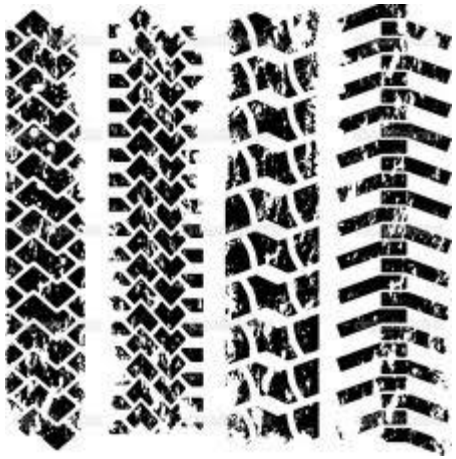
FORENSIC SCIENCE 'OTHER EVIDENCE'



TOOL MARKS, CASTS, IMPRESSIONS, AND GLASS EVIDENCE

CRIME SCENE DO NOT CROSS

TOOL MARKS

a. Tools are objects used to **simplify** everyday living by helping us do work.

   i. Examples include **hammers**, screwdrivers, **knives**, crowbars, and saws.

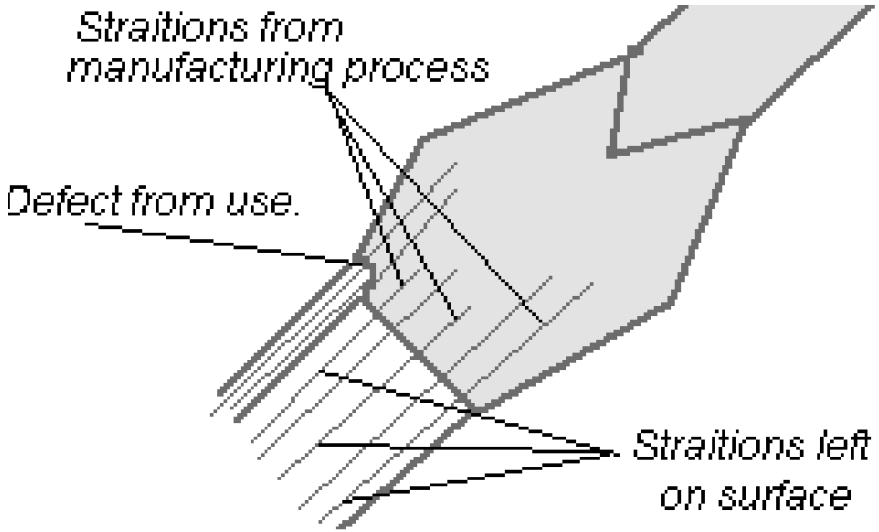
   ii. Criminals will often use these tools during crimes, to **break** into cars or buildings. In doing so, they often leave behind evidence called **tool marks**.

b. A tool mark is any impression, **scratch**, or abrasion made when contact occurs between a tool and an object.

i. Tool marks can be linked to tools used at a crime scene, and ultimately may be used to help find the suspect who used it.

Tools (on left) associated with tool-marks array on a metal plate, enhanced by Reflectance Transformation Imaging (on right)

1. Certain **defects** or patterns may be left on a tool when it is made or **used** over time.



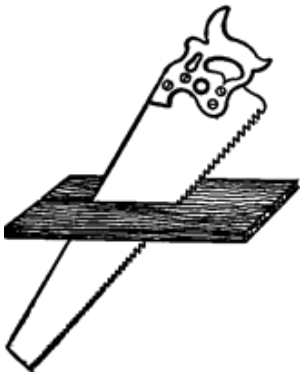
2. Tools may also oxidize or **rust** making them more unique.
3. Tools often come with **serial** numbers as well. Even serial numbers which have been rubbed off can often be recovered and used as evidence.

c. There are three major categories of tool marks: indentations marks, abrasion marks, and cutting marks.

i. Indentations Marks
   1. Indentations marks are made by a tool when it is pressed against a **softer** surface, often forming a **negative** impression on the object receiving the force.

ii. Abrasion Marks
   1. Abrasion marks are made when surfaces **slide** across one another.

iii. Cutting Marks
   1. Cutting marks are produced along the **edge** as a surface is cut.



iv. More than one type of mark can be made at the **same** time.

TOOL MARK EVIDENCE

a. Tool marks are encountered most frequently in **burglary** cases but may also be found in other types of crimes.

b. **Photography** is the best way to documents tool and tool mark evidence. Photographs should include a **ruler** for size reference.

c. Whenever possible, submit the whole object containing tool marks to the laboratory instead of just removing the area containing the mark.

d. When there is no tool left at the scene of the crime, a **cast** can be made of marks left behind from the tool.

Video Clip 1, 2

CRIME SCENE DO NOT CROSS

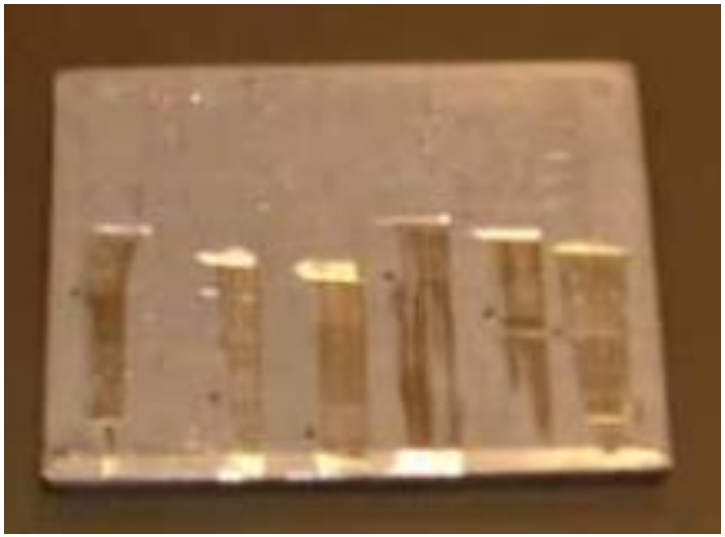
e. All areas on recovered tools which contain transferred paint, building material, or other contamination should be wrapped in paper and packaged to prevent the edges from contacting any other surface or object.

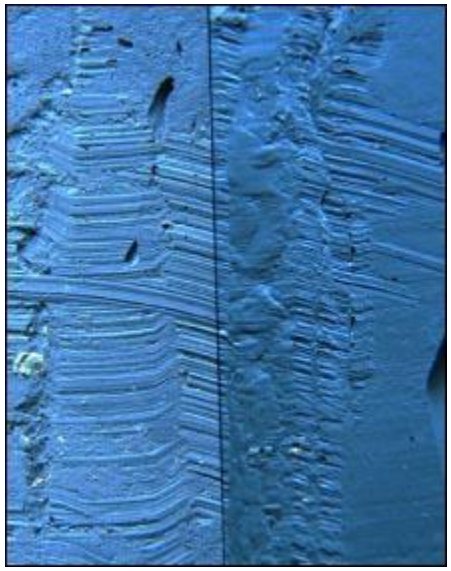
f. Attempts should never be made to **fit** tools into questioned marks or to make test marks prior to laboratory examination.

TOOL MARK DATABASE

a. The Department of Energy's Ames Laboratory at Iowa State University developed a tool mark image database to better analyze tools and tool marks using **3-D** characterization scans.

THE Ames Laboratory
Creating Materials & Energy Solutions
U.S. DEPARTMENT OF ENERGY



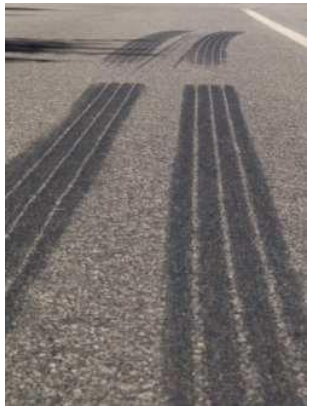


CRIME SCENE DO NOT CROSS

CASTS AND IMPRESSIONS

a. Often there are no witnesses at a crime and no cameras to capture what happened, so detectives must rely on **evidence** to figure it out.
b. Impressions made by **shoes**, **bare feet**, **teeth**, **tires**, and other objects are helpful because they can form impressions and leave clues.

