Bad Impression
A Lab on Bite Marks Analysis

The Mystery of Lyle and Louise
# National Science Education Standards:

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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 two of the victims, was brought in for questioning, investigators noticed a bite mark upon his upper arm. Gretzky claimed he received the mark in 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. Students will then compare impressions made by 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 characters to the photograph and, using multivariate analysis with the help of a spreadsheet program, students will determine if any of the impressions are a possible match to a photograph of the suspicious bite mark.

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.
Teacher’s Notes

These notes are provided to assist in the preparation and execution of the laboratory experiment. A solutions key for the pre- and post-lab questions can be found on pages 9 and 10, respectively.

Supplies

- Base Plate Wax (1 box, 60 pieces)
- Base Plate Wax labels
- Bite Mark Photos (6)
- Matching Bite Impressions (6)
- Bite Impression from Victim (6)
- Protractors (6)

Running the Lab

This lab is designed to take two lab sessions. In the first session, students will create impressions of their bite, identify irregularities, measure given characters, and develop rudimentary characters to measure on their own impression.

During the main section of the lab students will each make two impressions and will place them into ‘evidence’. At this point, you will need to follow the steps below to facilitate the scenario.

1. Assign each student a number to place on their impressions.

2. At this stage, look for students who did not follow the lab procedure correctly and created impressions that are different from all others — for example, the impression may be made on a corner or side, or may be improperly labeled. Either have students remake these impressions, or assign them numbers but then set them aside for your own use later.

3. After class, remove from evidence the bite impressions made by students who failed to follow directions correctly or produced different looking impressions.

4. Label the bite impressions that match the bite mark in the photograph (included with the kit) with their number. Alternatively you could simply add the impressions that came with the kit to evidence, but observant students will realize that there are more impressions than students and will deduce that one must match.

5. In the next lab session, pass out the impressions such that each lab group receives twice the number of impressions as members of that group (possible because each student submitted two impressions). Be certain that no lab group gets two copies of the same impression, or their own impressions. If impressions were removed you will have just enough, but the exact number is not critical.

6. Tell your students that these impressions are from patrons of the bar where John Gretzky claims to have been bitten. In addition, give each lab group an impression from the car crash victim (included with the kit) to determine if she was the biter.

Do not give students the photograph immediately as students will often look for common features between the photo and the impressions and come to a visual, subjective conclusion instead of a well-measured objective one. Instead, have them first develop characters to separate all of the samples collected from the bar patrons. Additionally, encouraging students to choose continuous features over categorical ones will make separation of characters via multivariate analysis easier.

Multivariate Analysis

This lab contains a section on Multivariate Analysis. To aid you with these calculations a Microsoft Excel spreadsheet is available for download at www.LyleAndLouise.com.

Modules > Bad Impression > Bite Mark Analysis Spreadsheet

This spreadsheet will calculate the percent difference of each of the samples from the photo. Smaller values indicate a closer match. To be legally useful, values should be under 5%.
Teaching Timeline

Groundwork

Before conducting this laboratory exercise, the details of The Investigation should be shared with the class to provide the context of the crime. Covering this material once should be sufficient for all laboratory modules.

Day 1:

- Cover material in Forensic Odontology.
- Distribute lab procedures.
- Assign pre-lab questions as homework.

Day 2:

- Discuss characters used in forensic odontology.
- Discuss the statistical concept of variance with students in broad terms. Discuss what types of characters are good for separating groups using the worksheet Choosing Characters.
- Review pre-lab questions.
- Instruct students to follow Part One of the lab procedure (Take their own dental impression, identify distinguishing characters, and measure those characters on their impression).
- Collect student’s dental impressions using the evidence collection sheet.

Day 2, after class:

- Sort students’ dental impressions. Remove improper impressions and replace them with those included with the kit.

Day 3:

- Distribute bite impressions to students. Instruct students to follow Part Two of the lab procedure in which they identify and measure characters on the bite impressions.
- Instruct students to enter their data into the spreadsheet provided. This will score each of the impressions measured against the bite mark in the photograph using the characters determined by students.
- Instruct students to share which characters had the most separating power, or highest variance. Allow students to discuss various theories as to why these characters are useful.
Pre-Lab Solutions

Background

1. What makes teeth good for victim identification?
   Teeth are very durable and, therefore, capable of withstanding conditions that destroy other body tissues, and are unique to each person.

