# The Mystery of Lyle and Louise: Bad Impression
A Lab on Bite Marks Analysis

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WELCOME to Bad Impression, a Bite Marks Analysis lab in the Mystery of Lyle and Louise. A brutal murder case is unfolding in a small Appalachian town. Already the case spans two crime scenes and five people are dead. When John Wayne Gretzky, a business associate of the victims, was brought in for questioning, investigators noticed a bite mark on his upper arm. Gretzky claimed he received it during a bar fight the previous night.

In this lab, students will take wax impressions of their own teeth, examine them, and develop characters that describe the shape of their dental arch. Then, students will compare impressions from their classmates against a photograph of the bite mark on John Gretzky’s arm. After developing quantifiable characters that describe the impressions of their classmates, they will apply these same characters to the photograph. Afterwards, using multivariate analysis with the help of a spreadsheet program, students will determine if any of the impressions are a possible match to the mark in the photograph.

Once the lab results have been analyzed, students may host a mock trial to hold a chosen suspect accountable for their actions.

Teacher’s notes can be found at the beginning of the manual and copies may be freely made of all materials for your students.
Forensic odontology, also called forensic dentistry, is a unique field that combines the skills of a specially trained dentist with those of law enforcement. Unlike filling cavities and root canals, the forensic dentist's primary duty is human identification. Forensic odontologists are responsible for examining evidence from cases involving violent crime, child abuse, elder abuse, missing persons and mass disaster scenarios. The end result of these analyses is the identifying of victims or suspects and the establishing of investigative leads for law enforcement personnel. A perpetrator of a crime often leaves evidence at a scene. Bitten food or chewed objects, such as gum, may be recovered by scene investigators and examined by a forensic dentist. Autopsy investigations can reveal bite marks on the skin of a person who has died. The forensic odontologist can compare the bite marks with replicas of a suspect's teeth. Cases with these types of evidence require expert analysis by a forensic dentist.

Forensic dentistry have been practiced for over 200 years in the United States. The first recorded case using identification by forensic dentistry occurred following the Battle of Bunker Hill in 1775. An American officer, Dr. Joseph Warren, was killed and buried in an unmarked grave by British forces. Wanting to give him a proper burial, Warren's family enlisted the help of Paul Revere, a silversmith, part-time denture-maker, and patriot, to help identify the body. Revere was able to identify Warren's body based on a partial denture he constructed for the man.

It seems rather unsophisticated that the mere recognition of a partial denture would be considered forensic dentistry. However, dental evidence includes anything relating to human dental anatomy or derived from the oral environment. Tooth shapes, metal restorations, skull and jawbone irregularities or even skull fragments may possess features that can be associated with a single person. The hardy nature of teeth under catastrophic conditions makes forensic dentists essential in identification, since teeth are often all that remain.

Although the forensic dentistry crosses into many aspects of criminal investigation, the majority of the dentist's case load are two types of case: 1) missing and unidentified persons and 2) recognition, documentation, and preservation of bite mark evidence. Dental evidence becomes important for human identification cases when fingerprints or personal effects can not be obtained from skeletonized remains. Bite mark evidence is important when attempting to identify the perpetrator of a violent crime or place a suspect at a scene.

Teeth marks can be found in soft objects such as gum, food, and on human skin. The former are usually left at crime scenes, while the latter may be found on the bodies of victims, living or deceased, or even on a suspect. The most famous bite mark case of the 20th century involved the serial murderer Theodore "Ted" Bundy. The case involved a double homicide that occurred in 1978. The dental evidence was a human bite mark injury on the body of one of the murder victims. Although the dental evidence was not the only critical evidence in the trial, the jury attested that the bite mark evidence was very compelling in their decision to convict Bundy of murder.

Both victims and suspects may bite during the course of a violent assault. The patterns produced by teeth in any biting incident must be photographed and sometimes even impressed for three-dimensional modeling. The analysis of a bite pattern's possible link to a particular "biter" depends on accurate and reliable collection of the evidence. This includes immediate documentation as soon as these marks are noticed; especially when the individual exhibiting the mark is still alive, since natural healing will soon eliminate the bruises and cuts that are evidence.