THREE KINDS OF IMPRESSIONS



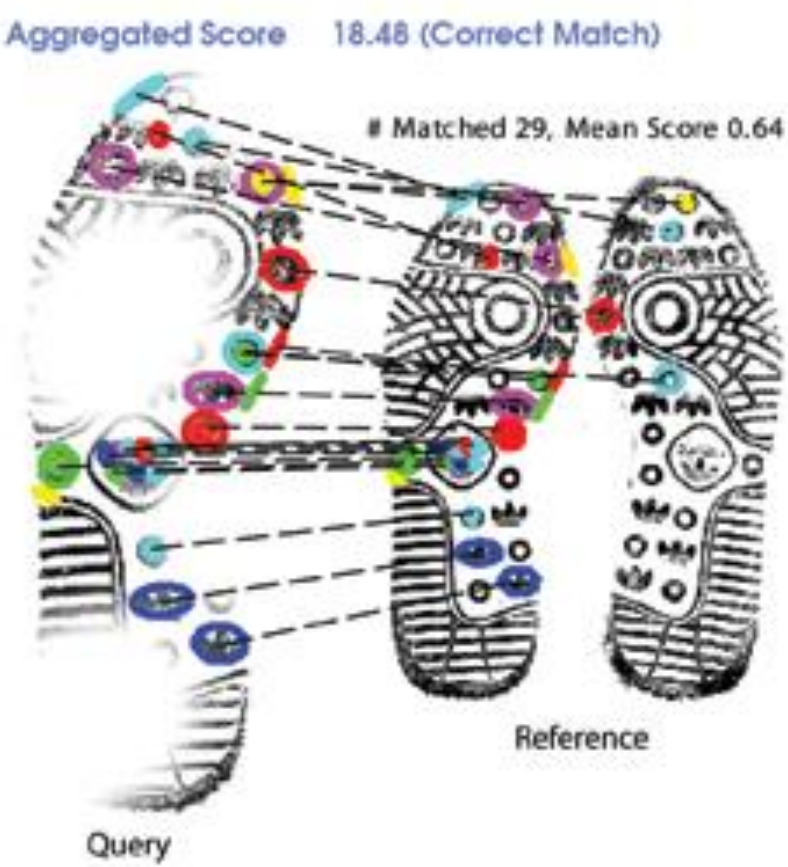
i. **Patent** impressions
   1. Visible, **two**-dimensional marks formed from soil, dust, paint, blood, ink, etc.

ii. **Latent** impressions
   1. Hidden to the naked eye but can be visualized through the use of **dusting** or electrostatic techniques.
   2. Like latent fingerprints, they are often caused by **oils** or microscopic dirt particles depositing on a surface.

iii. **Plastic** impressions
   1. **Three**-dimensional imprints left in pliable materials such as **snow**, mud, soil, or soap.
   2. As a result of the soft substrate, these prints can often be **lost** (melt or blow away) and should be photographed immediately.

SHOE IMPRESSIONS

a. Databases contain **tread** patterns used by different manufacturers, and can often be traced down to retailers which sell the shoe.



b. A shoe impression can help an investigator determine the foot size and the possible **height** and **weight** of a person.

Much information can be obtained from a shoe impression, including:

- Size of shoe imprint → size of a person's foot.
- Depth of shoe or foot imprint → person's weight.
- Type of shoe (e.g. work boot v flat dress shoe) → information on the person's job or personality.
- Brand of shoe → information about the buyer.

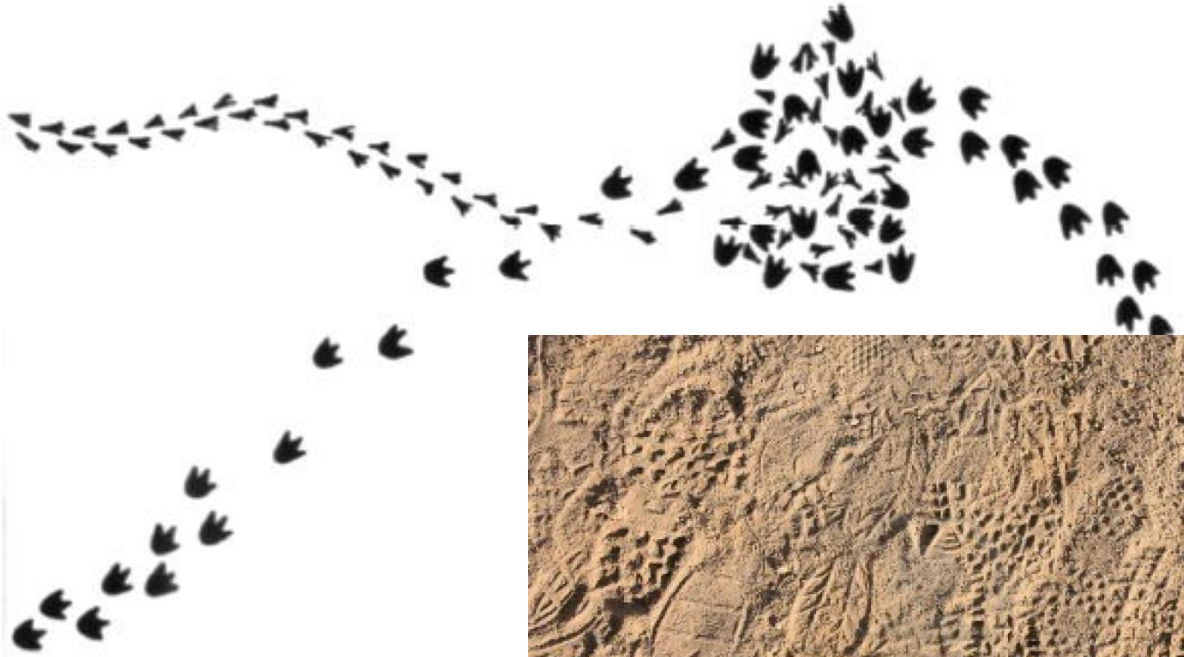
c. While many people may wear the same shoes, each person wears down his or her shoes differently, based on their **gait**, or walking pattern. Shoe wear patterns can help individualize evidence.

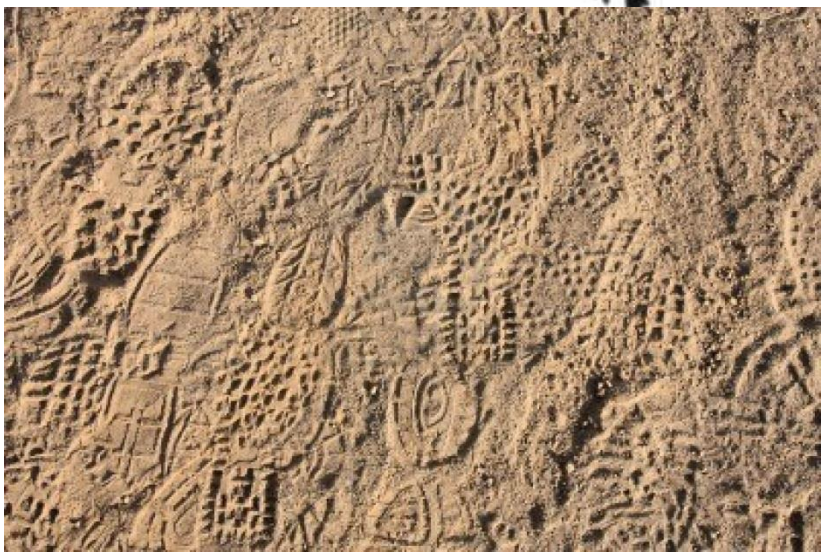
d. If numerous prints are found at a scene, detectives can gain information about:

i. the number of people at the scene

ii. Movements of individuals at the crime scene

iii. The **entrance** and **exit** to the scene

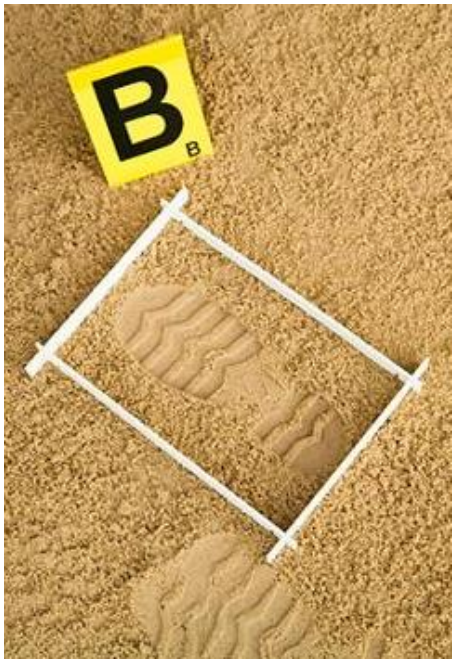




e. Collection of Shoe Impression Evidence

i. Photographing Impressions

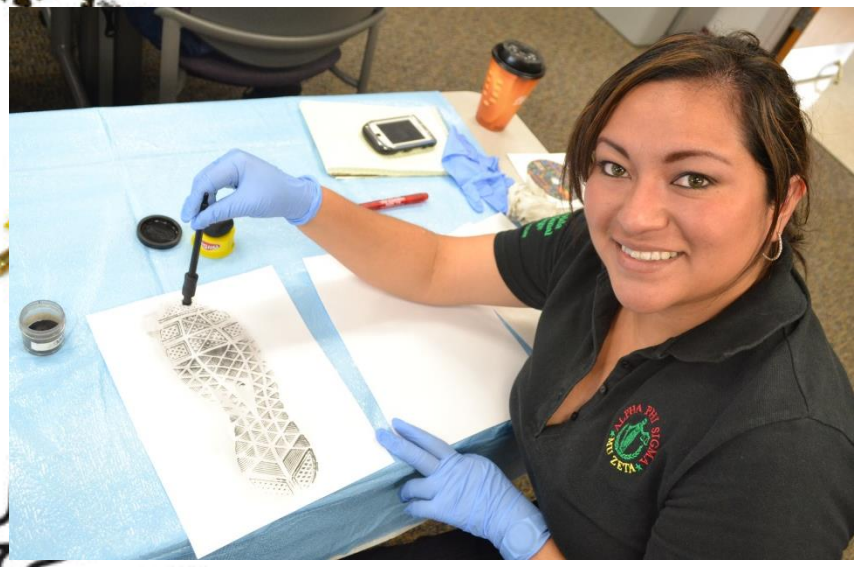
1. Take photos as soon as possible to avoid any alteration or contamination
2. Take multiple photos from several different **angles**
3. Include a label and ruler in the photo for reference