2. How should a bite mark on a person be documented?
   The bite mark should be photographed and a cast taken of the impression.

3. When evaluating a bite mark, what should be the first thing determined?
   Which teeth made the specific marks.

4. When comparing bite marks, what are three points of comparison mentioned in the text?
   Arch size and shape, unusual features (chips, wear, missing teeth), and tooth size, shape, and alignment.

5. Why might multiple forensic odontologists have different opinions on the same bite mark evidence?
   There is not a single set of objective criteria that all forensic odontologists follow.

Procedure

6. How many wax impressions should each person make?
   Two

7. How will you determine the orientation of the bite mark in the photo?
   Front upper teeth form larger rectangles than teeth from the lower jaw, which are smaller and closer together.

8. What mathematical trait makes a character good for separating samples?
   The amount of variability in the character. Alternately: variance, standard deviation.
Post-Lab Solutions

1. Did one of the bite mark samples match the mark on John Wayne’s Arm? If so, which one?
   Answer will vary dependent on which bite impression, if any, was substituted with the impression provided.

2. Was John Wayne lying about the bite? Explain how you know this.
   Answer depends as above.

3. Which of your characters had the largest variance?
   Answer will vary with the characters chosen.

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

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

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

7. What class of character is more useful for finding a match than those with high variance?
   Those characters are identified as unique to a suspect mark and, thus, separate only samples like the suspect mark from all others which are clustered.
Forensic odontology, also called forensic dentistry, is a unique field that combines the skills of a specially trained dentist with those of law enforcement. 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. A perpetrator of a crime often leaves evidence at a scene. Bitten food or chewed objects may be recovered by scene investigators and examined by a forensic dentist. Should autopsy investigations reveal bite marks on the skin of a victim, the forensic odontologist can compare the bite marks with replicas of a suspect's teeth.

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

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 remains in these cases.

Although 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
2. recognition, documentation, and preservation of bite mark evidence

Dental evidence becomes important for human identification cases when fingerprints or personal effects cannot be obtained from skeletonized remains. Bite mark evidence is also 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. In this 1978 double homicide a human bite mark injury was discovered 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, as 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: that the characteristics of the teeth involved in biting are unique in all individuals and that this supposed uniqueness is transferred 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
Forensic Odontology

may be useful in including or excluding possible suspects, it is difficult to identify a single individual as the biter in such skin injuries.

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, protecting the skin in that area. Thus, 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 identified, 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, and 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 damage, 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-

djacent 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 investiga-
tors. A dentist can examine the suspect’s teeth and
make a dental impression to produce life-size mod-
els of their teeth and dental arch. A dental stone
mixture is poured into the impressions, hardens,
and duplicates the dentition. Special notes are
made of unusual characters, such as chipped, worn,
or missing teeth. Each of these factors can have an
effect on the injury pattern caused by a bite. The
dental stone models of the suspect are then com-
pared to the photographs of the bite mark. These
photographs are typically scaled to a 1:1 ratio so
that transparent overlays of dentition can be used
during the comparison, however, if only measure-
ments are being used and the photograph has a rul-
er or other fixed distance in the image, a simple ra-
tio can be used later to correct measurements with
different scales.

The first characters considered are 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. Digital
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 another.
The weight given to these features in establishing a
positive match is based solely upon the opinion of a
forensic dentist, as there are no databases of these
unique characters. Bite mark evidence is, therefore,
subjective and has been subject to some scrutiny in
court.

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

**ADDITIONAL READING**

Bowers, Michael C. (2004) Forensic Dental Evidence,
First Edition: An Investigator’s Handbook. Aca-
demic Press.

Eliopoulos, L.N. (1993) Death Investigator’s Hand-
book: A Field Guide to Crime Scene Processing,
Forensic Evaluations, and Investigative Tech-
iques. Paladin Press, Boulder, CO.
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, the 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

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, policed 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 sweetheart, 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 of being involved with drugs, but that the friends believed she was involved with John Wayne Gretzky again. 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 restraining order 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.