Bite mark analysis attempts to connect a biter to the unique pattern left behind on a person or object, which is linked in some way to a crime. This is based on two assumptions: 1) the characteristics of the teeth involved in biting are unique in all individuals and 2) this supposed uniqueness is trans-
ferred and recorded in the injury. The ability of skin to register sufficient detail of a biter’s teeth is also highly variable. Many bite marks are not well-defined or are distorted due to the physical properties of skin itself. Therefore, while bite mark evidence may be useful in including or excluding possible suspects, it is difficult to identify a single individual as the biter in such skin injuries. Bite marks found in other more pliable materials such as cheese, gum, and softer substances have more potential for identification.

In order to make a comparison between individuals suspected of leaving bite impressions on a particular piece of evidence, the crime scene investigator or medical examiner must recognize that a wound is a bite mark. Because of the large degree of variability in teeth, bite marks are difficult to generalize. However, the typical bite mark is a circular or oval injury consisting of two opposing, symmetrical, U-shaped arches separated at their bases by open spaces. Along the margin of the arches are a series of round, almost circular, bruises. These bruises can be used to identify the size, shape, arrangement, and distribution of the contacting surfaces of the teeth. A series of small bruises or cuts, arranged in a semicircle may also be observed. Full bite patterns are often not present on a single piece of evidence; many times only the upper or lower teeth marks are left. Often this lack of a complete set of marks is due to some interfering object. For example, part of the bitten area could have been covered by a shirt sleeve which may have protected the skin in that area. Then only the area not covered by the sleeve may have a clear bite mark.

Because human teeth are arranged in predictable patterns, forensic dentists rely on the variations that occur in tooth size, shape, and position between individuals to provide the uniqueness required for a forensic comparison. Teeth change through a person’s lifetime through chewing food, and secondary use as tools. These changes are based on personal activity, health, and dental treatment. These activities can result in creation of a unique dental profile for an individual. Once a bite mark has been identi-

fied, the dentist must evaluate it for this “uniqueness” in preparation for a comparison to a typical example.

**Evaluation of a bite mark**

A human bite mark may have a variety of characteristics and show considerable variation due to incomplete teeth marks and the surface on which the bite is imprinted. Upper and lower teeth may not be equally represented. Bite features may be distorted due to victim movement or the jaw movement of the biter. Bite marks of high value as evidence exhibit markings from a significant number of teeth. The essential step in bite mark analysis is the determination of which teeth made specific marks. This identification is made using the following set of criteria:

- Front teeth are seen as the primary biting teeth in bite marks. There are six upper front teeth and six lower front teeth (the central and lateral incisors and the cuspids).
- The upper jaw (maxilla) is wider than the lower jaw (mandible).
- A bite mark showing the upper and lower front teeth will show a total of twelve teeth marking the skin.

Following these observations, the next step is the determination of which marks were made from upper and from lower teeth. The upper four front teeth make rectangular marks. The central incisors are significantly wider than the lateral incisors. Both the upper and lower cuspids tend to leave round or oval-shaped marks. The lower four front teeth make rectangular marks that are all similar in width.

Equally as telling as marks are portions of a bite imprint that are empty or missing an impression. Areas between known biting teeth that show significantly fainter bruising are attributed to teeth that did not impact the skin due to some feature present on the tooth. The likely reason for this is that the edge of the tooth has suffered some dam-
age like chipping or that the tooth is simply shorter
than the two neighboring teeth. Gaps may be seen
between marks and can have several explanations:

- The suspect may have no tooth present.
- One tooth is shorter due to its normal shape or
  some previous damaging event.
- An object, such as clothing, interfered with the
tooth contacting the skin.
- The skin moved during the act of biting.
- There was variation in the biting mechanism
  itself.

In addition to these bite mark pattern observations,
the physical parameters of the injury are also mea-
sured. Distances between teeth marks that are ad-

dacent or opposite one another in a bite mark are
compared to a suspect’s dental features at the cor-
responding positions.