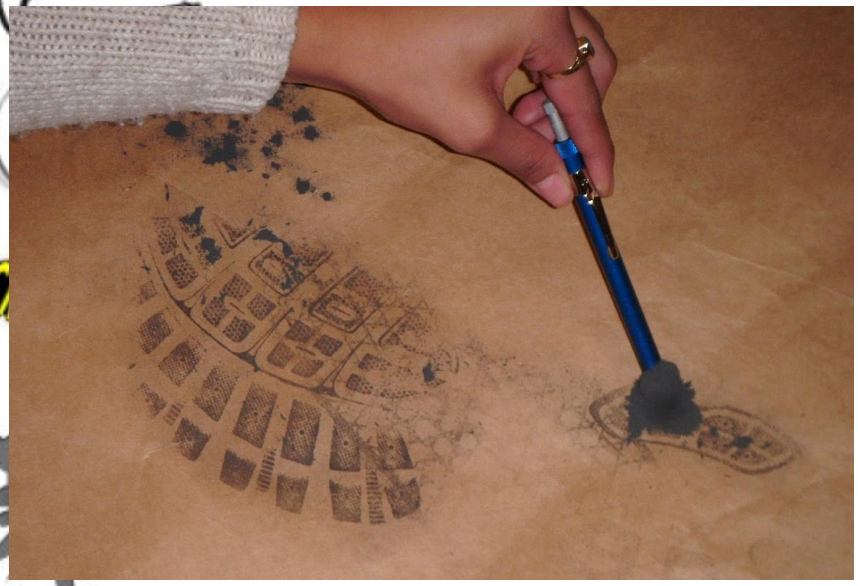


Video Clip

ii. Lifting Latent Impressions

1. Dusting of footprints is similar to dusting for fingerprints.





CRIME SCENE DO NOT CROSS

iii. Casting Plastic Impressions

1. 3-D impressions are able to be preserved using **Plaster** of Paris which fills in the print and produces a **cast**.

Video Clip 1, 2

Shoe print found in mud

Cast made from shoe print

Suspect shoe matches cast

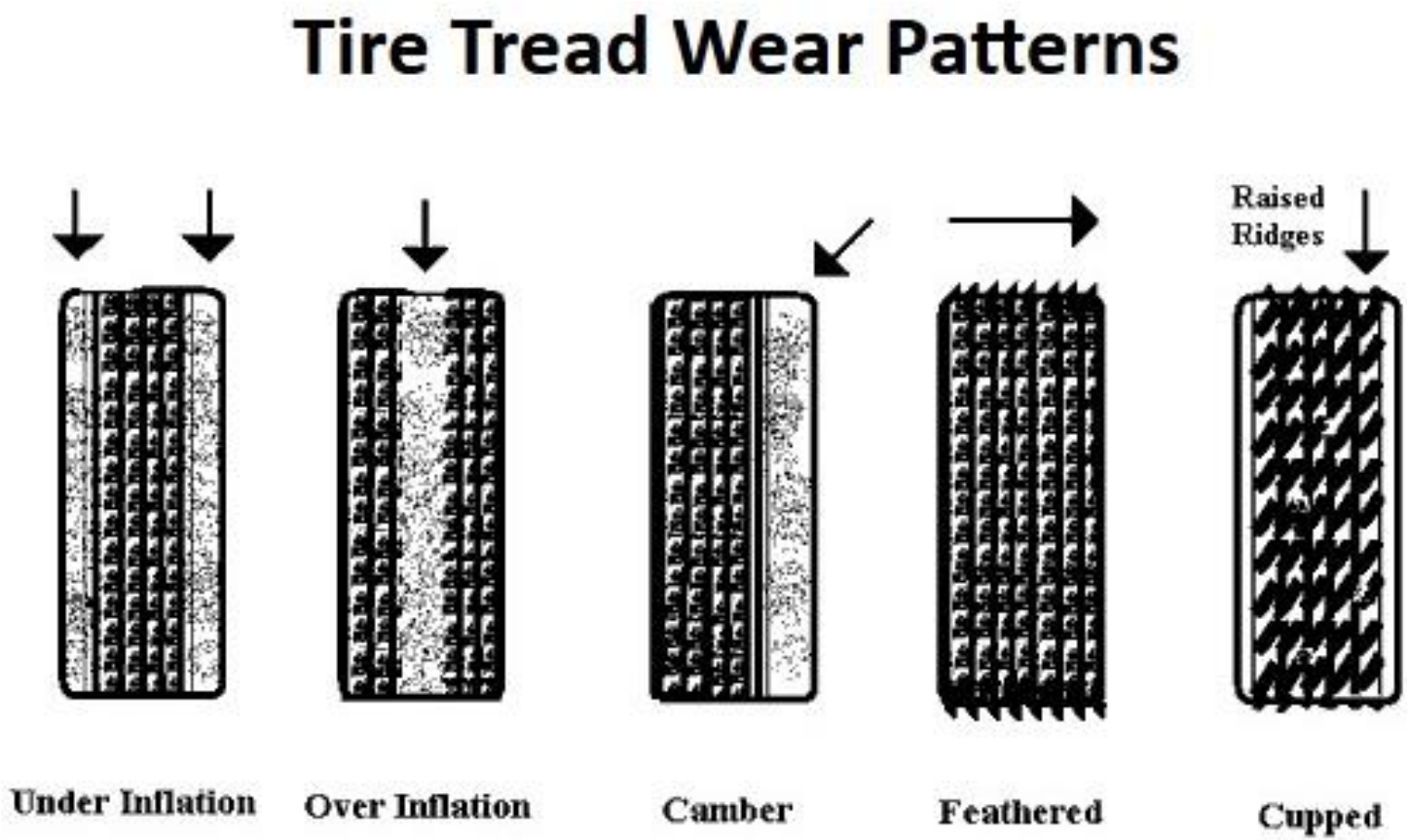
CRIME SCENE DO NOT CROSS

TIRE IMPRESSIONS

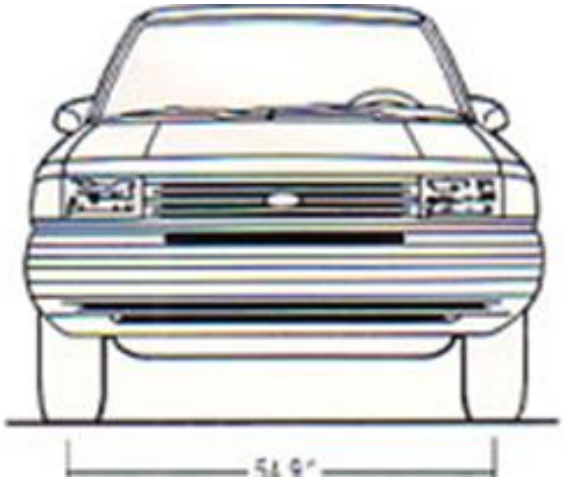
a. Tire evidence can be used to link a suspect to a crime scene and also to help the crime scene investigators reconstruct the crime.
b. Like other impressions, tire marks may leave patent, latent, and plastic markings.
    i. Patent impressions occur when a car travels over a **liquid** such as paint, blood, or tar.
    ii. Latent tracks can be deposited from the **oil** used to soften tires.
    iii. Plastic impressions can be made when a vehicle drives on **mud**, **sand**, or **snow**.