When attempting to contact Mitch Wilson and Lar
ry Gretzky for questioning about the car accident, police discovered that they had both skipped town along with Larry’s girlfriend, Mary Brady. 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 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**

This morning the bodies of two deceased victims were discovered in a remote fishing cabin on property owned by Tumbling Water Land Development Company. The cabin, isolated from view of the main road and deeply buried in the thick woods, lies along the bank of the Blackrock River and is accessible only by a gravel road cutting into the forest. Soon after the bodies were discovered, the small cabin was surrounded by police tape and investigators combing the scene in search of evidence.

Detective Murray, the lead investigator in the case, explained, “A Girl Scout on a hiking trip found the victims about an hour and a half ago. There are two bodies inside, both in advanced stages of decom; PMI undetermined. The female vic was identified as Louise Mondelo, the same woman identified in the car that ran off Backbone Mountain and caught fire during the storm last weekend. The bodies are in bad shape, but hopefully we’ll get a positive ID when DNA analysis comes back.”

Inside the cabin the smell of advanced human decay was overwhelming. The overturned chairs and tables led investigators to conclude that a violent struggle had taken place. The smaller body, dressed in a blouse and jeans, was found near the phone in the kitchen. The larger corpse was dressed in a man’s polo shirt and slacks lying in the corner to the left of the door, and blood covered the walls and floor around him. Investigators collected maggots from the corpses to help establish a time of death and collected DNA samples from both victims. While processing the scene, flesh was discovered scraped across the stone of the fireplace, and blood and skin were found on a piece of firewood lying near the woman’s body. Samples of both were collected for analysis. The wounds upon the head of the female victim appeared consistent with the firewood, but a definitive determination was difficult to make due to the state of decay. Outside of the cabin, a set of tire tracks were found deeply rutted in the mud and grass. As none of the investigators had driven near that area, dental stone molds were cast of the tracks and pictures were taken to preserve evidence.
On the day the car accident was discovered, John Wayne Gretzky was brought in for questioning by police investigators. During the interrogation, investigators discovered a bite mark on John Gretzky’s forearm, which he claimed to have received during a bar fight the previous night.

In an attempt to confirm or refute Gretzky’s claim, investigators collected wax impressions from regular patrons of the bar to compare to the impression on John Gretzky’s arm.

Investigators, with the assistance of morgue workers, also took a wax bite impression of the adult car crash victim for comparison.
The Mystery of Lyle and Louise

Persons of Interest

**The Mondelos**

Louise Ann Mondelo, the 38 year old wife of Lyle Mondelo and mother of Wally and Jan, 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, the 40 year old husband of Louise Mondelo and father of Wally and Jan, is a part owner of Tumbling Water Land Development Company along with his wife.

**John Wayne Gretzky**

John Wayne Gretzky is 41 years old. He is a friend and business partner of the Mondelo’s in the Tumbling Water Land Development Company. According to rumors, 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

Erupt
- 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.
Pre-Lab Questions

**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 with significant variance across the population sampled will permit better sample separation. Figure 2 shows such a character. Note 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 Figure 2, 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. Note 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 note 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](image1)

![Figure 2. Character with high variance](image2)

![Figure 3. Both characters combined, further separating samples](image3)
Bite Mark Impressions

1. Fold a piece of the pink baseplate wax in half to form a square.

2. Use gloves or place wax impressions in plastic bags to protect from transferring saliva from one student to another.

3. Insert the folded end into your mouth so that all of your teeth will make an impression when you bite down.

4. Bite the wax slowly and cleanly. 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 ‘Top’ in the upper right corner.

7. Flip the wax over, and label the upper right corner with a ‘Bottom’ with a sticker.

8. Repeat steps 1 through 6 with another piece of wax to make an additional impression.


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. Use gloves or place wax impressions in plastic bags to protect from transferring saliva from one student to another.

12. 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. Measurements 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.
Bite Impression Characterization

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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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?
Using this Kit in the Mock Trial

A Bad Impression contains information regarding John Wayne Gretzky’s alibi on how he received a suspicious bite mark. The evidence collected in this lab cannot prove conclusively that a specific person bit John Gretzky, however it can prove that the adult victim of the car accident did not make the mark. If everything in the lab was performed correctly you should have obtained the following information:

- The adult car crash victim did not create the bite mark found on John Wayne Gretzky’s arm.
- John Gretzky did not lie about being bitten at a bar the night before being questioned, and a bite impression from a man at the bar closely resembles the impression on John Gretzky’s arm.
- John Gretzky was at a bar the night the car accident occurred.