Once all the available bite mark evidence has been
documented, a forensic odontologist is usually
asked to compare the bite mark from the crime to
that of a suspect identified by the case’s investi-
gators. A dentist can examine the suspect’s teeth
and make a dental impression to produce life-size
models of their teeth and dental arch. A dental
stone mixture is poured into the impressions,
which hardens and duplicates the dentition. Spe-
cial notes are made of unusual characters such as
chipped, worn, or missing teeth. Each of these fac-
dors can have an effect on the injury pattern caused
by a bite. The dental stone models of the suspect
are compared to the photographs of the bite mark.
These photographs are typically scaled to a 1:1 ra-
tio so that transparent overlays of dentition can be
used during the comparison. However, if only mea-
surements are being used and the photograph has a
ruler or other fixed distance in the image, a simple
ratio can be used later to correct measurements
with different scales.

The first character considered is the general arch
size and shape. If there is a major discrepancy be-
tween these, the suspect can be eliminated with no
additional analysis. If the arch does not exclude
the suspect, the stone models are oriented in the
direction corresponding to the position of the bite
mark. Allowances are made for varying amounts of
pressure applied to the surface of the skin during
the attack. Prominent features of the dentition are
inspected first for agreement or concordance with
the bite mark. Secondary features must also match,
or a reasonable explanation must be offered for the
discrepancy. Wax bite impressions can be used to
capture just the biting edges of a suspect’s teeth
and are also useful for comparison purposes. Dig-
tal imaging techniques can also be used to correct
the distortion often seen in bite marks and allow
for a more accurate comparison.

Drawing Conclusions

Bite mark analysis uses characters such as tooth
size and shape, chips and fractures, jaw shape,
tooth alignment, missing teeth, and the dimensions
of the dentition to identify one person from anoth-
er. The weight given to these features in establish-
ing a positive match is a forensic dentist’s opinion,
since there are no databases of these unique char-
acters. Therefore, a forensic dentist will usually
state an opinion like: “Teeth like the suspect’s could
have made the bite mark.” The dentist must then
explain to the jury or investigators what is unique
about the suspect’s teeth that in turn links him or
her to the bite mark, and thus the bite. Bite mark
evidence is subjective and is only one of many
investigative tools at the disposal of a crime scene in-
vestigator.

Although the forensic dentist is an expert, the fo-
rensic importance of a bite mark is an educated
opinion. There are no guarantees the same bite
mark evidence would be interpreted in the same
way by two or more forensic odontologists. Spe-
cialized expertise is necessary to understand both
the strengths and limitations of bite mark analysis.
Extensive training in forensic dentistry, certifica-
tion by the American Board of Forensic Odontology
(ABFO), and membership in the American Academy
of Forensic Sciences (AAFS) are just a few of the

The Mystery of Lyle and Louise
Forensic Odontology

steps a well-qualified forensic dentist will take in order to build the credibility necessary to be recognized as an expert in the field of forensic dentistry.

ADDITIONAL READING


NINE days ago, during the night of a sudden summer thunderstorm, the Mondelo family car went over the side of Backbone Mountain and caught fire on impact. Three bodies were found in the wreckage; an adult woman, a teenage male, and a female child. All were burned beyond recognition. The three victims were identified as Louise Mondelo and her children Wally and Jan by personal effects that survived the fire.

Pictures of the scene were recorded, but, due to the rainstorm, the crash was initially believed to be simply a tragic accident and was not treated as a crime scene. When Lyle Mondelo could not be reached and was found to be missing, he became a possible suspect, and the wreckage was thoroughly processed. The scene was substantially disturbed and some evidence was undoubtedly lost, however, upon retracing the path of the vehicle, investigators found several pieces of broken glass lying in the roadway. Becoming increasingly more suspicious of foul-play, these broken glass fragments were packaged and retained. In addition, investigators cut and removed a section of charred carpet from the vehicle for further laboratory analysis. The bodies, as part of an ongoing criminal investigation, were kept in the county morgue.

The small town of Highland Park was shocked, since nothing this terrible had ever happened in the area. Tips from neighbors and friends poured into the police department, but none of the tips were eyewitness accounts or provided specific information regarding the car accident. Lyle was the likely suspect but was nowhere to be found. An all-points bulletin was issued for everyone to be on the lookout for Lyle Mondelo. He was presumed armed and dangerous and to be driving a missing, blue, 1993 Ford Ranger with Tumbling Water Land Development Co. logos. Four days ago, Lyle Mondelo's credit card was used to purchase gasoline and food at a gas station in Texas.