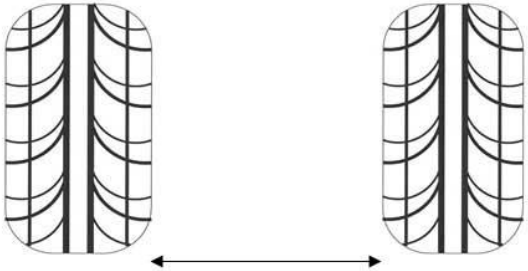
c. Tire treads are ridges and **grooves** that channel **water** away from the wheel and provide **traction** for the vehicle.

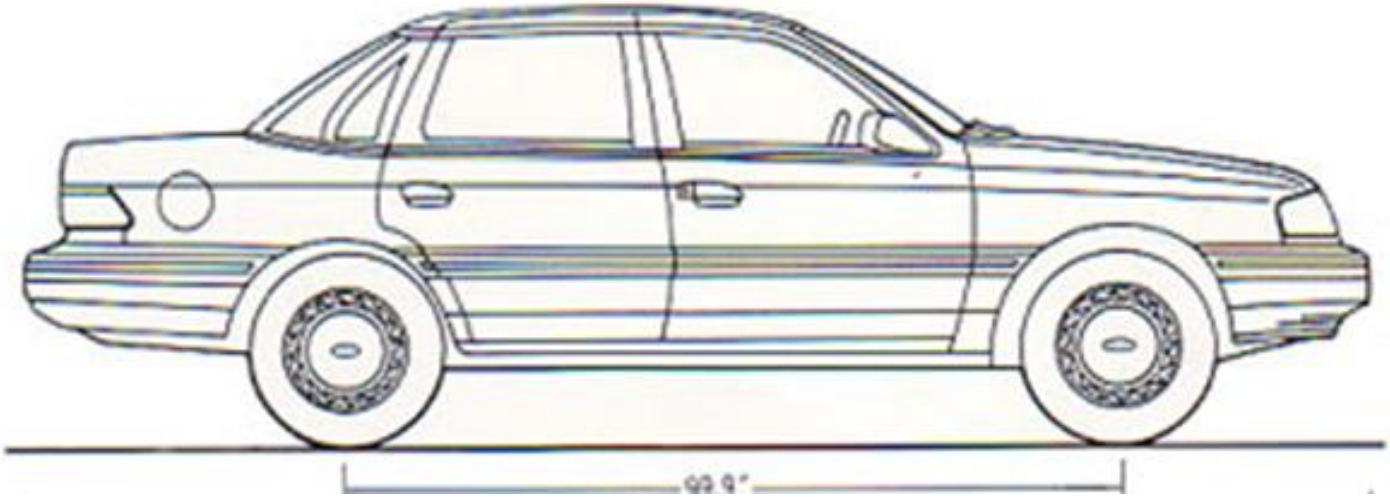
i. Tread patterns can be measured and used to identify the type of tire, and sometimes even the make and model of the vehicle that left the mark.



d. To help identify a vehicle, investigators measure track **widths**, wheelbase **lengths**, and turning **diameter** and check them against a vehicle database.







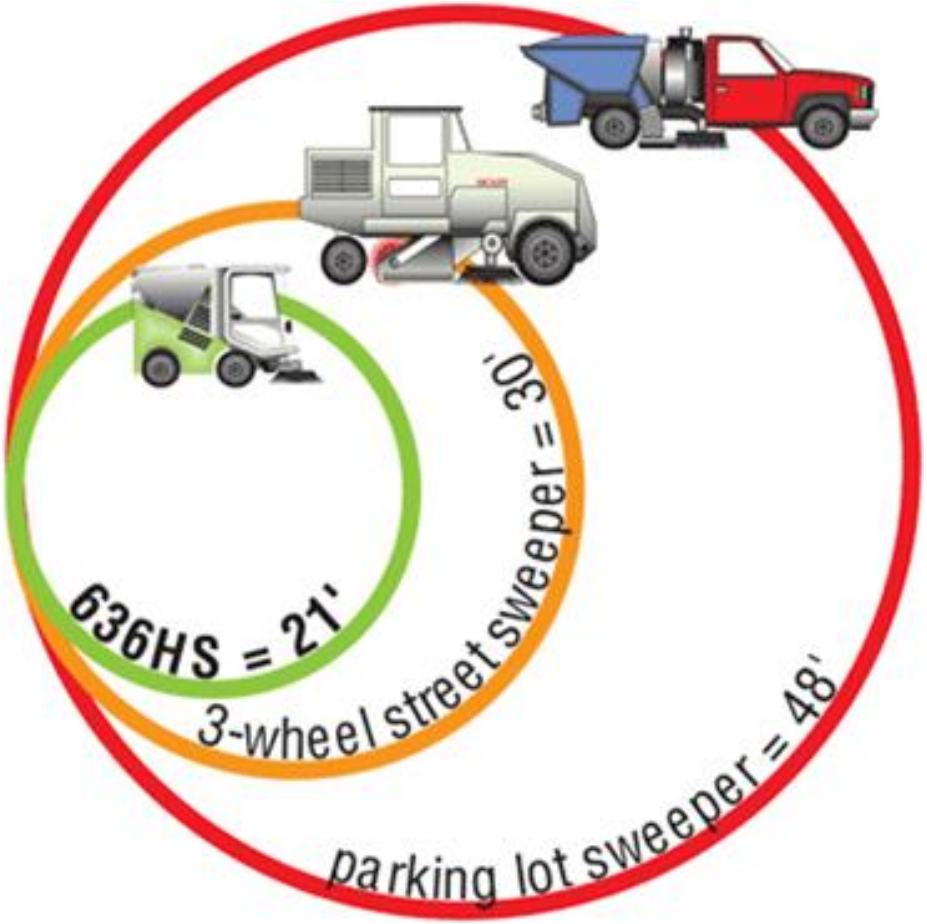
CRIME SCENE DO NOT CROSS

i. Track width- the distance from the **center** of one tire to the center of the other tire.

1. Front and rear track widths may **differ** so both should be measured.

ii. Wheelbase- the distance from the center of the front **axle** to the center of the rear axle.

ii. Turning diameter- the amount of space required for the car to make a **sharp** U-turn.



CRIME SCENE DO NOT CROSS

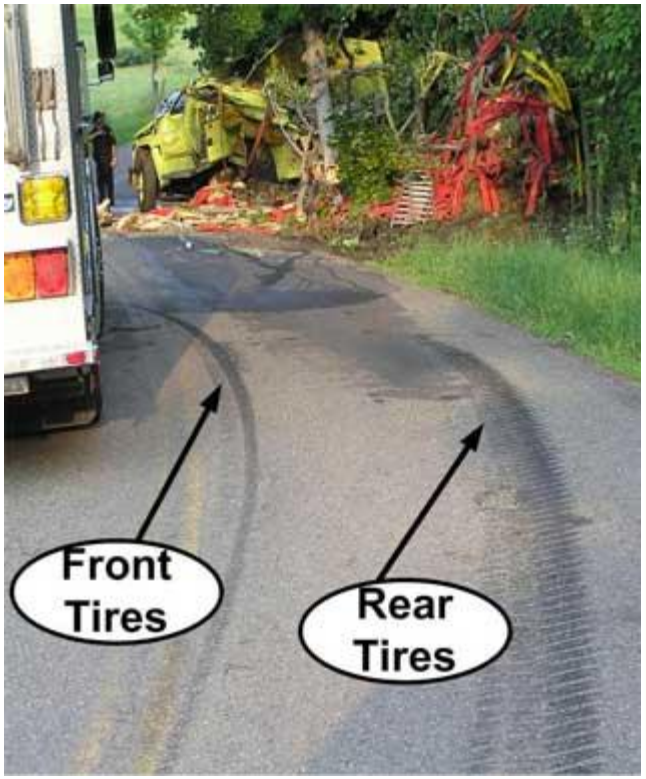
e. Tire marks can also give clues to **speed** and **direction** of the vehicle.

i. Skid marks

1. Form when a driver slams on the breaks suddenly.
2. Skid marks show the distance he vehicle traveled after the brakes were applied.
3. Skid marks can help calculate the speed of the vehicle.