During trial, students should call witnesses who place (or do not place) John Wayne Gretzky at the bar during the time the murders took place.

If A Bad Impression is the only kit done in the Mystery of Lyle and Louise, a mock trial is unlikely to be useful, as prosecution has no evidence to try a suspect. Instead, leave the results as an exercise in bite mark analysis. If other exercises were performed, a mock trial can help students take all of the evidence presented in the investigation and available from other kits into account and provide a more interesting and thorough trial. Information on running a mock trial follows.

Before the trial

If a more thorough social studies activity is desired, students may be instructed to read through the procedures for trial of criminal cases and the simplified rules of evidence. Additionally, lessons designed to familiarize students with the court system and judicial procedure may prove beneficial.

Brainstorming

Using the story and module evidence, list the facts of the case on the board.

Determine, as a class, who should be charged for each crime.

Put students into brainstorming groups. Give all groups five to ten minutes to develop hypotheses for each of the following:

1. Identify how each fact may support the case presented by the prosecution.
2. Identify how each fact may support the case presented by the defense.
3. Identify critical weaknesses in the reliability of each fact.

Review the brainstorming results as a class and instruct students to connect various facts and evidence to make logical assumptions about the case.

Student Roles

Allow students to select, or assign, various roles relative to the characters.

Additional students may serve as the court, filling the roles of judge, bailiff, and clerk. The judge must research court proceedings and make determinations of law, therefore the instructor may wish to take this role themselves. The bailiff is responsible for swearing in witnesses and keeping order in the court. The Clerk is responsible for recording the trial proceedings. You may wish to omit these roles or have these students work with the prosecution or defense during the planning stages. With large classes, students may also play the role of jury. Ju-
Mock Trial

rors must attend to the trial proceedings and also review the evidence and written documents prepared by the defense and prosecution to come to a conclusion about the case. They must then either meet outside of class and come to a unanimous decision, or each write a short paper justifying their own decision.

At least one student should act as an expert witness (the forensic scientist who processed analyzed the evidence presented); if multiple laboratory modules were utilized, several students should fill this role. This student must be very familiar with the laboratory procedures used to process the evidence and should also be aware of the ways the evidence can be mishandled and the precautions taken against evidence contamination and faulty methods, as these are likely to come up in court.

The remainder of students should split, approximately evenly, into the prosecution and defense teams. The student filling the role of the accused should work with the defense. Each side should assign their members as either lawyers or witnesses called. The lawyers are responsible for building their case, developing the questions to ask their witnesses, and for identifying key witnesses called by the other side to exploit during cross examination. Each side should also identify critical weaknesses in their own case and prepare counter-arguments for these weaknesses. As there are always surprises during trial, each side should prepare strategies to deal with the unexpected.

The prosecution must provide a reasonable series of events that are consistent with the facts of the case, a motive for the events that occurred, and prove beyond a reasonable doubt that the accused is guilty. The defense may present their own accounting of the facts or undermine the prosecution’s case by showing that the prosecution’s witnesses are unreliable, that the prosecution’s version of the events make no sense or is inconsistent, or by introducing reasonable doubt into the prosecution’s case.

Unlike a real trial, witnesses may help the lawyers build their case; their primary duty, however, should be to become intimately familiar with their testimony. Expert witnesses are especially useful when dealing with forensic evidence, and each side may wish to call their own or use the other side’s expert. The students playing the role of expert witness must become very familiar with that field and be able to field questions about the accuracy and limitations of the techniques.

Preparation

To ensure that students will be ready to argue their case, the prosecution and defense should answer the following questions:

1. What are the facts of the case?
2. Why did these things happen?
3. Who was involved?
4. Does sufficient evidence exist to participate in the courtroom?
5. What is key to you proving your point?

Additionally, witnesses should answer the following:

1. To what are you testifying?
2. What are the most important parts of your testimony to the prosecution? The defense?
3. What weaknesses are present in your testimony? If you are an expert witness, what are the limitations of the evidence presented that is relevant to your field?