The Mystery of Lyle and Louise
The Investigation

When contacted, business associate John Wayne Gretzky told investigators that Lyle had been slipping into a deep depression because of trouble at their jointly owned business, Tumbling Water Land Development Company. Gretzky also hinted that there had been problems in the Mondelo family. At this time, investigators noticed that John had a large bite mark on his upper arm. When asked about the wound, Gretzky claimed to have been bit during a bar fight the night before and allowed the bite to be photographed. He was not held or charged with any crime.

Background Investigation

With no additional leads, police launched a full investigation into the Mondelos. Louise Wilson and Lyle Mondelo had met at college while receiving Business Degrees in Management. They married in college and moved to Highland Park, Louise’s hometown, after graduation. The town was still ailing at the time, suffering from the shut down of the mines a little over a decade ago. Although at first Lyle thought their business prospects in the small town were poor, he soon discovered that money could be made developing land for the private lodges and ski resorts that employed most of the residents.

After returning to Highland Park, Louise ran into her old High School sweet heart, John Wayne Gretzky. While talking to him, Louise learned that he was also a developer. Glad to see an old friend, and thinking that a favorable business relationship could develop, Louise asked John to meet with her and Lyle over dinner. Lyle and John soon became friends, and rather than compete for business against each other, the three decided to join together and start Tumbling Water Land Development Company.

A year after Tumbling Water was founded, Louise conceived her first child, Wally. Friends of the Mondelos said that Lyle suspected Louise and John of having an affair at the time, and the two nearly divorced. The couple, however, worked out their relationship with the help of a marriage counselor.

Tumbling Water became prosperous and was able to buy several hundred acres of land adjacent to Blackrock River, a prime recreational waterway. Soon thereafter, Louise had another child, Jan, and took leave from the office to work from home while she raised the two children. Friends say that Louise never really went back to Tumbling Water, even after the children were older and in school. Their friends also suggested that Lyle and Louise’s relationship was healthier with them not working together.

Tumbling Waters’ lawyer told investigators that she began preparing bankruptcy papers for the company about a year ago; the ski resort was dragging out negotiations for a property purchase, and the company’s other business deals weren’t making enough profit to keep the business afloat. Soon after being asked to begin the bankruptcy filing, though, she said an unexpected deal was made to build a number of fishing cabins on the Blackrock River land. That was enough to keep the business going, and after that, Tumbling Water began making deals at a steady rate.

A potentially related case recently touched on the Mondelos’ lives. Three weeks ago, a crystal methamphetamine lab was discovered in an abandoned camper on Tumbling Water land. Louise’s nephew, Mitch Wilson, and John Wayne’s brother, Larry Gretzky, were found in the lab and indicted for possession with intent to sell the 6 kilograms of meth found in the lab. Two days later they were both released on bond, posted by Lyle Mondelo and John Gretzky. Mitch and Larry gave no names of possible suppliers or dealers.

Two weeks before the crash, Louise Mondelo filed for divorce. Friends say she told them that she suspected Lyle of being involved with drugs, but that the friends believed she was involved with John Wayne Gretzky again. Two days later after filing for divorce, Louise requested a peace bond against Lyle, stating that Lyle had harassed her and the children. Louise also told police that she was afraid that Lyle might try to take the children away.
The Investigation

When attempting to contact Mitch Wilson and Larry Gretzky for questioning about the car accident, police discovered that they had both skipped town along with Larry’s girlfriend Mary Bradey. Authorities believed that their disappearance could be related to the accident, and they were described as possibly armed and dangerous in the warrant posted for their arrest.

Two days ago, an abandoned blue Ford Ranger with out-of-state plates was found on a strip of New Mexico highway. The pickup was dirty, dusty, and a headlight was broken, but investigators noticed a Tumbling Water Land Development Co. sign on the back tailgate. Forced entry was apparent. Upon access to the truck, investigators discovered several pieces of trace evidence and sent it to Highland Park for analysis.