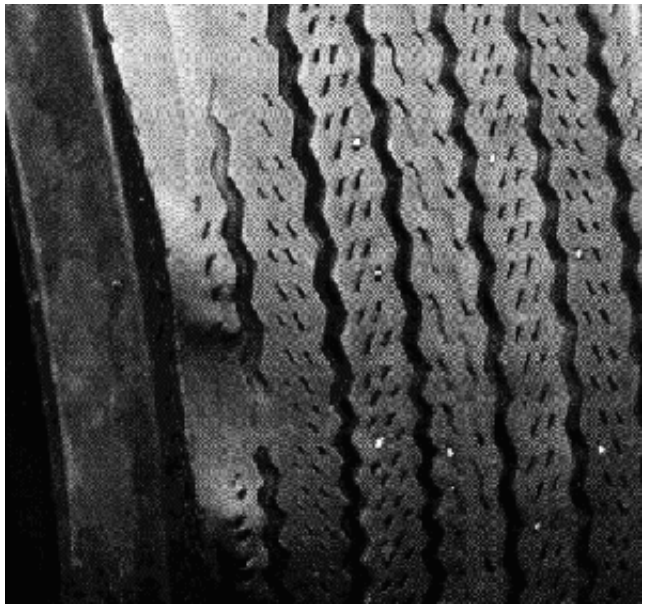
ii. **Yaw** marks

1. Sideways skid marks, produced when a vehicle turns faster than it can handle.
2. Often accompanied by smoke and squealing sounds.



iii. Tire **scrubs**

1. Damage to tires can show the area of impact.

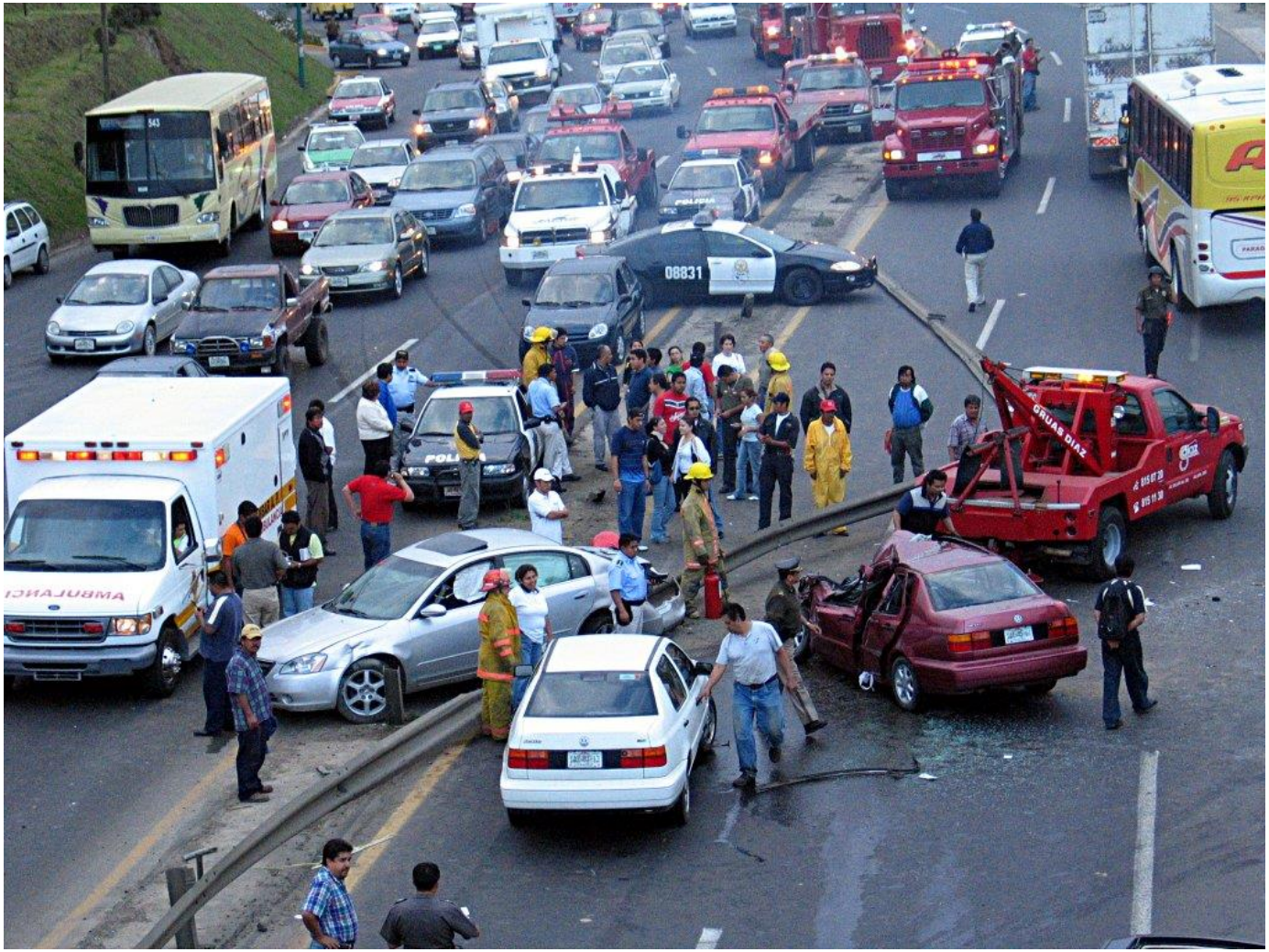


Video Clip

CRIME SCENE DO NOT CROSS

e. Investigators will use information provided by evidence to try to reconstruct an accident. Their overall goals are to determine:

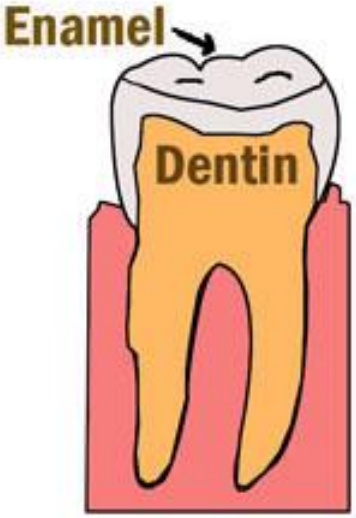
i. What happened? When did it happen? Why? How? Who was involved? How fast were the vehicles travelling? Who is at **fault**?



DENTAL IMPRESSIONS

a. Teeth are one of the most distinct and long-**lasting** features of mammals.

b. Teeth are not made of bone; instead the hard white portion of a tooth is **enamel** and dentin.



i. Both are composed of **calcium** and phosphorus.

ii. Enamel is the **hardest** substance in the human body, to protect the teeth from high temperatures and pressure. It also protects the **living** dentin layer underneath.

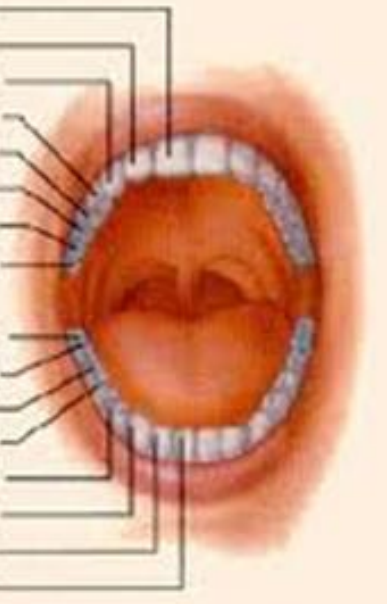
CRIME SCENE DO NOT CROSS

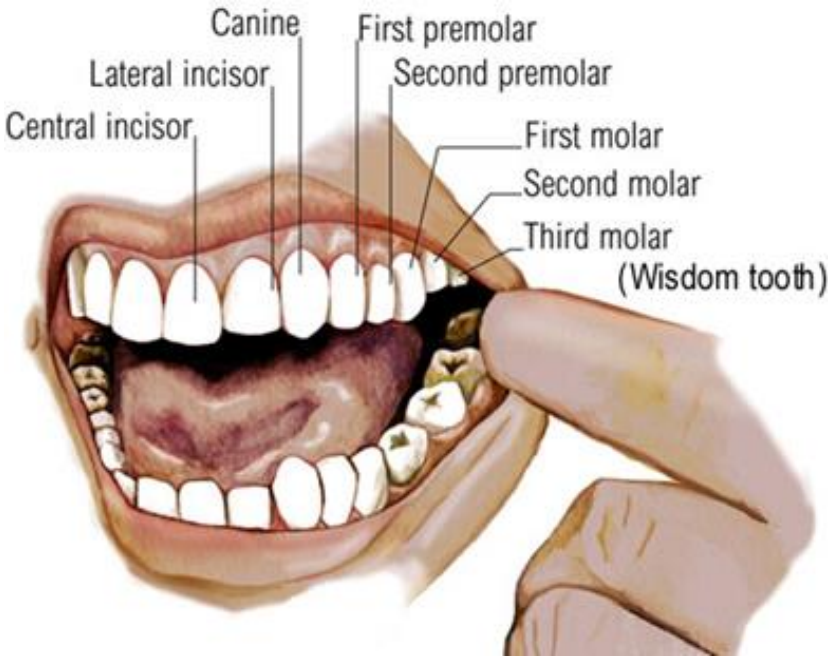
c. Babies are born without visible teeth, which eventually appear in predictable stages.

i. Children have **20** primary teeth, while adults have **32** permanent teeth.

ii. Because permanent teeth develop at different rates, teeth can be used to determine a rough estimate of a person's **age**.

