the garbage)
two sets of professional dental impressions (optional)
2 metric rulers

Time Required to Complete Activity: 45 minutes

Safety Precautions:

Use tissues to wipe any residual saliva from the Styrofoam dental impressions. When the activity is completed, all tissues should be discarded in the trash (or in a resealable plastic bag) to avoid spreading bacteria. Students should wash their hands with soap and water after wiping their Styrofoam dental impressions.

Procedure:

Part A: Making Bite Plates

1. Obtain two equally sized Styrofoam plates from your instructor. The plates must be large enough to be in contact with all of your teeth but small enough to fit into your mouth. If the pieces are too large, cut the Styrofoam plate with the scissors. You need to put in the largest size possible to get a good impression of your back teeth. It will be a tight fit and a little bit uncomfortable!

2. Label one plate *upper* and the other plate *lower*.
3. With the upper and lower plates aligned, place both plates in your mouth at once. Make sure they are placed back far enough to sit between your back molars.
4. Bite down firmly on the plates and gently grind your teeth. Do not chew on the Styrofoam or bite completely through the Styrofoam plates. Remember that all you are trying to do is to get an impression of your teeth.
5. Remove the plates and wipe off any residual saliva with a tissue. Immediately discard the used tissue and place it in a resealable bag.
6. Wash your hands with soap and water to avoid spreading bacteria.
7. Obtain two transparency sheets. Label both with your initials in the upper right-hand corner. In the upper left-hand corner, label one as upper and the other as lower.
8. Examine the bite marks on the Styrofoam plates. Place a transparency sheet labeled upper over the upper impressions.
9. With a permanent pen, outline the pattern made by each of your upper teeth. Be careful to trace each tooth individually.
10. Repeat the process for your lower teeth.
11. Compare your dental transparencies with those of your partner.

Styrofoam bite plates.

Part B: Identifying Dental Patterns

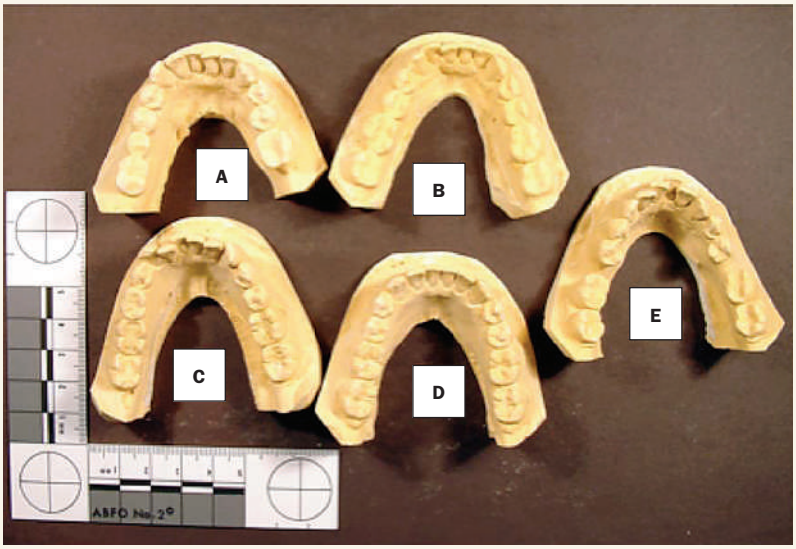
Compare the photographs of five dental molds made from the upper and lower jaws of five different people.

1. Using a permanent pen and a half sheet of transparency, carefully trace the dental pattern of each of the five upper jaws (1 through 5). The front incisors can be drawn as dashes, while the side and rear teeth can be drawn as irregular circles. Label your transparency sheet with your initials, and label each dental pattern 1 through 5.
2. Using your tracings of the upper jaws (1 through 5), attempt to match the upper jaw with the lower jaws labeled A through E. The lower teeth should fit into the arch of the upper teeth. For most people, the upper teeth will extend beyond the lower teeth. Report

Procedures

1. Print, copy, and distribute Activity Sheet 15-5 from the IRCD.
2. Obtain Styrofoam trays from the supermarket and cut them for use. Cut several different widths to accommodate different-sized dental patterns.
3. Cut overhead transparencies in sixths for use in step 7 and step 1 of Part B.
4. Obtain dental castings from your local dentist. These are often disposed of, and a local dentist should give them to you for free.
5. Always photograph a ruler with your dental impressions. That way you can adjust the photograph size later if necessary.
6. Be aware that some students may be very sensitive about their teeth, especially if they have very crooked teeth. If you have dental castings available, you might make these available for any students who do not want to make impressions of their own mouths or for students who have a sore throat or cold.