At the Scene

The forest gets thicker and buildings less frequent the farther you drive along old Route 52. You see the sign for Tumbling Water Land Development Company and make the turn onto the gravel road cutting into the forest. Before long you see the other police vehicles, and Detective Murray is motioning you over to the side of the road. A small cabin, now surrounded by police tape, is sheltered by trees here, and you see several other similar cabins further down the road. You hear the Blackrock River roaring not too far off behind the cabin.

As you and your partner get out of the car, the hot July sun hits you. Detective Murray comes up, sweating in the heat. “Hey folks,
Investigators discovered a bite mark on John Wayne Gretzky's forearm when he was brought into questioning the day the car accident was discovered. John Gretzky claims he received the mark during a bar fight the previous night.

Investigators collected wax impressions from regular patrons of the bar to compare against the impression on John Gretzky's arm.

Finally, investigators, with the assistance of morgue workers, took a wax bite impression of the adult car crash victim for comparison.
The Mondelos

Louise Ann Mondelo is the 42 year old mother and wife of the Mondelo family. She is also one of the owners of Tumbling Water Land Development Company. Friends say that Louise was in an unhappy marriage and had recently filed for divorce.

Lyle Christopher Mondelo is the 44 year old husband and father of the Mondelo family. He is a part owner of Tumbling Water Land Development Company along with his wife.

John Gretzky

John Wayne Gretzky is 43 years old. He is a friend and business partner of the Mondelo’s in the Tumbling Water Land Development Company. Rumors have it that John Wayne and Louise had a brief affair when Lyle and Louise first moved to Highland Park. He is known around town to be a greedy businessman, and has been suspected of shady deals in the past.
Adult Teeth Diagram

**Upper Teeth**
- Central Incisor
- Lateral Incisor
- Canine (Cuspid)
- First Premolar (First Bicuspid)
- Second Premolar (Second Bicuspid)
- First Molar
- Second Molar
- Third Molar (Wisdom Tooth)

**Erupt**
- 7-8 yrs
- 8-9 yrs
- 11-12 yrs
- 10-11 yrs
- 10-12 yrs
- 6-7 yrs
- 12-13 yrs
- 17-21 yrs

**Lower Teeth**
- Third Molar (Wisdom Tooth)
- Second Molar
- First Molar
- Second Premolar (Second Bicuspid)
- First Premolar (First Bicuspid)
- Canine (Cuspid)
- Lateral Incisor
- Central Incisor

17-21 yrs
12-13 yrs
6-7 yrs
10-12 yrs
10-11 yrs
11-12 yrs
8-9 yrs
7-8 yrs

Diagram courtesy of Forensic Dentistry Online.
Background

1. What makes teeth good for victim identification?

2. How should a bite mark on a person be documented?

3. When evaluating a bite mark, what should be the first thing determined?

4. When comparing bite marks, what are three points of comparison mentioned in the text?

5. Why might multiple forensic odontologists have different opinions on the same bite mark evidence?

Procedure

6. How many wax impressions should each person make?

7. How will you determine the orientation of the bite mark in the photo?

8. What mathematical trait makes a character good for separating samples?
Choosing Characters

When attempting to match bite marks with a suspect mark, it is important that the characters measured are able to separate different samples. If samples are well separated, it is immediately obvious which sample matches.

Some characters will not vary significantly but will cluster around one or sometimes two values. Figure 1 shows measurements of a character with little variation; the suspect mark is plotted as a star. Two of the samples are outliers and can be easily removed from consideration. However, even though the suspect mark is on the edge of the cluster and one sample mark is very similar, all nearby samples should be included for further analysis because of possible measurement errors.

Characters that have significant variance across the population sampled will separate samples better. Figure 2 shows such a character. Notice how at least five samples can be readily removed from consideration. Both characters can be approximated by a bell curve, and in the figures, both have means of 5.0, however, the variance is higher in two, resulting in a flatter hump and a more even distribution. In both figures arrows point to the sample that is closest to the suspect mark.

When characters combine, their separating power increases. Figure 3 shows measurements from the two characters plotted on different axes. Notice how some samples, which were part of the clump near the center in one or the other characters alone, are now separated from the center by the inclusion of the other character. Also notice that the two suspects that were closest to the suspect mark when looking at only one character alone are now removed from the suspect mark.