	Primary Erupt	Permanent Erupt
Upper Teeth		
Central incisor	8-12 mos.	7-8 yrs.
Lateral incisor	9-13 mos.	8-9 yrs.
Canine (cuspid)	16-22 mos.	11-12 yrs.
First premolar		10-11 yrs.
Second premolar		10-12 yrs.
First molar	15-19 mos.	6-7 yrs.
Second molar	25-33 mos.	12-13 yrs.
Third molar		17-21 yrs.
Lower Teeth		
Third molar		17-21 yrs.
Second molar	23-31 mos.	11-13 yrs.
First molar	14-18 mos.	6-7 yrs.
Second premolar		11-12 yrs.
First premolar		10-12 yrs.
Canine (cuspid)	17-23 mos.	9-10 yrs.
Lateral incisor	10-16 mos.	7-8 yrs.
Central incisor	6-10 mos.	6-7 yrs.





d. Dental patterns are used in forensic science in two main ways:

i. Teeth can be used to identify body **remains**.

ii. Teeth can be used to identify a suspect from bite **marks** left by a victim, or by the suspect at the crime scene.

Video Clip 1, 2

- Mt. Carmel Doe 35 -- allegedly Shari Doyle
- Alleged cause of death: gunshot wound, left posterior head
- Identified: 4/25/93 by dental comparison

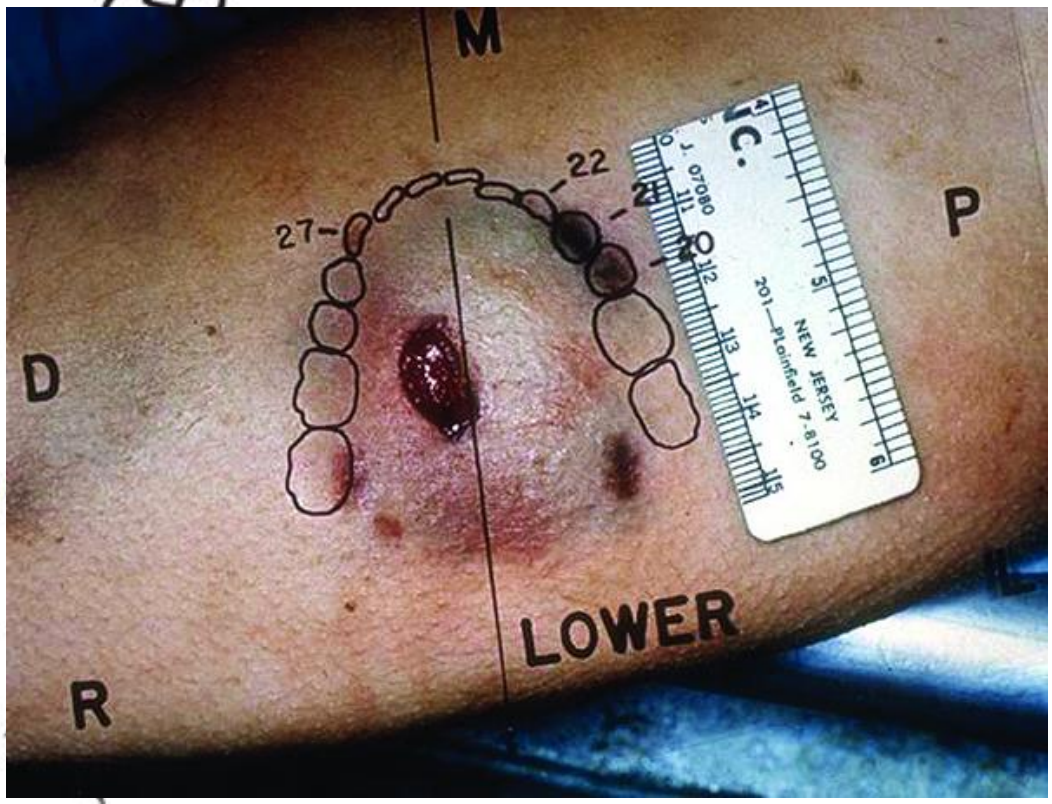
e. Collecting bite mark evidence

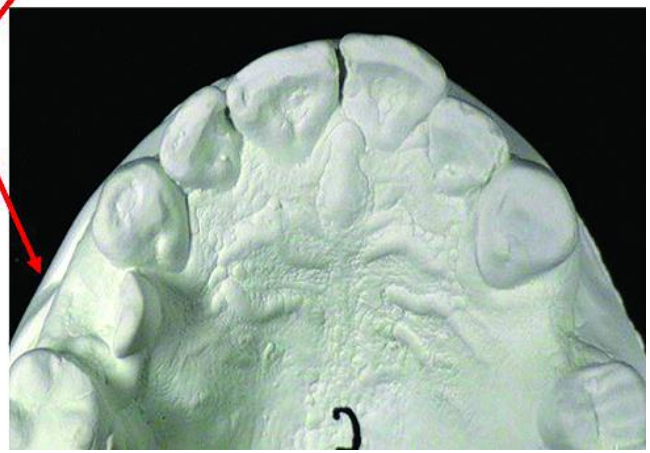
i. Bite marks should be photographed as soon as possible while the impressions are most **visible**. Photos should include a ruler.

ii. Bite marks should also be swabbed for **saliva**, which may contain **DNA**.

f. Differences in the **size** of teeth and jaw affect the positioning and possible crowding of teeth, making each person's mouth **unique**.

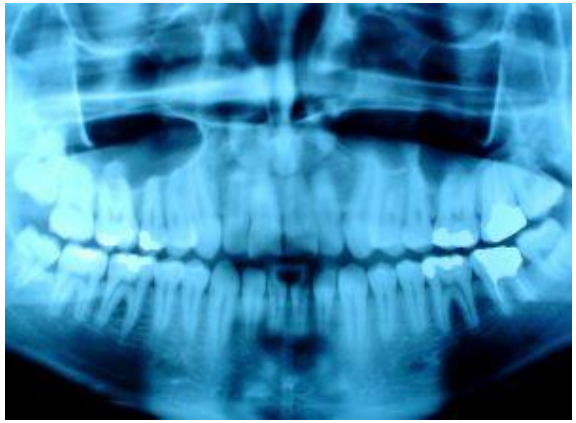
i. Up to **76** points of comparison may be used when matching bite marks, making bite marks very individualized.

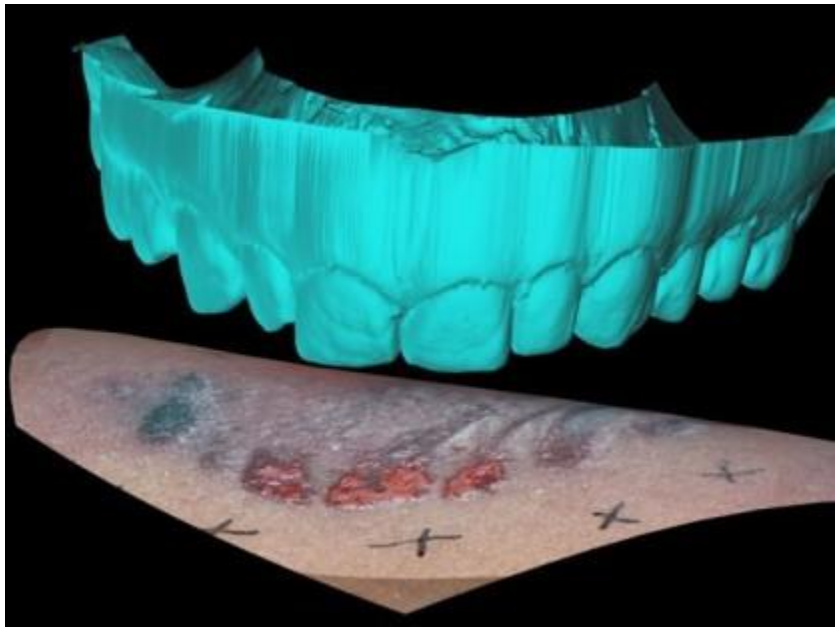




ii. Some of these individualizing factors include:

1. Dental **work** (fillings, crowns, caps)
2. **Damage** (chips and cracks)
3. **Coloration**
4. Distances between teeth
5. Alignment of teeth
6. Dimensions of each tooth
7. Arch of the **roof** of the mouth

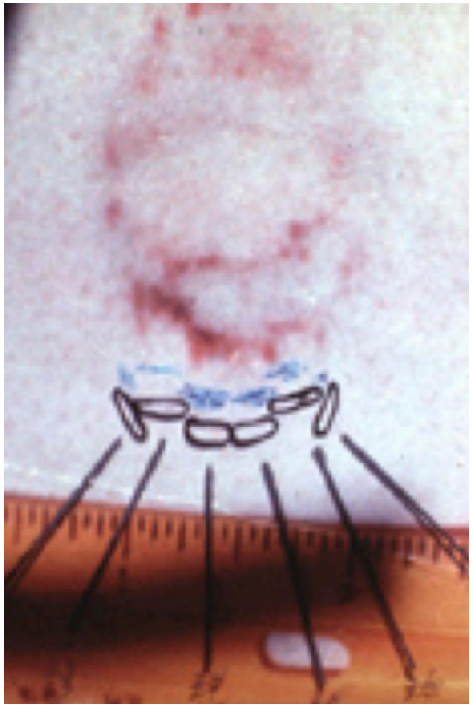




Video Clip

FAMOUS CASE

The most famous incident where bite mark evidence led to a conviction, was in the case of the notorious serial killer, **Ted Bundy**. He was responsible for an undetermined number of murders between 1973 and 1978 and was finally tied to the murder of Lisa Levy through bites that he had inflicted on her body.