Five sample sets of teeth, upper teeth (top photo) and lower teeth (bottom photo).

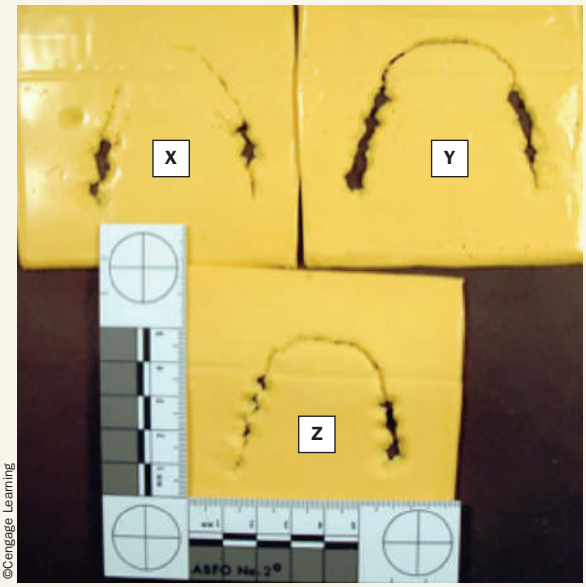


your results on Data Table 1. Check your results with your teacher before proceeding to the next step.

Part C: Bite Mark Identification

3. Compare your five tracings of upper dental impressions with photographs X, Y, Z of bite marks made in cheese by placing the transparency over the photograph. Report your results on Table 2.

Bite marks in cheese



Data Table 1: Matching Upper and Lower Dental Plates

Upper Teeth (number)	Matches Lower Teeth (letter)
1	
2	
3	
4	
5	

Data Table 2: Bite Marks

Bite Mark (letter)	Upper Teeth (number)
X	
Y	
Z	

Questions:

1. Measurements can be taken of dental patterns and bite marks. List what characteristics make dental patterns unique.
2. Explain how a dental impression provides clues to someone's age.
3. How would obtaining dental records help in the identification of unknown bodies?
4. Besides the use of dental impressions to identify a person, DNA analysis is also being done on teeth. What part of the tooth could contain DNA? Explain your answer.
5. Refer to the diagram of adult teeth in your text and your dental impressions. Based on the structure of the teeth, what do you suppose is the function of each of the different types of teeth: Incisors, Canines, Molars

Further Study:

1. Using the transparencies of your bite marks and those of several other classmates, design a demonstration that requires the use of dental impressions to help solve the crime. Do not actually bite anyone! Someone in your team could bite into a slice of American cheese to provide the evidence bite mark. Others in your team could become some of the suspects. Using the bite marks in cheese and the transparencies of your teammates, demonstrate how the suspect's bite mark can link that suspect to the crime.
2. During wartime, soldiers were each issued their own dog tags. Research these military dog tags and describe:
   a. What are they?
   b. How were they made?
   c. What was their function?
   d. How did they identify the individual soldier?

Answers

Check students' data tables.

Questions

1. Sample answer: tooth position, the arch of the plate, the width of the plate, unique spacing, the number of teeth.
2. Sample answer: The presence or absence of wisdom teeth can distinguish someone under the age of 21. Children's ages can be estimated with dental impressions based on the presence or absence of baby teeth and adult teeth.
3. Sample answer: Dental records contain X-rays of a person's mouth that would indicate the presence or absence of fillings, crowns, and cavities. The X-ray would also show tooth alignment and spacing.
4. DNA analysis would have to be done on the living portion of the tooth found within the tooth's pulp area.
5. a. Incisors cut food.
   b. Canines tear food.
   c. Molars grind food.