Because of measurement error and distortion caused by biting pliable materials such as flesh, the closest sample is not necessarily a match – indeed none of the samples may be a match. However, those samples within some predefined error tolerance should be included as possible matches. In Figure 3 this error tolerance is shown as the shaded ellipse around the suspect mark. In this case, the size of the tolerance is equal to five percent of three standard deviations around the mean of each character. It is an ellipse because the standard deviation is a measure of variance in the sample, which is different for each character. The spreadsheet provided is designed to help you calculate this error range.

Figure 1. Character with low variance

Figure 2. Character with high variance.

Figure 3. Both characters combined, further separating samples.
Lab Procedure

Bite Mark Impressions

1. Use gloves or place wax impressions in plastic bags to protect from transferring saliva from one student to another.
2. Fold a piece of the pink baseplate wax in half so that it forms a square.
3. Insert the end with the fold into your mouth, so that all of your teeth will make an impression when you bite down.
4. Bite the wax slowly and cleanly. Take care to bite hard enough to leave an impression with your teeth, but not hard enough to bite through the wax.
5. Remove the wax from your mouth.
6. Using one of the stickers included with the kit, label the side with the impression of your upper teeth, the side that was facing up when you bit, with a ‘T’ in the upper right corner.
7. Flip the wax over, and label the upper right corner with a ‘B’ with a sticker.
8. Repeat steps 1 through 6 with another piece of wax to make an additional impression.
9. Complete the worksheet, Bite Impression Characterization.
10. Enter your impressions into evidence by taking them to your instructor who will assign you a number. Using the stickers provided, number your wax impressions.
11. Record your name in the suspects sheet beside the number given to you by your instructor.

Measuring Bite Pattern Characters

The comparison and matching of bite marks is not an exact science. Since no bite pattern database exists, no statistical information can be determined. Although recommendations exist, each forensic odontologist will weigh characteristics of a bite mark differently, and may reach different conclusions as to whether two impressions match.

1. Identify quantifiable bite pattern characters that describe the shape, size, and arrangement of a bite impression. Measures may include the distance between teeth, the distance between a tooth and a baseline, or the angle an incisor makes to a baseline.
2. Adequately describe each character on the Data Collection sheet.
3. For each impression, measure and record each character.

Multivariate Analysis

1. Enter your data into the Spreadsheet template provided by your instructor.
2. The template will calculate a term representing the percent difference each wax impression was from the photographed impression using the values of the characters you input. Record on your data collection sheet which impression has the smallest difference.
3. Compare the impression with the smallest difference with the photograph.
Compare the impression of your teeth with the diagram. Place the appropriate mark over teeth that exhibit the following characters:

- X Tooth is missing from your impression (but not necessarily from your mouth).
- \ Tooth has only a faint impression.
- \_ Draw an arrow from a tooth pointing in the direction of a misalignment.

Wisdom teeth are often missing, either because they have not yet erupted, or because they have been surgically removed. Front teeth are commonly chipped or misaligned.

Take measurements on your wax impression of the distances between specific teeth in your upper dental arch.

A. 2nd Left Molar to 2nd Right Molar: 

B. 2nd Left Molar to 1st Right Premolar: 

C. 2nd Left Molar to Central Right Incisor: 

D. Right Cuspid to Left Cuspid: 

Now find similar measurements that characterize the size and shape of the lower dental arch. Draw them on the diagram, and take those measurements on your wax impression.

A. 

B. 

C. 

D.
Data Collection and Calculations

Character Descriptions:

A.
B.
C.
D.
E.
F.

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<tr>
<td>Impression Number</td>
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<td>Crash Victim</td>
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<td>Photo</td>
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Post-Lab Questions

Short Answer

1. Did one of the bite mark samples match the mark on John Wayne's Arm? If so, which one?

2. Was John Wayne lying about the bite? Explain how you know this.

3. Which of your characters had the largest variance?

4. Which character was the most useful for separating samples from the suspect mark? Why?

5. Which character was the least useful? Why was it not useful?

6. Did the most useful characters have high variance? If not, explain what caused it to be useful.

7. What class of character is more useful for finding a match than those with high variance?