Ted 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.

Source: http://www.telegraph.co.uk/news/worldnews/northamerica/usa/8678555/Blood-of-serial-killer-Ted-Bundy-discovered-by-police.html

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!

CRIME SCENE DO NOT CROSS

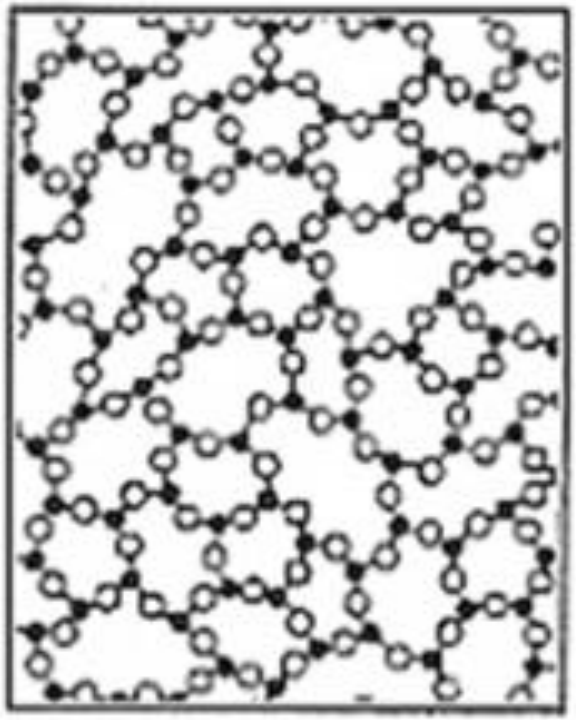
GLASS EVIDENCE

a. Glass evidence can be found at many types of crime scenes: **break**-ins, car accidents, **shootings**, etc.

b. Glass is a rigid material formed by heating a mixture of dry materials to a viscous state, then **cooling** the ingredients fast enough to **prevent** a regular crystalline structure.

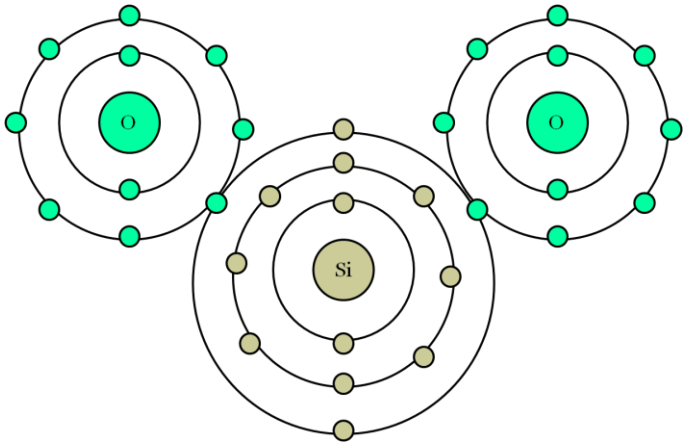
   i. As the glass cools, the atoms become locked in a **disordered** state (like a liquid) before they can form into the perfect crystal arrangement of a solid. We call this random arrangement pattern **amorphous**.

   ii. Because of the irregular atomic structure of glass, when it breaks it produces a variety of fracture **patterns**, which can be analyzed by forensic detectives.

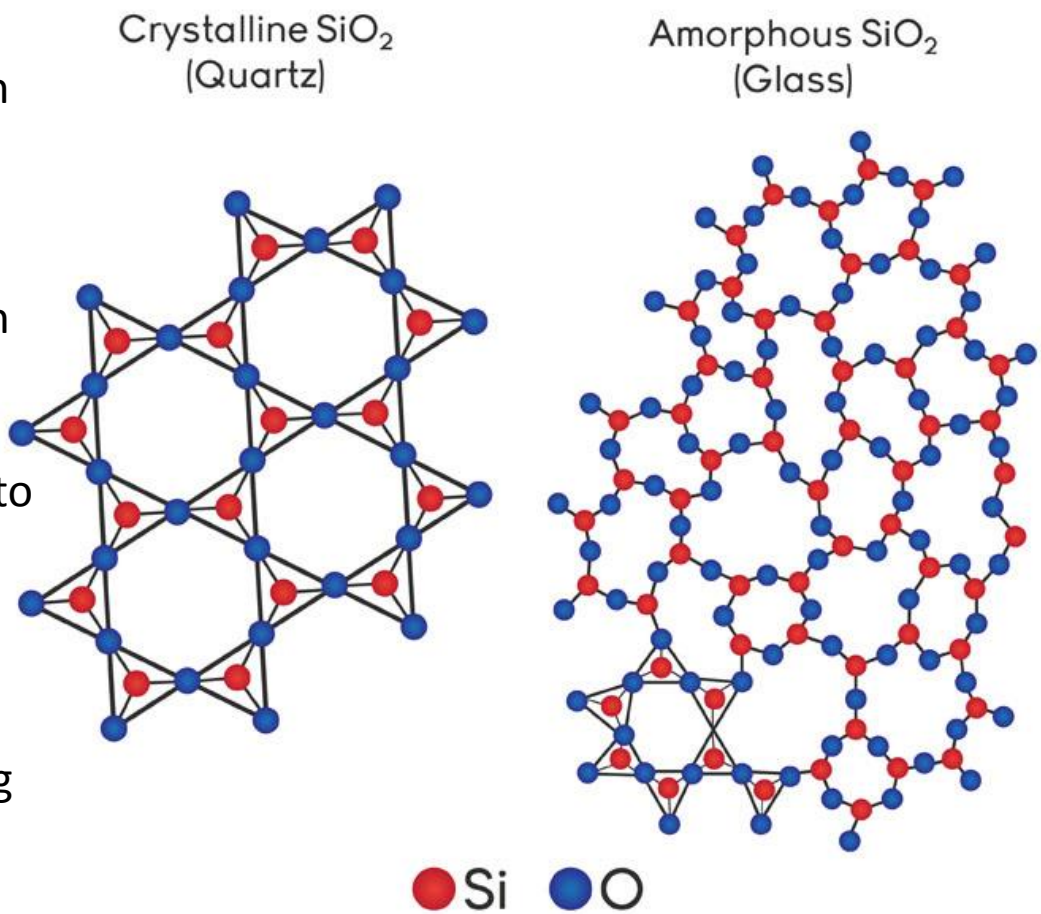


CRIME SCENE DO NOT CROSS

c. The primary ingredient of glass is Silicon dioxide (**SiO_2**), or **silica**.



Fused quartz or fused silica is glass consisting of silica in amorphous (non-crystalline) form. It differs from traditional glasses in containing no other ingredients, which are typically added to glass to lower the melt temperature. Fused silica, therefore, has high working and melting temperatures.



TYPES OF GLASS

i. Soda-lime glass

1. Called such because it contains sodium compounds and **Calcium** Oxide (CaO), also known as lime.
2. Most **common**. Inexpensive and easy to melt and shape. Relatively strong.
   - The most prevalent type of glass
   - Used for windowpanes, and glass containers (bottles and jars) for beverages, food, and some commodity items

ii. Crystal or leaded glass

1. Calcium oxide of other glasses is **replaced** with lead oxide (PbO).
2. This glass is **denser**, which causes it to **sparkle** as light passes through.

iii. Pyrex

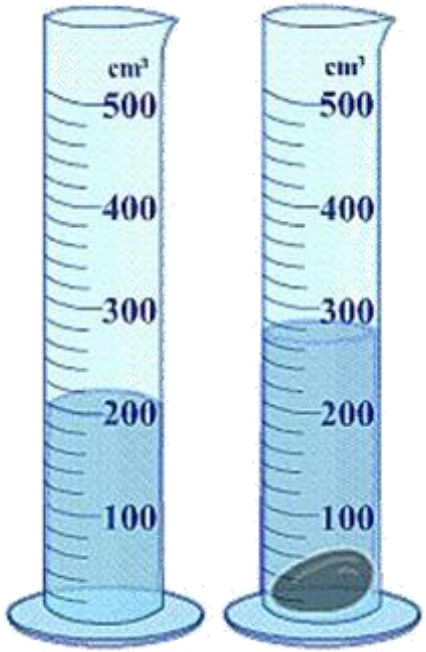
1. Used in **ovenware** and laboratory glassware; able to withstand a wide range of **temperatures**.

A kitchen staple for more than 90 years, Pyrex® glass bakeware can handle almost every job in the kitchen and is versatile enough to use in the refrigerator, freezer, oven, microwave, dishwasher and on the table.

PROPERTIES OF GLASS

i. Because glass is made of a variety of compounds, it is possible to distinguish one type of glass from another by examining its unique **physical** properties:

1. **Density**
   a. Each type of glass has a density specific to that glass.
   b. To find the density of glass, **divide** the mass (**g**) by the volume (**mL**).
      i. Mass can be determines by using a **balance**.
      ii. Volume can be determined by using water **displacement** in a graduated cylinder.



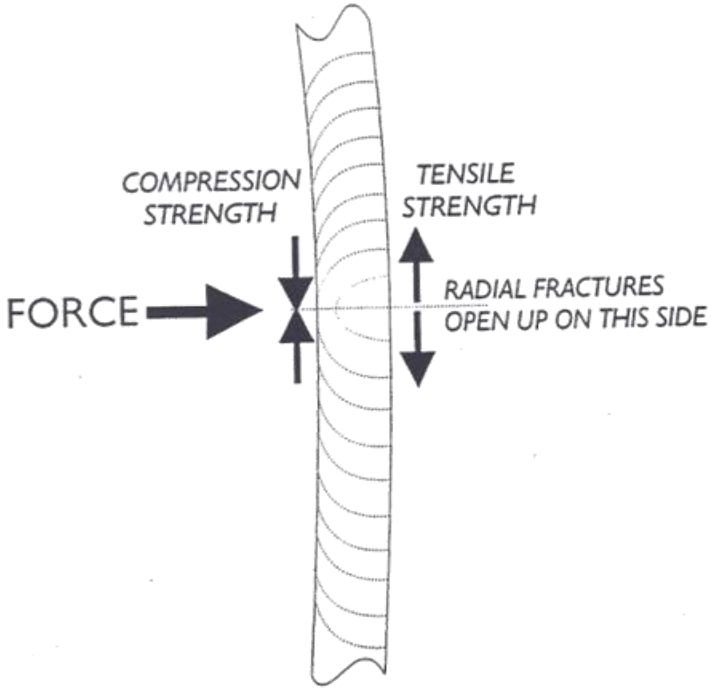
CRIME SCENE DO NOT CROSS

2. Refractive Index
   a. Refraction is the **bending** of light. It causes a change in the direction of light as it changes speeds when moving from one **medium** into another.
   b. A refractive index measures how light bends as it passes from one substance and into another.

3. Glass is also cut to have different thicknesses based on its function.
   a. **Doors**, windows, **picture** frames, etc. will all have unique measurements.

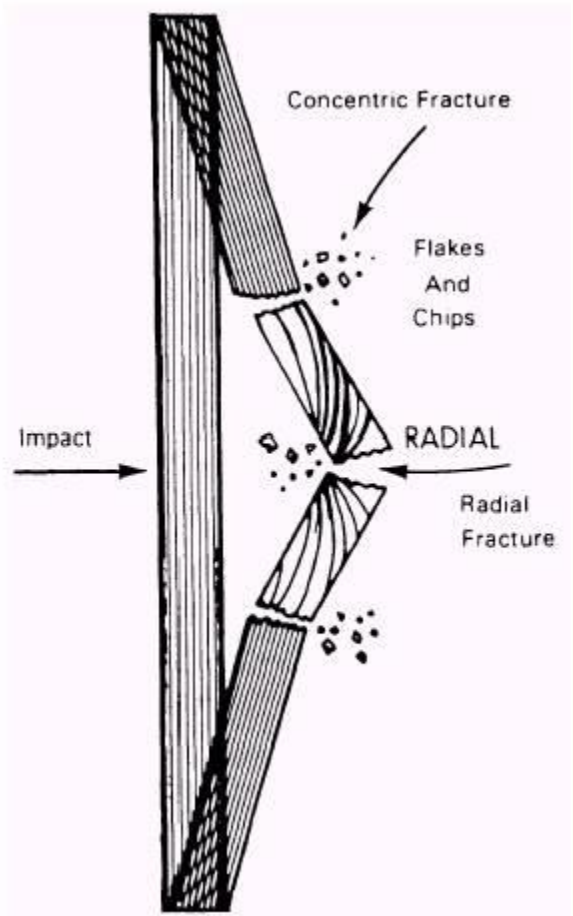
4. Glass can be made a variety of colors depending what metal oxides are added to it.
   a. Cobalt- **blue**
   b. Selenium- **red**
   c. Nickel- can range from **yellow** to purple

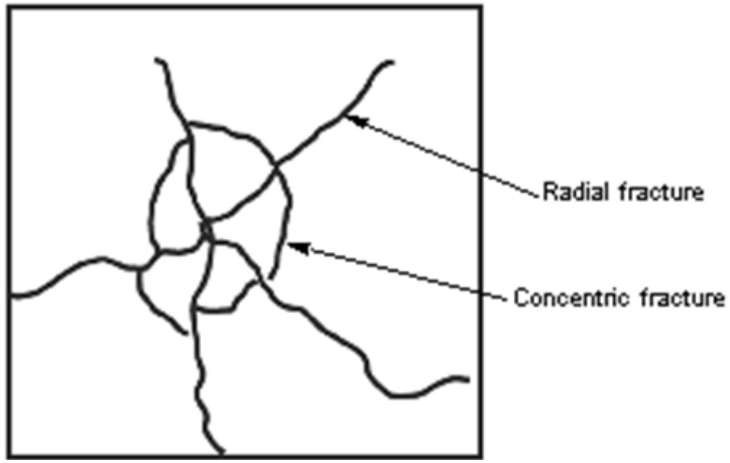
5. Fracture Patterns
   a. Fracture patterns on broken glass can provide clues about the **direction** and rate of impact.
      i. Glass has some **flexibility** and is able to stretch a tiny bit. When it cannot stretch far enough, it cracks, and may break.



1. The side where the **impact** takes place, the glass surface is compressed, or squeezed together.
2. The other side of the glass, the side away from the impact, stretches and is under tension, and develops **fractures**.

a. **Radial** Fractures
   i. Form first; **radiate out** from the point of impact.
b. **Concentric** Fractures
   i. Form second; **circle** around the point of impact.
   ii. Objects at higher speeds cause **fewer** concentric fractures than objects at lower speeds.
c. By studying fractures, an investigator can tell which **side** of the glass was hit.

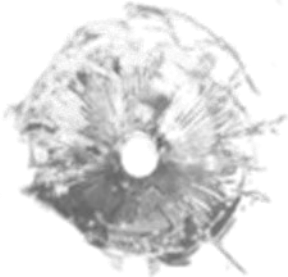




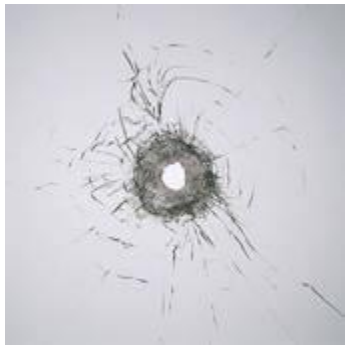
CRIME SCENE DO NOT CROSS

d. High temperatures, such as **fire**, also cause glass to fracture. Fractures caused by heat have unique **wavy** patterns. The glass also breaks **towards** the heat, rather than away from.

BULLET HOLES



1. As a bullet passes through glass, it **pushes** some glass ahead of it, causing a **cone**-shaped piece of glass to exit along with the bullet. This cone also makes the exit hole **larger** than the entrance hole of the bullet.
2. The shape of the bullet hole can also help figure out the position of the shooter.
   a. **Round** bullet holes signify the shooter was perpendicular to the glass.
   b. **Oval** patterns will be irregular depending on if the shooter was to the left or right.



CRIME SCENE DO NOT CROSS

GLASS AS EVIDENCE

i. Photograph and try to **identify** glass evidence before moving it.
ii. All glass should be collected because more than one type may be present and **physical matches** might be made.
iii. Identify and mark the **inside** and outside surfaces of the glass.
iv. Place small glass fragments in paper bindles, then in coin envelopes, pill boxes, or film canisters.
v. Place large glass fragments in boxes. Separate individual pieces with **cotton** or tissue to prevent breakage and damaged edges during shipment.